INTRODUCTION TO AGRONOMY STUDIES

Dr. N. K Pruthi
Utsav Shroff

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CONTENTS

CHAPTER 1

AN INTRODUCTION TO AGRONOMY AND ITS BENEFITS IN MODERN ENVIRONMENT

Dr. N. K Pruthi, Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

In order to maximise crop output and sustainable farming methods, gronomy, a subfield of agricultural science, integrates a variety of disciplines. The purpose of this research paper is to investigate the value of agronomy and its advantages in the contemporary setting. The research dives deeply into agronomic concepts and practises, such as crop choice, irrigation, and pest control. It looks at how to increase agricultural production and resource efficiency using contemporary technology like remote sensing and precision farming. The study also explores the contribution of agronomy to environmental sustainability, resource conservation, and climate change adaptation in agriculture. For the purpose of tackling global concerns connected to food security, resource scarcity, and environmental degradation, it is essential to comprehend the role of agronomy in the contemporary world. The report also emphasises how agronomic practises may be used to enhance rural lives, spur economic development, and guarantee food supply for the expanding world population.

KEYWORDS:

Agronomy, Crop Production, Environmental Sustainability, Precision Agriculture, Sustainable Farming.

INTRODUCTION

The production of food, clothes, shelters, medicines, and recreational activities, agriculture assists in meeting the fundamental requirements of people and their society. As a result, agriculture is the most significant industry in the world. The free gifts of nature, such as the land, light, air, temperature, and rainwater, among others, are used productively in this unit. are incorporated into a single essential component that humans cannot live without. Animals, including cattle, birds, and insects, which are secondary production units, feed on these primary productive units and produce concentrated goods like meat, milk, wool, eggs, honey, silk, and lac [1], [2]. Aside from providing a free meal, a clean environment, enough of food to end hunger, and resources for and from industries, agriculture also supplies food, feed, fibre, fuel, furniture, and other necessities.

It also promotes peace by reducing conflict. A nation's citizens experience peace, prosperity, harmony, health, and riches thanks to satisfactory agricultural output, which also drives away mistrust, unrest, and anarchy. It promotes the community as a whole, bringing about improvements in its social, cultural, political, and economic conditions. In terms of time and geography, agricultural growth spreads quickly and in several directions. After the green revolution, farmers began using more advanced agricultural inputs and cultural practises in labor-intensive cropping systems to increase the output potential per unit of land, time, and input. It gave all of these enhanced genotypes the right conditions to develop and show off their production potential in fresher locales and seasons. Agriculture involves raising plants and animals for harvest and production, which contributes to the preservation of the biological balance in the natural world. By supplying food, clothes, housing, medicine, and leisure activities, agriculture serves to address the fundamental requirements of people and their society. As a result, agriculture is the most significant industry in the world. The free gifts of nature, such as the land, light, air, temperature, and rainwater, among others, are used productively in this unit.

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Latin terms ager and cultura are the origin of the word agriculture. Ager and Cultura both refer to land or a field. Consequently, the word "agriculture" refers to land cultivation. i.e., the science and art of raising animals and crops for commercial gain. It is also known as the science of raising animals and crops using just the earth's natural resources. Agriculture's main goal is to increase the amount of food the land can produce while also guarding against damage and exploitation. The production of food, fodder, and other industrial products is synonymous with farming [3], [4]. The Agriculture Act of 1947 defines agriculture as "horticulture, fruit growing, seed growing, dairy farming, and livestock breeding and keeping, as well as the use of land for grazing, meadow, osier, market gardens, nursery grounds, and woodlands when those uses are incidental to the farming of land for agricultural purposes." Additionally, it is described as "purposeful activity in which natural resources are used to create plants and animals that serve human needs. It is a biological manufacturing method that relies on the expansion and maturation of certain plants and animals within the regional environment.

Agriculture has received a significant allocation in each of India's five-year plans. In the 8th five-year plan, agriculture and related small-scale agro-based cottage industries get close to 23% of the national budget allocation. Over 60% of India's population (1.05 billion people) rely on or engages in agriculture and related activities. The agriculture industry contributes close to 40% of the nation's gross domestic GDP. Agriculture generates around 35% of the nation's jobs, of which 75% are located either directly or indirectly in rural regions. Through the green revolution, food grain output in India grew by over four times, from around 50 million tonnes at independence to more than 220 million tonnes in 2005. The overall output of food grains increased by 2.7% year despite variations in the performance of certain crops and geographical areas, keeping pace with population growth, which was 2.2% annually. Milk output grew under the "white revolution," rising from 17 million tonnes at independence to 69 million tonnes (1997–1998).

Fish output increased thanks to the "blue revolution" during the last fifty years, going from 0.75 million tonnes to around 5.0 million tonnes. Since independence, oil seed output has grown five times (from 5 million tonnes to 25 million tonnes) because to the yellow revolution. Similar increases in egg production from 2 billion at independence to 28 billion as well as sugarcane and cotton production from 57 million to 276 million tonnes and 3 million to 14 million tonnes, respectively show our success. The world's biggest fruit grower is India. India ranks second in the world for both milk and vegetable production. Future agricultural growth in India will be influenced by issues such as environmental preservation, sustainability, and profitability in addition to the need of enhancing food and nutritional security. Globalisation of markets will necessitate competitiveness and efficiency in agriculture production by adhering to the General Agreement on Trade and Tariffs (GATT) and the liberalisation process. In the years to come, agriculture will encounter difficult circumstances on the fronts of the environment, the global climate, economic fairness, energy, and jobs [5], [6].

DISCUSSION

Branches of Agriculture

There are three primary subfields of agriculture: geoponic (earth-soil cultivation), aeroponic (air cultivation), and hydroponic (water cultivation). The scientific field that encompasses the practical applications of fundamental sciences is agriculture. The study of field crops and their management (Arviculture), including soil management, is one of the applied parts of agricultural science. Crop production is the process of growing different kinds of plants, such as food, fodder, fibre, sugar, oil seeds, and other crops. Agronomy, soil science, entomology, pathology, microbiology, etc. are all included. Better food production and disease management are the goals. The cultivation of flowers, fruits, vegetables, decorative plants, spices, condiments including narcotic crops like opium, etc., which have medical value, and drinks is referred to as horticulture, a branch of agriculture. Agricultural engineering is crucial to the production of crops and horticulture, especially for the provision of equipment and implements. In order to aid effective animal husbandry and food production, it aims to manufacture customised equipment, machinery, and implements. Forestry is the production of large-scale perennial tree cultivation for the supply of wood, rubber, lumber, etc. as well as raw materials for industries.

Animal production, care, etc. are all examples of animal husbandry. upkeep of different cattle kinds for direct energy (work energy). Animal and agricultural husbandry are both widespread practises. The goal is to produce as much as possible by feeding, raising, etc. Crops are arranged to get the minimum amount of light or air. This configuration is known as geometry. For both direct and indirect energy, there is husbandry. Fishery science is the study of marine and freshwater fish, as well as prawns and prawns. Home science: A better method of applying and using agricultural products. Production is increased when utilisation is raised. For instance, a crop formerly grown in the South was discovered to have a variety of modern applications.

Development of Scientific Agriculture

Early man relied on obtaining food, fishing, and hunting. Some communities continue to live in this modest fashion now, while others have carried on as wandering herders. However, agriculture was created as a result of purposeful wild plant and animal domestication by distinct groups of mankind. Crop cultivation, particularly the cultivation of grains like wheat, rice, barley, and millets, supported the development of permanent farm communities, some of which in different regions of the globe eventually became towns or cities. Digging sticks, hoes, scythes, and ploughs were among the first agricultural instruments. Each invention brought about significant changes in human existence over the course of centuries.

Indigenous irrigation systems were developed by men from the beginning, particularly in semi-arid regions and places with intermittent rainfall [7], [8].

Intimate ties existed between farming and political organisation due to land ownership. Use of slaves and tied or semi-free labour was necessary for the expansion of vast estates. The commercial revolution and Western Europe's rapid urbanisation tended to shift agriculture away from subsistence farming and towards the production of products for export, or the commercial agricultural revolution, at a time when the Middle Ages desired more communication.

The development of agricultural knowledge of various crops was aided by exploration, intercontinental trade, and scientific research. The exchange of mechanical devices, such as the cotton gin and sugar mill invented by Eli Whitney, supported the system of large plantations devoted to a single crop. After the late 18th century, the industrial revolution increased the population of towns and cities and compelled agriculture to become more integrated with broader economic and financial trends.

With the development of farm machinery such the reaper, cultivator, thresher, combine harvesters, and tractors, which continued to emerge throughout the years and gave rise to a new kind of large-scale agriculture, the age of mechanized agriculture started. Food processing has been transformed by modern science. Highly specialized animal, plant, and poultry types have been created via breeding operations, considerably enhancing production efficiency. The release of new plant and animal species, along with ongoing, intensive research into fundamental and applied scientific principles related to agricultural production and economics, are all methods used by agricultural colleges and government organizations around the world to try to increase output.

The primary input for agricultural production is land. The size of the planet is 15.2 billion ha, with 3.8 ha available per person (3.8 ha each for Canada, Australia, South America, the United States, France, India, and Japan). In 2050, the amount of cultivable land per person will decrease globally due to population growth from 0.3 ha in 1988 to 0.17 ha, with just 0.11 ha per person in emerging nations. In addition to organic content, one of the excellent top soils had nutrient losses from soil erosion of 4 N, 1 P2O5, 20 K2O, and 2 CaO per kg.

Only 10 to 11% of the total land under cultivation is really unrestricted in terms of crop output. According to the FAO's research of agricultural output growth trends in 93 developing nations, greater yields and increased cropping intensity must account for 63% of production increases. Only 22% is anticipated from the land reserve. Only 30% of the entire 6444 m. ha of rainfed agricultural potential is acceptable, 10% is marginal, and 60% is unsuitable across various nations. The semiarid tropics (SAT), which include all or portions of 50 nations on five continents (Central America, SW Asia, Africa, South America, and South East Asia), are home to 700 million people who often experience starvation and are always under danger of drought. The largest improvements to the global food ladder would come from bettering agriculture, which has untapped potential for grains, pulses, and oilseeds on around 65% of the world's arable land. Of all the emerging nations, India has the highest SAT area (10%).

1. The rate of environmental deterioration is accelerating, which is reducing land productivity and jeopardising the livelihood of rural residents. According to the Global Assessment of Soil Degradation (GLASoD), soil degradation is a process that explains human-induced processes that reduce the soil's ability to sustain human existence in the present and/or the future. The following factors contribute to degradation: • Removal of vegetative cover due to agricultural clearance; 1, Reduction in soil cover due to removal of vegetation for use as fuel, fencing, etc.

2. Overgrazing by animals resulting in a reduction in the amount of vegetation cover and soil trampling
3. Soil contamination with pollutants such waste discharges and excessive use of agrochemicals; cultivation on steep slopes; farming without anti-erosion measures in dry regions; poor irrigation; and use of heavy equipment.

On healthy soils as opposed to infertile ones, modern farming techniques are more productive. By temporarily delaying the impacts of soil deterioration, technology may be able to preserve harvests. If the soil had not been eroded, technologically enhanced yields may have been higher [9], [10].

Water Resources

Sea water makes over 97% of the 1400 million cubic kilometres (M cu km) total amount of water. Less than 1% of the remaining 3% of water is freshwater that may participate in the hydrological cycle since 77% of the remaining 3% is groundwater and 22% is locked up in glaciers and polar ice caps. Between 1940 and 1980, the world's water demand doubled; by 2010 A.D., it is anticipated to do so once more, with two-thirds of the increase going to agriculture. From its 280 M hectares of irrigated land, one-third of the world's crops are produced now. Following World War II, international assistance made irrigation possible even in desert regions of the globe. Approximately 270 million hectares (ha) or 17% of the world's cultivated land was under irrigation as of 1990. Salinity, inadequate drainage, and bad management pose a severe danger to the survival of the irrigated agricultural systems of the past. As a proportion of the total area irrigated by 1985, the top five nations with salinized irrigated land are: Pakistan 25, China 17, India 36, and the USSR 18. India had 0.057 ha of irrigated land per person in 1989 compared to the global average of 0.049 ha.

The global cropping intensity in rainfed agriculture is 0.74. The present intensity of 1.21 might rise to 1.29 with irrigation. 300 m3 of water must be consumed per day to sustain a 2000 calorie diet, and 420 for a 3500 calorie diet. A year's worth of food for about five persons at the FAO's minimum nutritional requirement of 1600 calories per day will be produced by cultivating one hectare of additional land. The overall yield rises fourfold to 3.5 tonnes ha-1 if the area is irrigated. In the future, if the world's irrigated land reaches 1.0 billion hectares, there will be enough food to feed 10 billion people, which is double the FAO goal. Despite the fact that irrigation can help feed a growing population, recent attempts to expand the irrigated area have run into a number of issues that have resulted in soil degradation. Aquifer depletion, declining water tables, abandonment of waterlogged and salted land, reservoir silting, and the diverting of irrigation water for non-agricultural uses are all factors that contribute to changes in the world's irrigated area from year to year. Future food production from irrigated regions will be more dependent on improvements in water use efficiency than on new water sources.

Food Scenario

Around the globe, cereals are farmed to provide food for humans as well as feed and fodder for cattle. They account for 74.5% of the worldwide output of calories and are cultivated on 73.5% of the world's arable land. With a growing global population, there is a rising need for food. The demand for grains is anticipated to increase to 2.4 billion tonnes by the year 2000 A.D. from the current output of around 1.9 billion tonnes. The demand for coarse grains might quadruple over the next 20 years, while the demand for wheat and rice may rise by 31 and 53%, respectively. Developed countries may be able to fulfil their demand for grain by increasing output by 1.8% annually.

However, the majority of emerging nations fall short of meeting this demand, which is rising at a pace of 3.3% per year owing to rapid population growth, with a growth rate of 2.5% per year in grain output. The FAO statistics unequivocally show the growing lack of grains in 90 developing nations. Food production increased significantly worldwide between 1972 and 1992. The introduction of high yielding varieties (HYVs) that are responsive to inputs of fertilisers and irrigation water, along with an increase in the area under cultivation, has contributed significantly to the productivity and production of the technologically advanced agriculture of the developed countries, reaching heights that would have been unimaginable half a century ago.

A distinct image was offered by developing nations. With China excluded, just roughly a third of their total population resided in nations that produced enough food. In some places, production growth lagged behind population growth. Africa in the 1970s became the glaring example of inadequate output. The productivity of agriculture was greatly constrained, especially that of small farmers in emerging nations.

1. Because of the continued uneven distribution of land, farms got gradually smaller as rural populations increased.
2. Resources allocated to research, training, and extension were very few, input supplies and services were inadequate, and access to them was highly uneven.
3. Industry was given precedence over agriculture, and food prices were influenced to favour metropolitan customers over rural farmers.

Between 1980 and 2000, the FAO sought to increase agricultural output in developing nations by a factor of two. The success of an ambitious transformation that involves extensive technological upgrading and is based largely on a significant increase in agricultural inputs is necessary for the positive result.

Because they continue to expand their agriculture, developed nations do not immediately enter the exploration of the future. The plan is to: Invest heavily in the agriculture industry to fully use the new technologies.

1. Increasing sources of agricultural production via increases in arable land, crop yield, and cropping intensity.
2. Increasing land use for crop production through irrigation, fertilisers, better cultivates, plant protection, and mechanisation.
3. Expanding and conserving the land based on land reforms targeted at bringing underused land in to more intensive exploration and soil and water conservation to the dangers of land degradation.

In contrast to the 6.2 billion people who lived on the planet in 2000 A.D., the World Bank predicts that the population will reach a fixed level of just under 10 billion people by the end of the 21st century. These forecasts are significant since population is expected to increase more quickly than food demand. Today's emerging nations, which have low per capita spending levels, account for 95% of the population growth. The global demand might rise by 50% in the next 20 years, then more than double again in the first half of the following century, according to projections.

It seems difficult to double global food and agricultural output between 2000 and 2055 A.D. It will need at least suggestive global source use planning to adequately supply the food and agricultural needs of the world's roughly 10 billion inhabitants, taking into consideration non-agricultural usage of the land and oceans. It is obvious that the major driver of future production growth must be a sustained, fast rise in agricultural and livestock yields. The growth of arable land over the following 20 years would result in almost all of the possible arable land being farmed by the middle of the twenty-first century. The support of agricultural research and extension has to be more focused on the issue of agriculture in developing countries.

A food and agricultural system in developing nations that is far more productive and egalitarian than it is now must be passed down to the twenty-first century. by always incorporating new ideas. Therefore, the remainder of this century must be used to provide the groundwork for a huge rise in production requirements in the first half of the twenty-first century. In order to improve the lives of future generations as well as those already living, it is necessary to achieve the goals set for this latter time.

CONCLUSION

In light of the current environmental difficulties, agronomy is an essential subject in contemporary agriculture and provides a number of advantages. The importance of agronomy and its advantages in the contemporary environment have been examined in this study article. The curriculum focused on agronomy's fundamental ideas and methods, including crop choice, irrigation, and pest control. For maximising agricultural productivity and guaranteeing food supply, these procedures are essential. Understanding how current technologies like remote sensing and precision agriculture are used may help improve agricultural output and resource efficiency. The study also looked at how agronomy might support environmental sustainability. For agriculture to be less affected by climate change and environmental deterioration, sustainable agricultural methods and resource conservation are crucial. Understanding the relevance of agronomy in the contemporary world opens doors for tackling international problems with resource scarcity and food security. The information acquired via studying agronomy may be used to enhance rural lives, foster economic development, and guarantee the supply of food for the expanding world population. The advancement of our knowledge of agronomy and its consequences for contemporary agriculture and environmental sustainability requires further study in this area. Putting agronomic practises into practise may boost food security, resource efficiency, and agricultural output. Additionally, encouraging sustainable agricultural methods may help preserve natural resources and improve both rural and urban people' general well-being.

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CHAPTER 2

A STUDY ON AGRICULTURE IN NATIONAL ECONOMY

Dr.Ashiwini Kr Tyagi, Associate Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

For a very long time, agriculture has been a crucial pillar of the national economy, supplying raw materials for several businesses as well as jobs and food security. This study examines how agriculture affects the national economy, highlighting its contributions, patterns, difficulties, and implications for long-term sustainability. The research examines the contribution of agriculture to the economy's gross domestic product (GDP), foreign currency profits, and rural lives. It looks at how modernization and technology developments in agriculture, such precision farming and agro-processing, have changed the productivity and efficiency of the industry. The study also looks at the difficulties that agriculture faces, such as the effects of climate change, the deterioration of the land, the lack of water, and market volatility. For the creation of efficient policies, supporting rural development, and building agricultural resilience, it is essential to comprehend the dynamics of agriculture in the national economy. The paper also identifies possible uses for this information in agricultural diversification, agrarian reform, and sustainable land use, providing chances to increase national food security and economic stability.

KEYWORDS:

Agricultural Diversification, Agrarian Reforms, Climate Change Impacts, Precision Farming, Rural Development.

INTRODUCTION

The Indian economy is based on agriculture, and despite deliberate modernization over the last 40 years, agriculture still has a special place in the nation's heart. About 70% of the working population is employed in agriculture, which also accounts for a large portion of the nation's foreign currency profits and almost 30% of the national revenue. It offers the food grains needed to feed the enormous 85 crore people. Additionally, it provides raw materials to several businesses. As a result, agriculture forms the foundation of the nation's economic system [1], [2].

Manpower's contribution to industry

The rural agricultural worker has historically been a source of employment for industry. According to the Commission on Labourer's conclusions, the majority of the Indian manufacturing workers were migrants from rural regions. This migration to cities is still happening. This is brought on by both the dearth of work and income prospects in rural regions and the allure of employment, greater income, and metropolitan amenities on the other.

Contribution to Resources for Foreign Exchange

A significant portion of the export of the nation is made up of agricultural goods, both primary production and produced from agricultural raw materials. An estimate states that in 1988–1989, agricultural products such raw cotton and jute, unprocessed tobacco, oilseeds, spices, tea, and coffee made up around 49% of the entire value of exports. This contributes significantly to the nation's foreign currency reserves [3], [4].

Agriculture and industry's reliance on one another

A tight relationship exists between industry and agriculture. This refers to the flow of inputs and raw materials from agriculture to industry and vice versa; the supply of wage goods to the industrial sector; the provision of basic consumer goods to the agricultural population; and, finally, the provision of materials for the construction of economic and social overheads in the agricultural sector. As the economy grows, the connection between agriculture and industry is intensifying. Innovations in industrial items utilised in agricultural production are prompted by the use of science and technology in agriculture. Oil, sugar, jute and cotton textiles, and the tobacco industry all heavily rely on agricultural outputs such as fertilisers, pesticides, diesel oil, electric motors, diesel engines, pump sets, agricultural tools and implements, tractors, and power tillers. Even the processing industries, which use agricultural raw materials and create meat, milk, and fruit cans, for example.

Capital Formation Contribution

The rate at which production assets grow dictates the pace of growth in major part. Prior to independence, India's agricultural sector had low levels of capital creation. Agriculture suffered during this time due to ongoing poor yield technologies, an unfair land tenure system, and the exploitation of the rural populace. Land development, housing building, and other forms of capital production are included.

Since independence, there has been a significant increase in state and private investment in agriculture. Land development, irrigation facility construction, road and communication construction, farm buildings, agricultural machinery and equipment, warehouses, cold storage facilities, market yards, etc. have all been used to create physical assets in the past. The growth of the economy as a whole, as well as agriculture, is aided by this capital accumulation.

Contribution to People's Purchasing Power

In addition to individuals who are directly involved in it, agriculture also benefits others who work in related businesses and services. Farmers spend more as their income rises. Hundreds of blacksmiths, carpenters, masons, weavers, potters, leather workers, utensil manufacturers, tailors, cotton ginners, oil pressers, transporters, and countless more benefit from the expansion of their markets and employment prospects. As a result, there are several enterprises whose success and employment are reliant on the spending power of the rural populace. As a result, it is determined that in addition to providing raw materials for consumer businesses and food for non-agricultural employees, it has generated demand for a large number of new sectors, which in turn has produced high-quality jobs. Given that agriculture now plays a significant part in the Indian economy and that its success mainly reflects that of the economy as a whole, it is imperative that Indian agriculture be developed to its maximum potential. The importance of agriculture stems from the fact that the growth of the agricultural sector is a prerequisite for the growth of the national economy [5], [6].

Food Problem

India has had a food crisis even before it gained independence. In the beginning, India's food crisis was one of scarcity, with a shortfall of wheat and rice after the division of the country in 1947 and the secession of Myanmar (Burma) from India, respectively. The government's first top priority was to boost local supply via either expanded production, imports, or a combination of the two. The government's top priority changed to price regulation of food grains in the second part of the 1950s and the 1960s. In 1956, the Indian government and the United States agreed into the PL 480 agreement, which allowed for the import of wheat and rice. The PL 480 food imports were deemed by the government to be an effective measure for controlling the nation's food costs. In fact, PL 480 imports formed the cornerstone of our nation's industrial and agricultural growth. In order to reexamine the food issue, the government established the Food Grains Policy Committee in 1966. The committee concluded that India's continued reliance on food imports was unlikely to be simple.

It seriously noted the fact that the food assistance was openly exploited to influence the government's domestic economic and foreign policy decisions. Production of food grains increased annually in Punjab, Haryana, and Uttar Pradesh between 1967–1968 and 1989–1990 at rates of 5.4, 4.0, and 3.4%, respectively. The foundation of our public distribution system consists of these states. These states have protected the nation from a shortage of food grains. From the initial objective of 5.0 million tonnes, there has been an increasing excess of stocks throughout the 1970s, especially after 1974; the government was successful in building up a buffer stock of more than 30 million tonnes of food grains during the 1980s. Actually, the government's vast stores of food grains were what allowed it to effectively weather the three years of subpar food grain production, which culminated in the severe drought of 1987–1988 [7], [8].

The issue with food is no more one of scarcity or high pricing, but rather of how to make it so that lower income groups can buy the food grains that are readily accessible and how to utilise the vast food supplies to hasten the process of economic expansion. The food for work initiative was created in 1977–1978 with the goal of giving the rural poor, the jobless, and famine victims jobs while also building long-lasting communal assets. The government is also putting into action a plan to provide food grains to the less fortunate, particularly in tribal regions, at a cost far lower than the already subsidised price under the public distribution system. There is widespread consensus that the major causes of India's food shortage are the country's growing population (which raises food demand), a lack of food grain supply, and certain elements of the government's food policy.

DISCUSSION

Measures to Increase Production

technical advancements: Of the strategies to improve the production of food grains, technical advancements are the least contentious. In the nation kicking off the green revolution, intensive farming using enhanced varieties and abundant irrigation and fertiliser usage is being rapidly expanded. The most recent phase is to achieve a breakthrough in dry land and rainfed agriculture. Organising principle: The second strategy for agricultural growth is the organisational strategy, or by appropriate and efficient organisation, which encompasses the complete framework of official and semi-official organisations and agencies in addition to the governmental administrative system.

According to others, the fundamental reason why attempts to boost agricultural productivity via technical advancements have not been particularly successful is because the organisation was insufficient and ineffectual. Institutional alterations The second method of raising agricultural output is to implement institutional changes, or land reforms. There are no incentives for increasing productivity under the current agricultural system. Expecting the tiller to work hard to boost food production on small holdings that are dispersed across the village and in a system of landholdings where the tenant has no security of tenure is not a good idea. The Government has been pursuing a number of land reform initiatives, including as the creation of cooperative farms, the capping of holdings, the control of tenures, and the consolidation of holdings. Since there are several gaps in the law governing land reforms, the government must act immediately to close these gaps via effective legislation.

Distributional modifications: The government has significantly increased the public distribution system's (PDS) reach in recent years. The public distribution system handled more than 19 million tones in 1987–88, up from more than two million tones in 1956. The PDS's coverage was expanded to 1700 blocks in remote and underserved areas in 1991, including economically depressed, drought-prone, desert, and mountainous regions. For the lean season, the PDS allocation of rice, wheat, etc. should be increased. The country's public distribution system has to be strengthened urgently. Price stabilisation for food grains: In recent years, controlling the price of food grains has been the primary goal of food policy. The government has been implementing short-term strategies like maintaining high stock levels, expanding internal procurement, increasing government purchases of food grains for distribution through fair price shops, putting restrictions on profiteering and hoarding, and fixing maximum control prices.

These actions did have some effect on price control, but historical data indicates that price stability has not yet been entirely attained. The government's buffer stock programmed is the solution to the issue of stabilizing both food prices and the nation's overall price level. The government made the decision to accumulate a buffer stock of 5 million tons of food grains by 1973–1974, but the real stock with the government starting in 1979 has been above 20 million tons, which is a favorable indicator. It is believed that, if handled wisely and adaptably, it would go a long way towards safeguarding both the farmer and the customer from significant price swings. A sense of confidence that the food scarcity is a thing of the past arises from the presence of vast food stores. With the development of irrigation infrastructure, the availability of fertilizers, the electrification of rural areas, etc., there is every chance that the production will increase. However, it must be noted that the very variable monsoon and the ensuing ups and downs in food production might always indicate trouble [9], [10].

The Greek words agros and nomos, which mean field and manage, respectively, are the origin of the phrase agronomy. Agronomy is defined as the "art of managing a field" in its literal sense. The "science and economics of crop production by management of farm land" is what it implies technically. Agronomy is the art and science that underlies the production and improvement of field crops via the effective use of soil fertility, water, labour, and other crop production-related elements. The study and use of techniques for producing food, feed, and fibre crops is known as agronomy. According to Wikipedia, agronomy is "a discipline of agricultural science concerned with the concepts and practises of field crop production and management of soil for improved productivity.

Importance: Agronomy is considered as the mother branch or fundamental branch of agriculture since it plays a key role in all other agricultural disciplines. Similar to agriculture, agronomy is a combined and applied branch of many pure scientific fields. Crop science, soil science, and environmental science are the three distinct subfields of agronomy that solely address practical issues.i.e., the interaction between soil, crop, and environment. Agronomy is a synthesis of a number of disciplines, including crop science, soil science, environmental science, and crop ecology. Crop science encompasses plant breeding, crop physiology, and biochemistry, among other topics. Planning, planning, and putting into action procedures to make the best use of land, labour, money, and other production elements. Proper field management through tillage, preparing field channels and bunds for irrigation and drainage, checking soil erosion, levelling, and adopting other suitable land improvement practises;

Adoption of multiple cropping and also mixed or intercropping to ensure harvest even under unfavourable environments; the application of green manure, farm yard manure, organic wastes, bio fertilisers and profitable recycling of organic wastes to correct negative effects of soil reactions and conditions and increase soil organic matter; the selection of high-quality seed or seed material to maintain the necessary plant density per unit area with healthy and uniform seedlings; the appropriate management of water with regard to crops, soil and the environment through conservation and utilisation. Adoption of suitable and appropriate management practises, including intercultural operations, to get the most out of expensive and difficult-to-get, low-monetary and non-monetary inputs; Adoption of suitable method and time of crop harvesting to reduce field losses; Adoption of adequate, need-based, timely and exacting plant protection measures against weeds, insect-pests, pathogens, as well as climatic hazards; In 1908, the American Society of Agronomy was founded.

The supercontinent Pangea started to fragment 180 million years ago during the Mesozoic Era.The same reason why the plates are shifting now, according to scientists, is what caused Pangea to split apart. Convection currents that roll over in the higher zone of the mantle are to blame for the movement. The plates move slowly over the surface of the Earth as a result of this movement in the mantle. Pangea disintegrated into four halves. The split between Laurasia and Gondwanaland originally appeared in the Triassic epoch, some 200 million years ago. The modern continents of North America (Greenland), Europe, and Angara land, which included northern Russia, Siberia, and China, formed up Laurasia.

The modern continents of South America, Africa, India, Australia, and Antarctica originally up Gondwanaland. Keep in mind that India and Asia were not linked at this period. The vast Panthalassa Ocean still existed, but the Atlantic Ocean will soon be created when the North American Plate separated from the Eurasian Plate. Due to a three-way breach in the crust, which allowed tremendous lava flows in three directions and poured forth lava across hundreds of square miles of Africa and South America, "The Triple Junction" was created. In terms of age and mineral composition, the rocks of the triple junction, which now includes the west central region of Africa and the east central region of South America, are exact mates. In other words, the rocks on these two continents were formed simultaneously and at the same location. This demonstrates the historical connections between South America and Africa. These two continents are now divided by the nearly 2000-mile-wide Atlantic Ocean.

Around 135 million years ago, during the Jurassic era, Laurasia was still in motion, and as it did so, it fragmented into the continents of North America, Europe, and Asia (Eurasian plate). During the Jurassic and Cretaceous periods, the continents of the Gondwana era split from one another. South America and Africa split apart in the late Jurassic. Another concave basin was therefore formed between these two continents. The Moroccan bulge of Africa split from the eastern coast of North America. The Atlantic and Indian Oceans became accessible with the dissolution of Gondwanaland. In stage three, the Tethys Sea, the forerunner of the Mediterranean, was sealed off on the eastern end by the Atlantic expanding northward and Eurasia rotating clockwise. In 135 million years, the Indian Subcontinent travelled at a rapid rate of 4 inches each year, covering hundreds of kilometers. The Himalayan Mountain range was formed when the Indian plate slammed against the Eurasian plate (Asia) with such speed and power. As India neared Asia, the Tethys was being pushed out of existence to the east of the Alpines.

The Himalayan Mountains and the enormous volumes of silt they produced were so heavy that they pushed the Indian-Australian Plate to sink, resulting in a zone of crystal subsidence and the formation of geosynclines into Madagascar (Madagascar) and Australia. The Permian Gondwana sediments contain the majority of India's coal reserves. Indian continent is regarded highly for its prospective future for mining opportunities due to its proximity to mineral-rich South Africa and West Australia. The Red Sea began to expand when Arabia began to split off from Africa. The direction of the continental motions is shown by the red arrows. Significant portions of the Gondwanaland margins broke off and sunk into the seas as a consequence of the earth's motions. Africa and Antarctica experienced rifting, which spread northeastward to India. Australia and Antarctica split apart in the early Cenozoic. Early Cenozoic times saw Pangea's ultimate stage of fragmentation. The North Atlantic Rift persisted to the north until Eurasia (Europe) and North America split apart. Australia and Antarctica split apart at this time. About 45 Ma ago, the continents finally split apart. Pangea disintegrated over a period of 150 million years.

Geography of India

The Himalayas, the vast mountain system to the north, the Indo-Gangetic alluvial plain of northern India extending from Punjab to Assam, and the Peninsula of the Deccan to the south of the Vindhyas a solid stable block of the earth's crust, largely composed of some of the most ancient rock are the three distinct segments of totally different character that naturally divide the country. Peninsular India's landmass has never been completely covered by water. While the Himalayas and the Indo-Gangetic plain are relatively young, the western and eastern ghats create the western and eastern edges of the plateau, which slopes east. At the summit of Everest, marine sediment is present.

The Cretaceous era lasted for 50 million years and started 110 million years ago. The land regions, particularly in the Puducherry and Tiruchirappalli sector, are mostly littoral during the middle and upper Cretaceous. The fauna of this region is comparable to that of South Africa, Madagascar, and the southern edge of the Assam range. Some marine fossil ferrous layers can be found in the Narmada Valley on the west coast. These fossils are more similar to those from southern Arabia and Europe during the Cretaceous Period than they are to Assam and Tiruchirappalli. The difference suggests that there was still some form of geographical barrier separating the Arabian Sea from the Bay of Bengal.

Lellluria, which covered Peninsular India and Malagasy (Madagascar), was the name given to this geographical barrier. Volcanic eruptions engulfed a sizable region during the middle and upper Cretaceous, including what is now Gujarat, Maharastra, and Madhya Pradesh. Extremely mobile lava erupted from cracks, flooding several hundred thousand square km. The Deccan traps are a group of lava-formed hills that are over 1,200 metres high in certain areas. In the Tertiary Period, the Deccan trap's creation proceeded. Sind, Kutch, Bihar, and the Andhra Pradesh coast are all covered by the Deccan trap.

The early Eocene is when the Himalayan component of the Tethys assumed its current pattern, gradually moving southward and becoming narrower. The Himalayan chain's shape has been shaped by the existence of tongue-like Gondwanaland expansions, one in the Kashmir-Hazara area (the Punjab wedge) and the other in Assam's far northeastern corner (the Assam wedge). Any relief map of India will plainly show the influence of these two wedges. You'll see that the Himalayan range spans a vast arc from Namcha Barwa in the east to Nanga Parbat in the west. The arc's convexity points southward towards the Indian peninsula. The Siwalik Hills, which stretch from Jammu in the west to Assam in the east, are located under the Himalayas.

The majority of the Siwalik Hills are river deposits from the middle Miocene to the late Pleistocene Age that have been folded into synclines and anticlines. The fault planes that slope sharply into the hills have created steep scarps that face the lowlands. The sub-Himalayan region, also known as the smaller Himalayas, is located directly north and next to the Siwalik Hills. It is 65 to 80 km broad and has an average elevation of around 3,000 metres. Most of the rocks in this area lack fossils. The middle Himalayan zone, which consists of high ranges with snow-capped peaks, is farther north. Rocks that have undergone metamorphism make up the majority of it. The Indo-Gangetic plains, which stretch from Hazara to Assam at the base of the Himalayas, are the side of a deep basin with an estimated depth of 1,050 to 6,000 metres. This basin was formed as a consequence of the compression put on the peninsular edge by advancing crystal waves from the north. The Himalayas' ascent and the plateau to the south have both contributed river alluvium that has filled the basin.

CONCLUSION

Formulating resilient policies and sustainable land use plans requires an understanding of the difficulties encountered by agriculture, including the effects of climate change, land degradation, and water shortages. Agrarian reforms and agricultural diversification may benefit from the information obtained by researching the role of agriculture in the national economy. Increasing food security, reducing reliance on conventional crops, and fostering agricultural variety are all benefits. In conclusion, further study in this area is necessary to improve our comprehension of how agriculture affects the national economy and sustainable development. Secure national food security and economic stability depend on prioritising sustainable farming practises, fostering rural development, and funding agricultural research and innovation. It is crucial for guaranteeing the profitability and well-being of the agricultural sector and the whole country to place an emphasis on sustainable land use and climate-resilient agriculture.

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CHAPTER 3

A BRIEF DISCUSSION ON AGRICULTURE HERITAGE IN INDIA

Dr. Raj Kumar, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

With a history spanning millennia, India has a rich and diversified agricultural legacy. In order to better understand the importance and legacy of agriculture in India, this research paper will concentrate on its traditional methods, native plants, and cultural relevance. The investigation focuses on the ancestor-to-ancestor transmission of agricultural knowledge and practises. It looks at the significance of several plants, including rice, wheat, millets, and pulses, which have been crucial to Indian agriculture for many years. The study also looks at the social and cultural components of agriculture in India, such as festivals, rituals, and traditional agricultural methods that have a long history in the nation. For the purpose of conserving traditional knowledge, encouraging sustainable farming methods, and tackling contemporary agricultural difficulties, it is essential to understand India's agricultural legacy. The research also emphasises how this knowledge may be used in contemporary agriculture and rural development, providing chances to raise agricultural output and safeguard cultural identities.

KEYWORDS:

Agriculture Heritage, Cultural Significance, Indigenous Crops, Sustainable Farming, Traditional Practices.

INTRODUCTION

In India, agriculture has existed for a very long time, going all the way back to the Neolithic period, which lasted from 7500 to 6500 B.C. It transformed early man's way of existence from a nomadic forager of wild berries and roots to a farmer of land. Great saints' knowledge and teachings are beneficial to agriculture. Generation after generation has handed along the knowledge acquired and the practises embraced. Traditional farmers have created agricultural techniques that are favourable to the environment, such as crop rotation, mixed farming, and mixed cropping. The degree of knowledge that the older Indian farmers held is reflected in the great epics of antiquity. The value of old wisdom, which has undergone a process of refining over centuries of experience, has been overlooked by contemporary society. The rebirth of organic agriculture today is a reflection of the ecological concerns used by traditional farmers in their agricultural practices [1], [2].

The available ancient literature includes the four Vedas, nine Brahnanas, Aranyakas, Sutra literature, Susruta Samhita, Charaka Samhita, Upanishads, the epics Ramayana and Mahabharata, eighteen Puranas, Buddhist and Jain literature, and texts such as Krishi-Parashara, Kautilya's, Artha-sastra, Panini's Ashtadhyahi, Sangam literature of Tamils, Manusmirit, Varahamihira's Brhat Samhita, Amarkosha, Kashyapiya-Krishisukti and Surapala's Vriskshayurveda. The most plausible period for composition of this literature is between 6000 B.C. and 1000 A.D. These works include information on agriculture including animal husbandry and biodiversity.

India's oldest extant literary work is the Rig-Veda. It thought that among farmers, Gods were the best. The 'Amarakosha' claims that the Aryans were farmers. Agriculture, cattle husbandry, and trade were listed by Manu and Kautilya as being key things that the monarch had to understand. According to Patanjali, agriculture and cattle raising were essential to the nation's prosperity. The 'Puranas' include a wealth of knowledge that demonstrates how well-versed the ancient Indians were in all aspects of agriculture. There are many well-known ancient Indian classics, including Kautilya's "Arthashastra," Panini's "Astadhyayi," Patanjali's "Mahabhasya," Varahamihira's "Brahat Samhita," Amarsimha's "Amarkosha," and Manasollasa's encyclopaedic writings. The knowledge and wisdom of the ancient people are attested to by these classics.

Sage Parashara's 'Krishiparashara' was a technical text that dealt only with agriculture about 1000 A.D. The 500 A.D. Agni Purana and Krishi Sukti, both credited to Kashyap, are other significant writings. There is a wealth of important information on agriculture in ancient India in the Tamil and Kannada literature. India's agricultural sector made great strides in the production of trees, shrubs, spices, condiments, food and non-food crops, fruits, and vegetables, as well as in the development of environmentally friendly farming methods. These customs took on social and religious overtones and were adopted by the populace as a way of life. Domestic rituals and celebrations often coincided with the four primary agricultural activities of plough, sow, reap, and harvest. Thousands of cows, horses drawn by chariots, racing tracks where chariot races were performed, camels drawn by chariots, sheep and goats presented as sacrificed victims, and the use of wool for clothing are all mentioned in the Rig-Veda.

According to the well-known Cow Sukta (Rv. 6.28), the cow has already established itself as the cornerstone of rural economics. She is described as the mother of the Vasus, the Rudras, and the Adityas as well as the centre of immortality in another Sukta. According to the Atharva Veda, the Vedic Aryans seem to have had access to sizable woods for obtaining timber, and they also appear to have raised plants and herbs for medical reasons. Despite the fact that agriculture exclusively relied on the blessings of Parjanya, the rain god, farmers were respected for their work. His thunders are said to deliver nourishment [3], [4].

Over 75 plant species were referenced in the four Vedas, over 25 in Satapatha Bhrahamna, and over 320 in the Charkaa Samhita, an Ayurvedic (Indian medicine) book from around 300 B.C. Over 750 plant species are listed as medicinal by Susruta (circa 400 B.C.). Numerous aquatic and terrestrial, domestic and wild, deadly and non-poisonous species and animals are mentioned in the earliest text, the RigVeda (about 4000 B.C.). 500 plant species are mentioned in the Puranas. In Surapala's Vrikshayurveda, the science of arbori-horticulture is well-documented and has seen significant development. In the past, forests were of great significance. Forest preservation has been emphasised for ecological harmony from the time of the Vedas. Kautilya (321-296 B.C.) indicates that the forest superintendent had to get forest goods via the forest guards in his Artha sastra.

He gives a lengthy list of the plants, trees, bamboo species, creepers, fibrous plants, medications, poisons, animal skins, etc. that fall within his officer's jurisdiction. According to Manu (Manusmriti, 2nd Century B.C.), hunting was discouraged as a pastime and was seen to be harmful to the normal development of the ruler's character and personality. Particularly, the names of Shalihotra on horses and Palakapya on elephants have been identified as specialists in animal husbandry in the Puranas (300–750 A.D.). Aswashastra is a renowned treatise on the care of horses, while Garudapurana is a literature that deals with the treatment of animal illnesses. The care of trees and cattle are both covered in one chapter or section of Agnipurana [5], [6].

Development of Human Culture

Prehistory and recorded history are the two categories traditionally used to categorise the development of human society. The latter comes after the development of writing and, therefore, of recorded historical records. The vast majority of prehistoric stone artefacts discovered in South India and the Soan Valley point to the presence of the oldest races of humans in India between 400,000 and 200,000 B.C. He developed his ability to manipulate fire, which benefited his way of life. Homo sapiens, the modern human species, first emerged towards the conclusion of this era, somewhere about 36,000 B.C.

Development of Human Culture

Stone Age: The Prehistoric Period According to the kind of stone used to make tools, the Stone Age may be divided into three distinct periods:

The Palaeolithic Period, often known as the Old/Ancient Stone Age (2.5 million–12,000 B.C.), was a time in human history when stone tools were typically rough or chipped. Man was basically a forager who relied on the natural world for his nourishment. He developed his ability to manipulate fire, which benefited his way of life. Homo sapiens, the modern human species, first emerged towards the conclusion of this era, somewhere about 36,000 B.C. The Palaeolithic Period (Old Stone Age) began with the first tool-making humans approximately 2.5 million years ago and ended when people learnt to make better quality tools around 12,000 years ago and to farm around 8,000 years ago. The New Stone Age, also known as the Neolithic Age (12000 to 4000 B.C.), is referred to as the "Age of Food Producers," whereas the Old Stone Age is known as the "Age of Foodgatherers." According to this, the 'Age of Civilization' began at the end of the Neolithic Age and continued into the Bronze Age. There are three main categories of lifestyle: technological civilization, agriculture, and hunter-gatherer.

Settlement in predetermined areas, the construction of towns and cities, the creation of predetermined forms of governance, and the growth of trade and commerce all contribute to or characterise civilization. Along with the previous two, this social structure has existed and continues to exist. Huntsmen and gatherers Stone tools discovered from the Middle Palaeolithic, also known as the Middle Stone Age in Africa, between 200,000 and 40,000 years ago, are very comparable, demonstrating a global technology. Pebble tools were used in the earliest known tool site in East Africa 1.7 million years ago. Ancient "landmarks" on the way to mankind include tools and fire. There is evidence that Homo erectus utilised fire for the first time in Ghoukoutien, China, between 300,000 and 400,000 years ago.

Hunter-gatherers had a practical yet good understanding of their natural surroundings, including the plants, animals, and weather. Aborigines in Australia had access to up to 250 different food plants in fertile regions. 50 food factories were located in less wealthy communities. To 12,000 B.C., the Palaeolithic (Stone) Age was in existence. Rough stone was utilised for tools and other items by early man. Man was basically a forager who relied on the natural world for his nourishment. Eastern Europe and Siberia were home to mammoth hunters throughout the Ice Age (Upper Palaeolithic, 35,000 to 8,000 B.C.). Until recently, these nomadic hunters ate mostly meat, much as the Eskimos did. Their prey, which also included bison, horses, reindeer, birds, fish, arctic foxes, and hares, would have supplied them with all they needed. Vegetarian meals would have been a small addition. Even houses were constructed from skin-covered mammoth bones that had been neatly linked. A typical Australian aboriginal's haul for the day would contain a few wallabies, anteaters, lizards, frogs, and grubs. The Semang people of Malaysia survive on hunting and gathering honey from the forest, along with small animals like fish, birds, rodents, squirrels, and sometimes wild pigs, tapirs, and deer.

To kill certain animals, they fire a poisoned dart from a two-meter bamboo blowpipe. advent of agriculture The introduction of agricultural cultivation and animal husbandry, which gave rise to modern civilisation, was likely influenced by demographic pressure. There was a greater reliance on plants as the population rose. Next, the implementation of some kind of intensive agriculture was compelled by consumer demand within a small area. Another example of this pattern may be seen in Peru, where guinea pigs and camelids were domesticated 2,000 years prior to the introduction of crops. Between 15,000 and 8,000 years ago, with the end of the last Ice Age, agriculture would have begun. People who lived a hunter-gatherer lifestyle before were dependent on the environment [7], [8].

According to historical evidence, agriculture began in the Near East approximately 8,500 years ago, spread to Britain around 6,000 years ago, and reached Spain and Portugal by 5,000 years ago. Modern-day descendants of hunter-gatherer people include the American Indians of central Brazil, known as the Kayapo. They reflect the change from a hunter-gatherer lifestyle to an agricultural one via the use of chickens, crops like maize, sweet potatoes, sweet manioc and yams, as well as a hunting lifestyle. They had to share everything they took in when hunting, whether it was a tortoise, a deer, a fish, or a wild pig, and they opposed selfishness. Women gathered fruit, nuts, and plants in groups from the same forest where males go hunting. Ironically, when they came to a tall fruit tree, they used a metal axe to chop it down in order to collect the ripe fruit. Food production shifts from wild animals and plants to domesticated crops and animals. Although agriculture, which just began to develop between 12,000 and 8,000 years ago, has often harmed the environment and brought about societal upheavals that have made it possible for our current civilization to develop. Following agriculture, dogs and turkeys were domesticated.

DISCUSSION

Mesolithic period or Meso stone age

In India, the Mesolithic era started and lasted until 4000 B.C. Microliths, which are very small storage objects, are its defining feature. At this period, swiftly moving animals were dispatched with the use of pointed and sharp instruments. Plant agriculture also started to take off. Around 10,000 B.C., humans discovered how to make better tools, and around 8,000 B.C., they discovered how to cultivate crops. The Old World had semi-permanent agricultural villages. the transition of societies from one based on food collecting to one based on food production. In this era, tools often had "barbs" or hooks, or were interchangeable. Plant agriculture also started to take off. Some of the many Mesolithic sites may be found in the Chotanagpur plateau, in central India, and south of the Krishna River.

Technological Civilization

Rather than a specific point in time, the rise of a technological civilisation is an issue of degree. Early Egyptian cultures had advanced technology, which made it possible to build structures like the pyramids. Humans have used technology since they first used stones as tools, much as certain chimpanzee tribes do now. Due to the elimination of the need for people to travel in search of food, villages and cities were made feasible with the advent of agriculture. The Latin word "civitas" for city is the origin of the term "civilization". The contemporary civilization was built on the foundation of this sedentary lifestyle. By 5,000 years ago, Mesopotamia and Egypt had irrigation systems in place. By 2,600 years ago, the iron plough had been invented in China, where it had supplanted the stone and wood ploughs as a more efficient implement.

By 2,100 years ago, they had also invented the mould board plough. The use of fire, the use of metals like gold and copper, bows and arrows, the fish hook, spinning and weaving, agriculture, the domestication of animals, sailboats and ships, wells and irrigation, pottery, clothing, language, arithmetic, the alphabet, and written communication were all basic inventions made by ancient people. North Africa has the earliest evidence of the bow and arrow, which dates back 20,000 years. Seed drills, one of the most ancient agricultural innovations, were used in Mesopotamia 5,500 years ago. Over 4,600 years ago, people in Saqqara constructed the pyramid. Domes, for example, were created by architects and were constructed in Ancient Cyprus 5,000 years ago. The discovery and usage of "metals" had a significant role in the development of our culture. The construction of a far greater variety of utensils, tools, and instruments than could be manufactured with wood and bone was made possible by the malleability of metals, which allowed for inventions only limited by human imagination. The people who lived around the Euphrates and Tigris rivers in what is now Iraq were among the first to utilise metals some 10,000 years ago because copper was occasionally discovered in virtually pure form.

By 5,500 years ago, gold was in use. Two thousand years ago, gold was being used as tooth fillings by Roman dentists. There were 6,000 years of silver usage. Iron, the hardest metal to extract from its source, was first created by Egypt 4,000 years ago. Iron smelting was a sophisticated technique used by the Assyrians, who even produced steel from iron. The usage of labor-saving technologies was widespread in ancient Greece. They made use of the wedge, lever, pulley block, winch or windlass, and screw. Despite not being the innovators, scientists like Archimedes (2300 years ago) were engaged in these advances. The screw, which was likely invented in ancient Egypt, was used to convey water throughout the Middle East.

Crop rotation and the horse-drawn and wheeled Saxon plough were two significant breakthroughs that spread across Europe before the year 1000. In 1066 A.D., water wheels were being used in England for a variety of tasks, including sawing and grinding wood. Johan Gutenberg, a German, created printing using moveable type towards the end of the Middle Ages and the start of the Renaissance. The earliest known printed book was his Gutenberg Bible, published in 1455. The mechanical clock and the watch with balance wheel were created in the Middle Ages around 1286.

The remainder of the globe was first discovered and explored by Europeans in the fourteenth century. In 1492, Columbus arrived in the Americas. In 1494, Bartholomew Diaz travelled to Africa and arrived at the Cape of Good Hope. In 1497, Vasco De Gama travelled from Africa to India. The Copernicus "De Revolutionibus Orbium Coelestium" in 1543 proved that the earth orbited the sun. Marco Polo claims that between 1271 and 1292, China invented the compass, paper money, printing technology, and coal as a fuel, none of which were used in Europe. The development of the steam engine and automated regulators in the middle of the eighteenth century marked the beginning of the modern age of technology. Throughout the Industrial Revolution and up until 1830, the primary source of mechanical power in England was still water mills. In 1784, a wheat thresher was created in Scotland. In the 1830s, a horse-drawn combine harvester was in use to reap, separate the chaff, and dump the grain into bags.

China is where paper was first created about 100 A.D. In 1868, a functional typewriter was patented. In 1642, French mathematician Blaise Pascal created the first automated calculator. This was evolved into Boolean Algebra and Boolean Logic by mathematician George Boole. This served as the foundation for computer languages and reasoning. J.M. Jacquard mechanised fabric weaving in 1801 using punched cards. In the 1830s, Charles Babbage (1791-1871) endeavoured to create a "analytical engine" a mechanical computer using punched cards. Herman Hollerith, an American inventor, created a functional computer utilising punched cards and electricity in 1888. Producing tabulated results from payroll, census, and other data was the initial stage of automated data processing. He sold the Tabulating Machine Company in 1911, and it later changed its name to the Computing-Tabulating-Recording Company. In 1924, they used this corporation to create IBM.

Indus Civilization

Mesopotamia and ancient Egypt are the two greatest civilizations of the ancient world. Following them in a jumbled order are ancient China, Greece, Central and South America, and the Indus Valley civilisation, also known as the Harappan civilization. Indian culture has a long history and has many rich cultural traditions. The Indus Valley civilisation was the term given to this civilization since it was believed to have existed only in the Indus River Valley. Mohenjo-daro and Harappa, two of this civilization's highly constructed urban centres, stand as the pinnacle of human habitation. Archaeological digs conducted later revealed that this civilization's boundaries extended well beyond the Indus basin and into western and northern India. As a result, the Harappan civilisation is becoming a more popular name for this culture.

The main archaeological sites in India include Kalibangan in Rajasthan, Lothal in Gujarat, and Ropar in Punjab. Mohenjo-daro and Harappa are now in Pakistan. The most well-known Harappan site in Western Asia, according to recent study, is Sutkagen Dor in Baluchistan, near to Iran. The Indus Valley Civilization covered all of Gujarat, Baluchistan, Northern Rajasthan, Punjab, Sindh, and Baluchistan. One of the three major early civilizations that developed around the Tigris-Euphrates, Nile, and Indus rivers' three major alluvial systems in the late fourth and early third millennia B.C. India placed a strong emphasis on a rich culture without ignoring the material world. Indian culture, which has two centuries of history and tangible accomplishments, may be proudly compared to American or Australian civilization.

River Migrations in Western India

The main route between Hastinapur and Dwaraka could have been made up of the dried-up Sarasvati riverbed. Geographically, the Ghaggar canals are where the Sarasvati basin was first discovered. It's possible that Ghaggar was a stream that originated in the Siwalik Mountains and joined the Sarasvati. Through Sind, this network parallels the Indus. From the Himalayas to the Rann of Kutch, the river flowed. The whole Sarasvati riverbed and the arm of the Arabian sea that the river formerly extended into the salty Ranns of Kutch lie on an earthquake fault; an earthquake might have uplifted the entire river-sea bed profile, drying up the river. This might explain how the Thar desert in Pakistan and on the left bank of the river were formed during prior earthquakes. Did certain areas of the Thar desert formerly sustain agriculture? Certain areas have subsurface water, according to geological assessments. on Rajasthan, more than 2 million people still reside on these areas today! Maru-sthall is the name in Sanskrit; maruta-nilam is the name in Tamil.

On each side of the Indus river's path, there is a very large flood plain that may reach maximum widths of 100–120 km in the east and southeast. The Indus River has preferentially moved towards the north-west in the northern portions and towards the west in the centre and southern parts, as shown by the presence of such a large flood plain on just one side. The analysis of remotely sensed data in Rajasthan's desert region reveals that there are several paleochannels with well-developed tentacles all throughout the desert. In satellite images, a well-developed network of palaeochannels can be seen in the Ganganagar-Anupgarh plains, which are located on the northern border of the Thar-Great Indian desert. Originally flowing near to the Aravalli Mountain ranges and meeting the Arabian Sea at the Rann of Kutch, the Saraswati river has now moved west, northwest, and north until being lost in the Anupgarh plains.

The Saraswati River, which is thought to be lost in the desert, might be tracked via these palaeochannels as a migratory river, according to a remote sensing study of the Great Indian Desert. Its first path was near to the Aravalli hills, and the next six stages made shifts to the west and northwest until they met the dry bank of the Ghaggar river. These results are additionally supported by groundwater, archaeological, and pedological evidence together with chosen ground truths. The movement of the river Saraswati seems to be assisted by opposing climate changes in the Hardwar-Delhi ridge zone, Luni-Surki lineament, Cambay Graben, and Kutch fault. The Yamuna river's subsequent stream piracy is to blame for the final water loss and drying up of the Saraswati River.

The Indus Valley Culture as seen in the context of post-glacial climate and ecological studies in North-West India suggests that " the significant increase in rainfall at the beginning of the third millennium B.C., attested by palaeoecological evidence, played an important role in the sudden expansion of the Neolithic-Chalcolithic cultures in north-west India, eventually leading to the prosperity of the Indus culture. According to the data at hand, the Harappan civilisation in the dry and semi-arid regions of north-western India likely declined as a consequence of the beginning of aridity in the area about 1800 B.C.

Saraswati River Civilization

By supplying food, clothes, housing, medicine, and leisure activities, agriculture serves to address the fundamental requirements of people and their society. As a result, agriculture is the most significant industry in the world. The free gifts of nature, such as the land, light, air, temperature, and rainwater, among others, are used productively in this unit. are incorporated into a single essential component that humans cannot live without. Animals, including cattle, birds, and insects, which are secondary production units, feed on these primary productive units and produce concentrated goods like meat, milk, wool, eggs, honey, silk, and lac. Aside from providing a free meal, a clean environment, enough of food to end hunger, and resources for and from industries, agriculture also supplies food, feed, fibre, fuel, furniture, and other necessities. It also promotes peace by reducing conflict.

A nation's citizens experience peace, prosperity, harmony, health, and riches thanks to satisfactory agricultural output, which also drives away mistrust, unrest, and anarchy. It promotes the community as a whole, bringing about improvements in its social, cultural, political, and economic conditions. In terms of time and geography, agricultural growth spreads quickly and in several directions. After the green revolution, farmers began using more advanced agricultural inputs and cultural practises in labor-intensive cropping systems to increase the output potential per unit of land, time, and input. It gave all of these enhanced genotypes the right conditions to develop and show off their production potential in fresher locales and seasons. Agriculture involves raising plants and animals for harvest and production, which contributes to the preservation of the biological balance in the natural world.

Emblica officinalis), masur (Lens culinaris), linseed (Linum usitatissimum), and castor (Ricinus communis) were also planted, in addition to gramme (Vigna mungo), ber (Ziziphus nummularia), and amla (Emblica officinalis). Acacia, Albizia, Ziziphus mauritiana, and teak (Tectona grandis) wood were used to make agricultural tools and for timber. To designate moosal (mortar), Zizphus mauritiana wood was used. In the Neolithic period, between 8000 and 5500 B.C., in the northwestern sector, Baluchistan, Pakistan, and its borderlands with Iran and Afghanistan, full-time hunting-foraging practises were gradually replaced by the development of plants through diffusion and domestication in ancient India and the borderlands. Wheat, hulled barley, and bare barley were all grown during the early Chalcolithic era (4700-4300 B.C.). In addition to dates, cotton, jujube, and prunus fruits were introduced to the plant economy. High yielding hexaploid wheat (bread, club, and dwarf), as well as barley (hulled and naked), continued to be grown. crop remnants of hulled barley and wheat (emmer, bread, club, and dwarf) from 3500 to 3200 B.C., as well as apricots. Barley (6 row hulled, 6 row naked, 6 row shot), lentil, chickpea, flax/linseed, jujube, grape, cotton, and dates were all produced between 3200 and 2500 B.C. The Indus-Saraswati Yamuna Ganga valleys are home to several species of minor millets, cereals, legumes, oil seed crops, fibre crops, fruits, vegetables, and other economic plant species in addition to rice. At Atranjikhera (about 2000–1500 B.C.), farmers rotated rice and barely in addition to grass pea and chickpea. In the wet season, farmers grew rice, black gramme, green gramme, and bread and lentils in the winter. Along with grain, vegetables, and fruit, the population also consumed fish, poultry, mutton, beef, and pork. The cultivation of cotton was perhaps the most astonishing accomplishment. A vast system of canals was used for irrigation.

About 2900 B.C., the Sumerians invented the plough. It's possible that the Sumerians taught the Harappans how to utilise the plough. Wood is a perishable material, and all early ploughs were built of it. A plough model made of clay measuring 7 cm by 19.7 cm has been found at Mohenjo-daro. The Prince of Wales Museum in Bombay is where you may find this miniature plough. The plough breast culminates in a rectangular shape and there is a rather lengthy beam. Nothing suggests that it had a handle (munna) that the ploughman could grip. The inhabitants of Kalibangan engaged in agriculture and tamed animals. A field that had been ploughed was found to the southeast of the pre-Harappan village. It displayed a grid of furrows, one set running north to south and more closely spaced (about 30 cm apart) than the other (about 1.90 metres apart). This pattern is strikingly similar to the way that ploughing is currently done, where mustard and gramme are grown in separate rows in the same field.

In his book Lothal and the Indus Civilization, S.R. Rao reproduces an image of a seal from Lothal that he believes represents a seed drill. However, it has an odd form for a seed-drill. About 3000 B.C. at Dr, ox-drawn sledges were still in use to transport royal cadavers to their ultimate burial site. But long before that time, a discovery that revolutionised land transportation had also altered the sledge. The wheel was the pinnacle of early human carpentry; it is a necessary component of modern machinery, and when used in transportation, it transformed the sledge into a cart or waggon. Wheeled vehicles were depicted in Sumerian art as early as 3500 B.C., and possibly even earlier in northern Syria. Carts, waggons, and even chariots were widely used in Elam, Mesopotamia, and Syria by 3000 B.C. Wheeled carts were in use in Turkistan around the same time as the Indus Valley when the archaeological record dates back to about 2300 B.C. Mohenjo-daro, Harappa, Lothal, and C toys for kids.

At Harappa, cart models made of bronze have also been discovered. The wooden plough was heavily used by the populace. Kalibangan even produced a field that was divided into two parallel networks of furrows, where taller crops (like mustard) were planted in the spaced-apart north-south furrows, throwing shorter shadows, while shorter crops (like gramme) were cultivated in the continuous east-west furrows. This method is still used in the same area today. Additionally, there is evidence that cats, dogs, goats, sheep, and maybe elephants were domesticated.

A civilisation like that of the Indus civilization that is capable of town planning, shipping, fine arts and crafts, writing, and continuous commerce must obviously be well-versed in technology. Indus religious and cultural symbols were interwoven into pottery, jewellery, and commonplace objects in a manner that served to bind people together in urban areas and connect them to remote rural villages. In return for silver and other goods, cotton textiles, ivory, and copper were sent to Mesopotamia, as well as potentially China and Burma. A variety of metals, including copper, bronze, lead, and tin, were also produced. There was no iron among the Indus people. The ceramics, stone carving, and seal-making of the inhabitants showed their great artistic talent. The finding of brick-making kilns provides evidence that burned bricks were widely utilised in residential and public structures. The populace-maintained trade relations with Samaritans, Egypt, Mesopotamia, Afghanistan, and Persia. 'Barter' was the primary mode of exchange. A well-designed system of weights and measures was in place.

CONCLUSION

The study focused on India's agricultural practises, including customs, festivals, and traditional farming methods. These customs are strongly ingrained in national tradition and demonstrate the interdependence between agriculture and Indian way of life. Understanding India's agricultural legacy is essential for maintaining traditional knowledge, encouraging sustainable farming methods, and protecting cultural identities. Potential uses for the information acquired from researching this legacy include contemporary agriculture and rural development. Enhancing agricultural production and resource sustainability may result from combining ancient knowledge with contemporary agricultural techniques. For improving our comprehension of India's agricultural legacy and its consequences for contemporary agriculture and cultural preservation, further study in this area is crucial. Adopting traditional knowledge may help promote rural development and agricultural sustainability while providing creative answers to current agricultural problems. Additionally, cultivating a feeling of cultural identity and pride within farming communities may help preserve and promote India's rich agricultural tradition, assuring the survival of this priceless legacy for next generations.

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CHAPTER 4

DETERMINATION OF THE ARYANS OR VEDIC CIVILIZATION

Dr.Mohd Rizwan, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

The Aryans, also known as the Vedic culture, are an important and ancient cultural and historical group that had a major impact on the early history of the Indian subcontinent. The purpose of this study article is to investigate the tenacity and traits of the Aryans and their Vedic civilisation. The research explores the ancestry and migratory patterns of the Aryans, looking at the numerous hypotheses and archaeological data pertaining to their arrival in the Indian subcontinent. It examines the social, religious, and cultural aspects of Vedic culture with an emphasis on the Vedic writings and their influence on early Indian society. The study also explores the Aryans' contributions to language, philosophy, and religious beliefs, which still have an impact on Indian society today. Uncovering the early history of the Indian subcontinent and recognising the origins of its rich cultural legacy need an understanding of the Aryans and their Vedic civilisation. The study also emphasises the potential uses of this information in historical inquiry and intercultural communication, providing chances to investigate the relationships between ancient civilizations and their modern legacies.

KEYWORDS:

Aryans, Cultural Heritage, Indian Subcontinent, Migration, Vedas, Vedic Civilization.

INTRODUCTION

The Aryans referred to themselves as the "noble ones" or the "superior ones." Their name comes from the Indo-European root "ar," which means "noble." They were known as the "Aryas" (or "Aryans") in Sanskrit, but the same word, "ar," also served as the basis for the name "Iran" given to the captured Persian provinces. Because it occurs in the name of another nation, "Ireland" or "Eire," this idea of nobility seems to be at the core of Indo-European mentality. The Aryans were a nomadic tribe that lived in the steppe regions of Europe and Asia. They were a hardy, warlike, and violent tribe. Their way of life was centred on combat. They were controlled by a war-chief, or "raja" (the Latin term "rex" (king) and the English word "regal" have the same root word). They ride horses for travelling, and they charge into combat on chariots. In the year 2000 B.C., they started to move southward, conquering Persia and parts of India in waves.

They swarmed over the northern river plains of India as they swept across Persia with lightning-fast speed. They migrated into India from the north-west, establishing themselves initially in the Indus valley and then along the Ganges floodplain. Indian culture saw a fresh beginning with the Aryans, or Vedic civilisation (Rigvedic Period, 1700–1000 B.C.). These tribes swiftly colonised the Deccan and northern India. Since the two peoples are closely linked in time, it is thought that the Rig Veda represents Indo-European religion and shares many traits with Persian religion. Their population was once confined to the Punjab, which is located near the Ganges and the northern parts of the Indus and Yamuna rivers [1], [2].

They kept the Aryan tribal system in place, with a raja and a council presiding over each tribe. The religion seemed to have been almost completely centred on a succession of offerings to the gods, and each jana appears to have had a main priest. There were just two social classes among the Rigvedic peoples at first: nobles and commoners. They eventually added a third: Dasas, sometimes known as "darks." These were the folks of darker complexion that they had subdued. The Rig Veda never uses the term "Varna" to refer to Brahmana or Kshatriya.

By the conclusion of the Rigvedic era, society had divided into four distinct classes, known as the "four colours" or "caturvarnas." The priests, or "Brahmans," were located at the summit of the caturvarnas. Below the priests were the Kshatriya (warriors or nobles), the Vaishya (craftsmen and merchants), and the Shudra (servants), who made up the majority of society. The Aryans moved over the Doab, a sizable plain that divides the Yamuna river from the Ganges, in the early years of the "Later Vedic Period" or "Brahmanic Period" (1000-500 B.C.). The 'Epic Age' is known as the Later Vedic Period, and although though the 'Ramayana' and 'Mahabharata' were written between 500 and 200 B.C., it is likely that they were first conceived of and narrated during this time. The Vedas are the oldest extant pieces of Hindu literature written by Aryans.

The Rig-Veda, Sama-Veda, Yajur-Veda, and Atharva-Veda are the four collections that make up the Vedas. These are referred to as the Samhitas together. Indra, the deity of battle and weather, and Agni, the god of fire, were both referenced in the Rig-Veda. The two main sects of Hinduism, which worship Vishnu and Shiva, are at the top of the gods' hierarchy, which started with Indra and Varuna. A common life energy that unites all living things, human social interconnection, the idea of unity in variety, and how various social groups may have distinct prayers and aspirations are all mentioned in the greatest Vedic Shlokas. As a consequence of Indian experiences and intellectual endeavours, the Upanishads, the Sankhya and the Nyaya-Vaisheshika schools, the countless treatises on medicine, ethics, the scientific method, logic, and mathematics obviously formed on Indian soil. Buddhism is a religion that was established by Siddhartha Gautama (c. 563–483 B.C.) [3], [4].

Alexander the Great of Macedon started one of the biggest conquests in human history in 331 B.C. Following his conquests of Egypt, the Persian Empire, the Mesopotamians, and Gandhara (Afghanistan), he encountered eastern civilizations like Pakistan and India. Gandhara's plains are located just west of the Indus River. His army became weary as he attempted to advance through Pakistan, and in 327 B.C. he gave up on the eastward conquest. Alexander departed as soon as he arrived in the Indus and had almost little impact on Indian history. Alexander's conquests had two significant effects. First, Greek and Indian civilization would afterwards converge. Second, the invasion of Alexander may have prepared the way for Chandragupta Maurya (reigned 321-297 B.C.), the first major conqueror of India, to unify all the kingdoms of northern India into a single empire immediately after Alexander's departure. As Chadragupta Maurya used his arm to expand his kingdom, Kautilya, a cunning and calculating Brahman, created the political system. Together, they established India's first united states [5], [6].

Aryans and native peoples' cultures converged during the Vedic era. Indian subcontinent was the original home of Vedic civilization. The Rig-Veda cites a few symbols that are present in the Indus-Saraswati towns, including the trishul, the swastika, the pipal tree, and the endless-knot pattern. A ploughed field and fire altars are also seen in Kalibangan. The phrases siri and vayitri refer to a female weaver from the Vedic era. Gold was very valuable. The Rigveda makes reference to niskagriva, which is a gold neckpiece and gold necklaces that extend to the breast. Oceans have been traversed by ships utilised by the Vedic people. Wheat and barley were grown along the Sarasvati and Sindhu rivers.

The inhabitants are fed by the ploughshare ploughing of the land. Many of the Vedic people lived as pastoralists and herders on Sarasvati, the motherland of the Sindhis. The river runs freely, fertilising the land, providing a plenty of food, and sustaining (the people) with its waters.The Rig-Veda commended the many towns along the Sarasvati river as more proof of the similarities between Vedic and Harappan people. The Saptasindhu, which is exactly the centre of the Harappan area, was the Vedic people's ancestral home. The Sangam tradition is equally silent about the origins of the Tamil people in the north; all that is mentioned is the now-submerged island of Kumari Kandam to the south of India, and preliminary findings at Poompuhar suggest that, without taking this legend literally, there may be a few submerged cities along the coast of Tamil Nadu, particularly at Poompuhar and Kanyakumari, where fishermen have long reported seeing submerged structures [7], [8].

DISCUSSION

Status of Agriculture

Vedic period (1600 B.C.–1000 B.C.)

The steppes in southern Russia between the Danube, Volga, and Urals served as the early Aryans' home. Another passage said that Germany was the Aryans' ancestral home. In the year 1600 B.C., the Aryans abandoned their ancestral country and dispersed in vast numbers to the east and west. The Indus Valley was home to the early Vedic Aryans, who were predominantly pastoralists. They cleared forests to make way for their communities, grazed their cattle there, and grew barley on the area nearby where they lived. Cows and horses were common among Vedic Aryans; buffalo, which they named gouri or govala possibly an expansion of the term gau (cow) was a novel animal. 'Saptasindhavah' is the name given to the Indus Valley, a region with seven rivers. The Sutudri (Sutlej), the Vipas (Beas), the Parushini (Ravi), and the Askini (Chenab) were among the seven rivers, while the Indus and Saraswathi made up the last two. The Punjab is known as the "land of five rivers." As soon as the Saraswati River dried up, Aryans started to travel in quest of water. The Ganga entered the Indian plains thanks to the efforts of monarch Bhahirath, and storage cultures emerged in the Indo-Gangetic lowlands.

The Aryans were known as nomads because they were always on the road in search of pasturelands for their livestock. They have a met, camped, and departed way of life. This civilisation is superior to the people who had previously been inhabiting India for thousands of years and had created agriculture. Strong towns and a class of artisans and craftsmen were made possible by domesticated animals. The Aryans' introduction of horses to India is one of the compelling justifications for their invasion from the Russian steppes. The horse might have been imported to India during the Chalcolithic era when commerce with Mesopotamia and other civilizations was taking place, when cotton textile and other goods were being exported. Horses imported by merchants from the Middle East were for sale in the bazaars even during Chandragupta Mayurya's reign.

Rigveda

the Rigveda, was written approximately 3700 B.C. Ploughing was done with much pomp at the start of the agricultural season and was tied with a number of rites. Numerous hymns are dedicated to Shuna, Sita, and Shunshira. Sita has been described to as both the share of the plough and the goddess of the early. The three principal crops were sugarcane, sesame, and barley (yava). As a husbandman ploughs the ground repeatedly for barley, the barley is correctly sowed in the fields by the plough, and the animals consume the barley. The harvesting was done after prayers. Most of the time, a sickle was used to chop the crops at ground level or only the ear heads.

Environment (Rigveda)

The phrase "the sun destroys all non-visible poisonous creatures" refers to venomous nocturnal animals like snakes and scorpions. The sun serves as a protector, a cleanser, and a source of plenty. Water is said to rise from the ground throughout the summer via evaporation, cloud formation, and then return to the earth as rain. Summertime surface water loss must have been simple to see. Grishma (May–June), Varsha (July–August), Hemant (September–October), Sharad (November–December), Shishir (January–February), and Vasant (March–April) are the six seasons that make up a year. After June 21, when the sun begins to "move south," the rainy season officially begins (clearly in Pakistan and North-West India). On the seven rivers, there were dams. Building dams across rivers must have meant denying the Vedic people access to the water they needed to cultivate their fields, supply water to people and animals after rainstorms, and hence increase food production.

Farming resources and practices

A farmer regularly ploughs his fields. The sun created six seasons that cycle back on themselves. Sutlej and Vyas rivers were crossed using bullock carts and chariots. Bullocks should be yoked to the plough, yokes should be joined, seed should be sown, enough food should be provided, and the sickle should fall on the mature crop. Sumps were built to provide irrigation from never-drying pits, leather ropes, and animal drinking water.

Crop-raising activities in the fields were well established. For the Vedic Aryans, using a plough to cultivate ground and grow barley was already a "ancient practise". Different types of soils and productive and unproductive fields were identified. Multiple plowings were used to prepare the soil. It was decided to divide the seasons into six categories, which are still used today. For measuring land, a bamboo stick of a certain size was used. To make plough and sow operations easier, the soil profile was soaked with water. Although shallow wells were utilised for irrigation, well water was used for drinking.

There was a mention of irrigation that could have come from rivers. Undoubtedly in the post-rainy season, bovine strength was employed for plough work as well as for dragging cattle carriages and chariots over rivers like the Sutlej and Vyas. Work was available for labourers. Other farming activities included frightening birds, using a sickle to harvest, threshing, and winnowing using a titau (suba). Gains were also stored in storage containers, while garbage and waste were burned. After the grain crop was harvested, barley was ratooned on the remaining moisture maybe for feed. Other grains were eaten besides barley. Clearly, roasting the barley was done to produce saktu.

The Rigveda mentions animals including donkeys, camels, horses, sheep, and cows. Black and red cows are the two hues specified. It seems that long-nosed cows were prized. Horses, donkeys and camels were all utilised for transportation and probably for pulling cargo. The Rigveda makes reference to cow thievery because animals were considered a symbol of riches. The enemy's cows were taken as booty. Because chickpeas that have been soaked in water are still regarded as a beneficial meal for horses, they have historically been used as horse food. Horse cleaning was plainly preferable. Grazing in woodlands seems to have been a frequent practise while managing cows.

Barley fields were open to cow grazing, and it seems that cattle owners were aware of the advantages of supplying ponds with clean, safe water for their animals. Dogs were employed to control cow herds and track down stolen cattle. The lads clearly took care of the cows as they grazed since they were calling the animals for milking while holding some grass. It is common to burn dried cow dung as firewood. Killing cows was obviously forbidden due to the innocence of the animal as well as the fact that it was crucial for human existence. Agriculture tools were refined throughout the later Vedic era (1000–600 B.C.). There were iron ploughshares in use [9].

The Indus civilisation came to an end about 1750 B.C., when the Mohenjo-daro and Harappan cultures started to deteriorate and eventually vanish. It is difficult to pinpoint the reason or causes of the collapse of the Indus civilisation. Some attribute this to the soil's declining fertility due to an increase in salt brought on by the growth of the nearby desert. Others claim that it was caused by a land depression that led to floods. Groups of spreading bones from this time period at Mohenjo-daro point to a slaughter or invasion. The tribes whose priests wrote the Rig Veda included those who destroyed the Indus towns. After Harappa and Mohenjo-daro had fallen, the Indus Valley civilisation shifted from the west to the east of the Ganga-Jamuna-Doab area, with sites prospering in central and southern India. The story of the Aryan invasion of the south was partially told in the Ramayan. It is unclear how or why this civilisation ended, despite the fact that there are many ideas about its demise.

The social standing of farmers - Agriculture and animal husbandry were first established in India during the pre-Vedic era. Thousands of cows, horses drawn by chariots, racetracks where chariot races were conducted, camels drawn by chariots, sheep and goats presented as sacrificed victims, and the use of wool for clothing are all mentioned in the Rigveda. In another Sukta, the cow is deified as the mother of the Vasus, the Rudras, and the Adityas, as well as the key to immortality, indicating that it had already become the basic foundation of rural economics. According to the Atharva Veda, the Vedic Aryans seem to have had access to sizable woods for obtaining timber, and they also appear to have raised plants and herbs for medical reasons. Despite the fact that agriculture exclusively relied on the blessings of Parjanya, the rain god, farmers were respected for their work.

His thunders are intended to provide nourishment. One of the core tenets of Hinduism is the planting and protection of trees since the Rishis' residence, where Indian civilization first developed, was shaded by trees. With considerable attention, many tree species and their significance in life for both function and beauty were investigated. Farmers were regarded as second only to Brahmans in terms of social standing, and it seems that the whole village government was under the control of prominent farmers known as "Kutumbin" (from whence the name "Kunbi" is derived). There is significant evidence from the mediaeval era, when Hindu monarchs ruled, attesting to the skilled competence in cultivating crops including wheat, gramme, lentils, barley, sugarcane, indigo, cotton, pepper, and ginger.

uses the same slang term to describe what makes a good nation. Anecdotally, when a teacher sent a student to repair a break in the watercourse of a particular field, the student had to kneel down to halt the flow and avoid serious damage to the crops. This illustrates the advancement achieved in irrigation. A fable, the connotation of which is that guards were hired at the crucial locations of embankments, the rupture of which would create a major flood and destruction, confirms the argument. The King should use caution at exits to hazardous zones and at the dam of a major water project.

The Arthasastra strongly advises that highland (sthala) and low land (kedara) be recorded separately in the gopa's field register and orders the tax officer to grade villages three times in the way of Gautama and Manu (Samahartar; Sukraniti). This suggests that varied rates for various soil classifications are intended, along with a similar reference in Sukraniti. The Agnipurana once again detailed the income rates for various rice crop types. The sadbhaga was simply a traditional or average rate, not the fixed or universal rate, and as a result the land assessment fluctuated depending on the condition of the land and the kind of crop, something matching the "tithe" in European fiscal language.

Manu, the Arthasastra, and the Sumaniti all reference the meticulous grading of land, survey and measurement, computation of output, as well as costs per unit of land. A set share was not always implied by the king's portion. It was chosen after taking into account the soil's fertility and the demands of the State or the farmer. The method of measurement, survey, and differentiation of soil based on productivity also shows that the evaluation of land income was not continuous but rather subject to periodic revisions even if this was not required. The original Vedic irrigation devices were hardly improved upon during the time of the Buddha; water was extracted using a bullock team and a lever (tulam). The primary goal of Akbar's income system was to accurately measure the land.

The quantity of the output from each bigha of land was also determined, and the farmer was required to pay the government a set percentage of that total. Thirdly, to make a monetary equivalent for the percentage that has been determined. The primary source of income in Mughal India was the Land-tax. But after Turkish control was established, the situation of farmers altered. Farmers should be exploited if an Empire to endure, according to Allaudin Khilji, who used to take half of their income. Except for the brief time when Akbar expanded the land reforms proposed by Sher Shah, exploiting the farmers grew to be the norm.

Naturally, the farmers' standing declined, and his expertise eventually had to be limited to old-fashioned techniques. During Aurangzeb's rule, the exodus of peasants from the countryside become more pronounced. The assignees, the jagirdars, saw a decline in their revenue as the number of peasants increased. To make up for their loss, the jagirdars escalated their pressure on the labouring peasants. Additionally, the habit of selling provincial administrations for enormous amounts of cash emerged. Therefore, getting the purchase money back, which he had borrowed at a disastrous interest rate, inevitably became the main goal of the person thus designated Governor. This led to increased oppression of the farmers in turn.

Status of Farmers in Southern India

The position of the farmers in the various States of India was explored in a book named "Sons of the Soil" that was released in 1941 by the Indian Council of Agricultural Research. The forest-covered, stony, and rather arid and dry forestland of central India, presently known as Madhya Pradesh, divides the southern Indian states of Andhra Pradesh, Karnataka (Mysore), Tamil Nadu (Madras), and Kerala from the Indo-Gangetic alluvial region of North India. People from the North may not understand the natural beauty, the fertile soil, or the diverse cultural heritage of the people of South India if they haven't been there. Here, the old Hindu culture, which has mostly vanished from North India, is still there and is in utterly stunning condition.

The Western and Eastern Ghats' prehistoric mountain ranges, which date back to the Archazoic era, the genesis of life itself, are the oldest mountain ranges in the world. It lacks the Himalayas' snow-capped peaks and glaciers. These deep blue-purple hills are peppered with prosperous crops of rubber, coffee, and tea. Areca palms are grown in the foothills. As you go closer to the shore, you'll pass plantations of sugarcane, paddy, plantains, and coconuts. While Tamil Nadu is appropriately referred to as the "Land of Palmyra Palm," the State of Kerala is renowned as the "Land of the Coconut Palm." Paddy fields in emerald green contrast well with the blue hills of the Eastern Ghats, and between them are endless rows of Palmyra palms with black trunks bearing clusters of palmate leaves. The majority of agricultural tasks, such as transplanting paddy, weeding and hoeing, excavating groundnuts, or scraping grass, were done by women.

The villages in South India are often cleaner than those in North India. Coimbatore is regarded as one of India's most forward-thinking districts. The Agricultural College has a long history of producing high-quality research, which has helped this region's agriculture advance. However, the Naidus and Gounders, who are always willing to embrace any helpful innovations, deserve the most of the credit. Agriculture in this region really exemplifies man's victory over challenging conditions, making it all the more admirable. They bore through the unyielding rock to create tank-like wells that supply irrigation for their farms. They can irrigate land at various elevations thanks to a syphon irrigation system that uses concrete towers for water storage spread over their fields and linked by underground cement pipelines. Application of green manures, tank mud and fertilisers is fairly prevalent, as is line sowing. Give a Naidu a plot of unproductive land, and he will transform it via diligent soil management. The majority of prosperous farmers are also industrialists who have established modest spinning mills. They use industrial processes on their farms, which are operated on commercial principles, in addition to investing the savings from industry in agriculture. Even small farmers now practise diversified agriculture, growing rice alongside plantains, sugarcane, cotton and other crops.

Many farms cultivate Glyricidia and Sesbania as hedge plants. In one hamlet, you may see all paddy farming activities occurring simultaneously. While a nursery is being grown in one field, another is being transplanted, and a third is being harvested. This is due to the tropical environment, which has roughly constant temperatures throughout the year. Since the soil is often moist, rice and millets are frequently dried on the highways. One may witness rice drying on the road in the Madurai and Ramanathapuram regions as they are travelled while a lady keeps watch. Usually, passing cars take extra care not to step on the grain that is drying. The homes of the landowners are pucca, have red tile roofs, and are often white washed, with the exception of the cottages of the landless workers, which are thatched with Palmyra leaves. Huge representations of horses may be found close to the village's entrance. These are the chariots of the village of Ayanar's protector god.

The appreciative villagers who have benefitted from the kindness of Ayanar who has spared the suffering bullock from sickness or a youngster from a critical illness occasionally leave hundreds of baked clay pictures of horses near some of the villages. In the fields, scarecrows of hideous human races are also prevalent. They are claimed to be effective against the evil eye of envious neighbours in addition to safeguarding the crop from livestock and jackals. The festival of Pongal, when farmers clean their livestock and adorn their bullocks' horns, is the most fascinating one in Tamil Nadu. Villagers in their finest attire streamed towards the local temples in groups. The coconut and arecanut crops and the many irrigation tanks dot the Karnataka landscape in a characteristic way. Bamboos and coffee gardens may be found in the Karnataka Western Ghats' evergreen woods. The people of Karnataka constructed a massive monument in honour of the Nandi bull, the mount of Shiva, while the inhabitants of Mohenjodaro imprinted or carved their distinctive breeds on their seals. In the well-known temple of Halalebid, Krishna is seen playing the flute in front of a herd of Hallikars, a breed with long, pointed horns, who are enthralled by the sound of the instrument. One of India's more recent states is Andhra Pradesh.

The Kammas and Reddys are knowledgeable farmers who long ago understood the benefits of fertilisers and line sowing. Tobacco, chilies, turmeric, and groundnut are all grown scientifically using all the new techniques that agricultural professionals recommend. They have such excellent soil management that they apply fertilisers, organic manures, and green manures. In the past, people from the Andhra region known as the Naidus and Reddies moved to Karnataka and certain areas of Tamil Nadu. Wherever they landed, they improved agriculture. Their genuineness and audacity in expressing their opinions is one of their defining characteristics. In fact, in this day and age of hypocrisy, their candour is extremely refreshing. Kerala State in India has a distinctive environment and a variety of crops. Even in cities, people's residences are surrounded by a plot of land where vegetables for domestic food and coconut palms are produced. Kerala has a unique personality brought forth by its red soil and extensive cultivation of coconut trees. Beautiful temples and carefully constructed churches are scattered across the countryside as a testament to the people's culture. The colonies in the canal-irrigated regions of West Punjab were developed by Punjabi farmers, who are among the finest in all of India.

Advice by Sages to Kings

Lands may be taken from non-cultivators and given to others; alternatively, they may be worked on by labourers and merchants from the village, with the risk that non-cultivators will have to pay fewer taxes. Cultivators may get favourable supplies of grain, animals, and money if they pay their taxes promptly. The monarch must only provide favours and exemptions to farmers that will add to the treasury and refrain from giving them to farmers who would drain it. He will treat those who have reached the end of the tax-remission period with fatherly tenderness. He will build highways for both land-based and maritime transportation, provide facilities for the trade and raising of cattle, and establish market towns. Additionally, he must build reservoirs (sétu) that will hold water that is either perennial or obtained from another source. Anyone who refuses to participate in any cooperative construction (sambhya setubhandhát) must send his slaves and bullocks to complete the job; they will share in the costs but will not be eligible for any profits. When it comes to fishing in reservoirs or lakes, ferrying, and dealing in vegetables, the monarch must exert his ownership rights. He will defend agriculture from the abuse of harsh penalties, unpaid work, and taxes, as well as herds of cattle from robbers, tigers, toxic animals, and cow diseases. He will prevent thieves from destroying the cow herds. On unusable land parcels, the monarch must provide pastureland.

counsel for the wise to the king, Kashyapa Kashyapa has emphasised several times that the king or other relevant authority must really promote agricultural activity. This would include assistance from the federal and state governments in the contemporary era. The ruler's assistance is needed in locating land for agriculture, creating water reservoirs, planting trees along the banks of reservoirs, building canals and wells, water harvesting, providing seed, ensuring people have enough to eat, donating land and providing subsidies to less fortunate people, setting up markets, establishing uniform weights and measures, afforestation, and locating mines that produce metals like iron, copper, and zinc (brass?), gold, and silver. Thus, Kashyapa has firmly advocated for the ruler (modern governments) to play a very significant role in completely supporting diverse agricultural enterprises. He has emphasised that only if there is food security will everyone feel happy.

The monarch should assign individuals skilled at evaluating the (quality of the land) to look for and purchase the best land. The selection of a piece of land is based on a scientific study of the soil. According to legend, it is the king's responsibility to hire specialists to survey the whole territory and determine which areas are best for agriculture, horticulture, and reservoir construction. The setting may be in a hamlet, another region of the nation, such as a city or town, in the highlands, or on the grounds of forts and palaces. Any site is regarded suitable as long as there is a reliable supply of water and adequate soil. It will be helpful to keep an eye on hundreds of canals (or trenches), wells, and lakes, especially during the wet season. The king should be concerned with illness prevention, reducing the risk of fire, and ensuring the greatest welfare, all-around nutrition, and protection for both bipedal and quadrupedal animals.

Kautilya's Arthasastra

The Artha-Sastra of Kautilya (250 B.C.) is a comprehensive guide on ancient statecraft and science.'Chanakya' and 'Vishnu Gupta' are other names for Kautilya. The science of politics, economics, and the art of administration in its broadest sense the upkeep of law and order as an effective administrative apparatusare all topics covered by the Arthashastra. One of the four highest goals outlined by Hindu tradition is artha, which means "wealth" in Sanskrit. Accordingly, the state or government of a nation has a crucial function to play in preserving the material position of both the nation and its citizens, according to Kautilya's Arthashastra.

CONCLUSION

The Vedic civilisation, often known as the Aryans, played a key role in the early history of the Indian subcontinent. The tenacity, traits, and cultural heritage of the Aryans have been examined in this study work. The research focused on the many hypotheses and archaeological data pertaining to the Aryan origins and migratory patterns into the Indian subcontinent. Understanding the Vedic civilization's social, religious, and cultural facets in particular, its holy writings known as the Vedas offers important insights into the early emergence of Indian society and culture. The study also looked at the Aryans' contributions to religion, philosophy, and language. Indian culture continues to be shaped by its numerous traditions and cultural practises thanks to the Vedic legacy. Understanding the Aryans and their Vedic civilisation is essential to understanding the origins of the Indian subcontinent's rich cultural legacy as well as its early history. The information learned from studying the Aryans may be useful in historical analysis and intercultural communication. A greater understanding of cultural variety and historical ties may be fostered by investigating the links between ancient civilizations and their modern-day influences.

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CHAPTER 5

DETERMINATION OF ANIMAL HUSBANDRY IN AGRONOMY

Dr. Harish Kumar, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

Agronomy, the area of agricultural science that deals with maximising crop output and land management, includes animal husbandry as a key component. The purpose of this study article is to examine the value of animal husbandry in agronomy and its contribution to sustainable agriculture. The study explores the numerous facets of animal husbandry, such as breeding, feeding, and health care for animals. It looks at how crop production and animal husbandry work in harmony since animals are essential for producing manure for fertilisation, pest control, and agricultural labour. The study also looks at the financial and environmental advantages of incorporating animal husbandry into agronomic practises, such diverse sources of revenue and improved soil fertility. For the purpose of fostering integrated and sustainable agricultural systems, maintaining food security, and addressing environmental issues, it is essential to comprehend the role that animal husbandry plays in agronomy. The report also emphasises how this information may be used to help rural development, preserve natural resources, and advance rural livelihoods.

KEYWORDS:

Animal Husbandry, Agronomy, Integrated Farming, Livestock Management, Sustainable Agriculture.

INTRODUCTION

Five male animals must be present in a herd of 100 heads of asses and mules, ten in a herd of goats and sheep, and four in a herd of ten heads of either cows or buffaloes. For salaries, a certain quantity of dairy products, a tenth of the dairy products, etc., herds are kept. ‘Calves, steers, tameable cattle, draught oxen, bulls to be trained to yoke, bulls kept for crossing cows, cattle fit only for the supply of flesh, buffaloes and draught buffaloes, as well as female calves, female steers, heifers, pregnant cows, milch cattle, and barren cattle either cows or buffaloes are all classified as herds of cattle. Cowherds must provide treatments to young calves, elderly cows, and diseased cows. Cows and cattle are required to graze the herds in the woodlands, which are variously designated as grazing grounds for different livestock. Cowherds must let their animals to enter lakes or rivers with the same depth. Both fresh and dried meat are available for sale from the cowherds [1], [2].

During the rainy, autumnal, and early part of the winter (hemanta) seasons, the cowherds are required to milk the cows twice morning and evening, but just once (i.e., only in the morning during the later half of winter and the whole of the spring and summer seasons). During these times, a cowherd who milks a cow a second time would have his thumb amputated. He will lose the earnings from the milk if he let the milking period to expire. The cowherds must offer buttermilk to the dogs and pigs as a drink and save a little amount in a bronze jar for their own food preparation. They may also use coagulated milk or cheese (kláta) to give their oilcakes a delicious flavour (ghánapinyáka-kledartha). A quarter of the cow's rpa (worth) must be paid to the monarch by the person selling their cow from among the herds. When milk from cows is churned, it produces one drona of butter; milk from buffaloes produces one-seventh of a drona more; and milk from goats and sheep produces one-half of a drona more. Cowherds must transport their cattle either far or close, depending on their ability to guard the animals and on how far and broad they can go to graze. Sheep and other animals must have their wool sheared once every six months [3], [4].

Rations for Livestock: For bullocks, the required amount of food is one drona of green gramme or one drona of barley cooked with other things, as prescribed for horses, in addition to the special and additional provision of one tula of oilcakes or ten ádhakas of bran; for buffaloes, the required amount of food is twice the above amount; For a goat, ram, or boar, give half a ádhaka or a whole ádhaka of grain mixed with bran; for dogs, give an entire prastha of cooked rice; For a goose, a heron, and a peacock, give half a prastha. One tulá (100 palas) of oil cakes, 10 ádhakas of bran, 5 palas of salt (mukhalavanam), one kudumba of oil for rubbing over the nose (nasya), one prastha of drink (pána), one tulá of flesh, 1 ádhaka of curis, 1 drona of barley or cooked green gramme, 1 drona of milk; or half as an alternative to milk (pratipána), 10 palas of sugar or jaggery may be used, along with 1 pala of the fruit of the sringibera (ginger).

Tamil Literature A bird’s View

Information about the social, economic, and political lives of those who live in deltaic Tamil Nadu may be found in great depth in the Sangam literature. The period known as Sanga Kaalam is regarded as Tamil literature's Golden Age. Tholkappiar was said to have lived during the Ancient Sangam Age, which lasted from around 1000 B.C. to 200 B.C. The first Tamil text is called Tholkappiam. Our ability to trace the Tamil people's ancestry is greatly enhanced by the material provided by "Tolkappiyar," whose age is often dated to the 5th century B.C. Mountains, woods, plains, beaches, and deserts were used to represent the terrain, and the five different expressions of love union, patience, crying, separation, and sulking were used to represent the concept of love. The poet who addressed a certain facet of love restricted himself to a given area, season, hour, and flora and wildlife. Tolkappiyam explains these literary norms. The most important work from the third Sangam era is Tiruvalluvar's Tirukkural or Kural, which discusses philosophy and sage advice. With 1330 couplets (133 subjects, each with 10 couplets), it is the second great masterpiece. It has been translated into various languages, including English [5], [6].

The Late Sangam Period, which lasted from 200 B.C. to 200 A.D., is regarded as the Thiruvalluvar period. Silappathikaram, which is set in the Ilango period approximately 200 A.D., is the third noteworthy work in ancient Tamil. Thenmadurai, a city on the coast of the Indian Ocean, served as the Pandia monarchs' capital during the middle Sangam; however, it was subsequently destroyed by a sea inundation. After that, Sangam and the capital were moved to Kapatapuram on the east coast. Kapatapuram was also overwhelmed by the sea. Then, Sangam and the capital were moved to the inland city of Madurai. As a result, the current Madurai on the Vaigai River's bank was chosen as the third capital and the location of the Third Sangam of Poets. Both Kalithogai and Silapathigaram had allusions.

"The Kalabhra or the Dark Age" Buddhism and Jainism expanded throughout the interregnum era in the now-declining Tamil nation. Tamil literature and Tamil culture are altered by the Kalabhra invasion of Kannada land in 250 A.D. Five important Tamil epics were written during the post-Sangam era (200–600 A.D.): Silappadikaram, Manimekalai, Jivaka-cintamani, Valaiyapati, and Kundalakesi. Ten Idylls (Pattuppattu) and the Eight Anthologies (Ettuttohai) are divided into two categories in 400 A.D.: Akam, or exoteric literature dealing with love, and Puram, or esoteric literature dealing with battle. The majority of the writing from the third Sangam period is poetry, The Tamil Epic Era - Between 600 and 900 A.D., Saiva and Vaisnava saints known as Nayanmars and Alvars, respectively, had a significant effect on Tamil literature. The Devaram was initially composed by the Saiva saints. Later, the hymns of the Saiva saints were compiled into twelve collections known as Tirumurais. Sekkizhar (12th century AD) wrote the Periya Puranam, also known as the Tiruttondar Puranam, which is regarded as the twelfth Tirumurai. The hymns of the Vaishnava sect were collected into four volumes known as Divya Prabandham or Nalayira Divya Prabandham by the Vaishnavaite saint Nathamuni (824–924 AD). Periyalivar, Poigaialvar, Bhutattalvar, Andal (the only female saint among the Alvars), and Nammalvar are some of the other Alvar saints who have made contributions to Tamil holy literature. The third book of Divya Prabandham, Tiruvaymozhi by Nammalvar, is regarded as the core of the Upanishads.

Contemporary literature Tamil literature was influenced by both Islam and Christianity throughout the contemporary era. During the 13th and 14th centuries, Mohammedans ruled. The first of the Muslim Tamil poets was Umaruppulavar (1605–1703 AD). He wrote the Sirappuranam, a biography of the Prophet Muhammad written in poetry. Mohammad Ibrahim's Muhaidin Puranam (1845 A.D.) is another text that discusses Islam. Under the alias "Viramamunivar," Constanzio Beschi (1680–1747 AD) penned a well-known Tembavani about the life of Jesus Christ. The first example of Tamil novel writing is found in Viramamunivar's Paramartta Gurukathai, which was published in the 18th century. One of the best Tamil writers of the contemporary age was Subramanya Bharati (1882–1921 AD). He is well known for his fervent prose essays on current social issues as well as his patriotic and religious songs. His epic poem "Panchali Sabadam" is based on a single Mahabharata incident.

DISCUSSION

Agriculture

The primary employment of Tamils was agriculture. The ladies of the agriculturalists were referred to as "Ulattiyar" and the males as "Ulavar" (Tolporul, 20). The classes of those who owned land and those who worked it were known as "Vellalas," the farmer being the superior "Vellalas" and the latter being the lower "Vellalas." Valnar was another name for Ulavar. Or Yerin, or Ulutunbar. Ulavar is known as Kalamar in Purananuru. The words Ulavar and Vellalar itself refer to the usage of the plough and the ownership of the land, respectively. Cattle were valued in the society of cowherds, but among farmers, the number of ploughs was the yardstick by which prosperity was measured. A poet in Karuntogai mentions a farmer with one ploughshare named "Orerulavar." In PART-104, Thirukural, Thiruvalluvar underlined the value of agriculture. The vocation of agriculture is seen as being honourable (Kural, Chap. 104). Valluvar has outlined the appealing quality of a region or nation. A nation should have intelligent, rich, and skilled farmers. It must not be plagued by hunger, illness, or hostility. Famine should not be a factor in a nation. They must all ultimately rely on the farmer in whatever capacity they may be employed by others.

Farmers, the Founders of Civilization

In PART 104, Thiruvalluvar has highlighted the agricultural industry as follows: The best of all vocations, it is second only to the plough in the whole globe. Because they support everyone else who uses the plough and pursues other activities, tillers of the land serve as the axle-pin of the world's circling system. The only way farmers can survive is by cultivating their own land and raising their own food. Many of the surrounding nations will undoubtedly feel the effect of the lush fields that are laden with maize sheaves. Trade improves a nation's riches and prestige, but its true power and fortitude are found among the landowners.

The farmers, who solely consume the products of their labour, would never beg or refuse charity to a man in need who knocks on their door. Even those who have given up the world will lose their calm and focus of spirit if the tillers of the earth cease their activity. The householders who provide the ascetics with assistance will inevitably be impacted and lose focus if the tillers of the soil stop working. Without adding even a little amount of manure, a bountiful harvest will result from allowing the ploughed soil to dry to a fourth of its mass. Manuring is more necessary than ploughing, then, following correct weeding, plant protection is more vital than water management, according to Valluvar, who also views adequate aeration and deliberate nitrogenization as incidental to soil preparation. The field will turn its face away in loving rage if the husband-man does not give his land the particular care it deserves, much like the neglected wife. The good earth will mock people who lounge about and ignore their fruitful lan d while claiming to be poor [7], [8].

Climate

Rain is revered as the foundation of the planet and a fundamental human necessity). Without water, the world cannot survive cool showers are produced by rain-bearing clouds beneath enveloping darkness with lightning, whereas heavy rains are produced by clouds that are like a pounding drum with short, thick sticks and thunder. In PART III of Thirukural, Thiruvalluvar emphasised the need and significance of rain for human prosperity and spiritual well-being in addition to agriculture. Valluvar gave the downpour the following praise: The nectar of life or Amuta the drink of eternal Gods must be considered to be the pouring rain since it supports the planet. Food is created from rain, and from food comes the fourth. Rain, which itself is food once again, is the source of all food

Even if the planet is encircled by vast seas, hunger would bring about endless suffering if rain faiThe ploughmen will be compelled to become idle if the amount of rain ls decreases Lack of rain will cause prosperity to collapse, while enough rain to water the crops will bring about fresh prosperity. Disaster may sometimes be caused by even excessive rain and cyclonic flood. Even grass blades cannot grow if there are no raindrops falling from the heavens. Even the richness of the waters will decrease if the clouds the sea produces fail to provide their abundance The absence of rain throughout the summer months might harm pearl creation. Coral spawning would be impacted if there is a rain failure in October or November. There won't be any festivities or divine ceremonies if the rain doesn't fall. Alms to the destitute and penance for spiritual upliftment cannot be perpetuated if the heavens refuse to forgo their abundance to provide rain to this planet Even while life on earth cannot exist without water, virtue also ultimately relies on rain.

Rain is revered as the foundation of the planet and a fundamental human necessity. Without water, the world cannot survive. Cool showers are produced by rain-bearing clouds beneath enveloping darkness with lightning, whereas heavy rains are produced by clouds that are like a pounding drum with short, thick sticks and thunder significance of rain for human prosperity and spiritual well-being in addition to agriculture. Valluvar gave the downpour the following praise: The nectar of life or Amuta the drink of eternal Gods must be considered to be the pouring rain since it supports the planet. Food is created from rain, and from food comes the fourth. Rain, which itself is food once again, is the source of all food.

Even if the planet is encircled by vast seas, hunger would bring about endless suffering if rain faiThe ploughmen will be compelled to become idle if the amount of rain Ilavenil-(Chitrai-Vaigasi), Mudhuvenil-(Aani-Adi), Karkalam-(Avani-Puratassi), Kuuthgirkalam-(Ipachi-Karthigai), Munpanikalam-(Marghali-Thai), and Pinpanikalam -(Masi-Panguni) were the main categories used to classify the seasons. In the spring (early summer), Vengai flowers bloom with loosened petals, and the falling petals enhance the black sand locks of the riverbed. The delta's agricultural was divided into two types: a double crop economy and a single crop economy. In the former, rice was initially grown in a brief harvest and then again in a longer crop. Tamil Nadu has several rice producing seasons depending on the location. The short crop itself was divided into two varieties: the 'Kar' variety, which lasted four months, and the 'Kuruvai' variety, which lasted one hundred days. The former was limited to the delta's first reaches. where the seedlings could be grown before to the arrival of the freshes and with a fair expectation of its certainty, the latter of which was the most prevalent kind. On double crop land, the second crop was called as "Thaladi," as opposed to the first crop, "Mudladi." 'Samba' is a five-month crop that is the main crop economy. From June through October, the first harvest season, was in effect. From October until February, the second harvest. The single crop season spanned June through January.

Agricultural Implements

Rain is revered as the foundation of the planet and a fundamental human necessity Without water, the world cannot survive (Natrinai 1: 6). Cool showers are produced by rain-bearing clouds beneath enveloping darkness with lightning, whereas heavy rains are produced by clouds that are like a pounding drum with short, thick sticks and thunder. In PART III of Thirukural, Thiruvalluvar emphasised the need and significance of rain for human prosperity and spiritual well-being in addition to agriculture.

Valluvar gave the downpour the following praise: The nectar of life or Amuta the drink of eternal Gods must be considered to be the pouring rain since it supports the planet Food is created from rain, and from food comes the fourth. Rain, which itself is food once again, is the source of all food Even if the planet is encircled by vast seas, hunger would bring about eif rain faiThe ploughmen will be compelled to become idle if the amount of rain to plough with a wooden plough, buffaloes were used. Shallow ploughing was seen as inferior to deep ploughing. For levelling paddy fields, parambu, a labor-saving device, was utilised. Water was lifted from wells, tanks, and rivers using implements such the amiry, keilar, and yettam. Bird scare devices called thattai and kavan were used in millet fields. In millet fields, wild boars were captured using traps.

Marketing

Rain is revered as the foundation of the planet and a fundamental human necessity. Without water, the world cannot survive. Cool showers are produced by rain-bearing clouds beneath enveloping darkness with lightning, whereas heavy rains are produced by clouds that are like a pounding drum with short, thick sticks and thunder. In PART III of Thirukural, Thiruvalluvar emphasised the need and significance of rain for human prosperity and spiritual well-being in addition to agriculture. Valluvar gave the downpour the following praise: The nectar of life or Amuta the drink of eternal Gods must be considered to be the pouring rain since it supports the planet. Food is created from rain, and from food comes the fourth. Rain, which itself is food once again, is the source of all food. Even if the planet is encircled by vast
seaendlesssufferinfaiThe ploughmen will be compelled to become idle if the amount of rain P roducts were traded according to weight. There was a food grains mart at Madurai, the home of the Sangam poets, where 18 different types of cereals, millets, and pulses could be purchased. Each store had a banner stating the grains sold that was raised high enough to be seen from a distance. On imports and exports, customs duties were collected.

Agriculture-related income included land tax (also called as "irai" or "karai"), tolls, and customs taxes. 'Ulgu' and 'Sungam' were terms used to describe revenue collecting. The king's portion of the tasks was referred to as "Kadamai," "Paduvadu," or "Padu." Vari was a general word for revenue, or income. 'Iravu' was the term for excessive demands or forced fits. "Vari" stands for tax, "Variam" for the organisation that collects taxes, and "Variyar" for a tax collector. The rulers received one-sixth of the production from the land as land income. The king grants certain people or organisations access to tax-exempt territories. These areas were known as "Puravu" or "iraiyili nilam." Because of unexpectedly low crops brought on by a lack of rain, revenue assistance was granted. Twelve years of failure were described by the poet Iraiyanar Ahapporul for the Pandia kingdom. The farmer survived during such periods of great starvation by eating the seeds that were usually meant for planting.

Astronomy

Rain is revered as the foundation of the planet and a fundamental human necessity (Nartrinai, 139). Without water, the world cannot survive (Natrinai 1: 6). Cool showers are produced by rain-bearing clouds beneath enveloping darkness with lightning, whereas heavy rains are produced by clouds that are like a pounding drum with short, thick sticks and thunder (Kurunthogai 270). In PART III of Thirukural, Thiruvalluvar emphasised the need and significance of rain for human prosperity and spiritual well-being in addition to agriculture. Valluvar gave the downpour the following praise: The nectar of life or Amuta (the drink of eternal Gods) must be considered to be the pouring rain since it supports the planet (Kural, 11). Food is created from rain, and from food comes the fourth. Rain, which itself is food once again, is the source of all food.

Even if the planet is encircled by vast seas, hunger would bring about endless suffering if rain faiThe ploughmen will be compelled to become idle if the amount of rain The term "ecliptic" refers to the Sun's fixed course, which is a circle surrounded by other fixed stars. From West to East, the relative Sun travels along the ecliptic. The ecliptic is split into 12 equal sections called "Rashis" (Signs) and 27 equal sections called "Nakshatras" (fixed stars) to represent the motion of the sun, moon, and planets. The Sidereal Year refers to the set amount of time it takes the Sun to complete one round around the ecliptic. The Tropical year has 365.2422 days whereas the Sidereal year, Calendar year, or Julian year has 365.2568 days. There were 3 days, or 0.0078 days, extra every 400 years. The apparent Solar Time is 4 minutes longer than the Sidereal day. While the earth revolves around the sun in 24 hours, when seen in relation to a star, it does so in 23 hours and 56 minutes. Julius Caesar established the idea of a leap year, which occurs every four years and is equal to 365.25 days.

The sun seems to gently oscillate north-south and south-north due to the axis of revolution. Twice a year, when the sun is directly above the equator, one is referred to as the start of Vasantha (spring) ruthu and the other as the start of Sharad (autumn) ruthu. Another motion of the Sun is from north to south and from south to north. Twice a year, it traverses the East-West axis. Similar to the Western Zenith, it extends 23 12 degrees south-east and 23 12 degrees north-east. The Sun does not always cross the ecliptic at the same position, and the interval between each point's crossing from North to South and from South to North is not always constant. The term for this is precession. In other words, the time between one Vernal Equinox and the next may be referred to as the Tropical Year. The 'tropical year' is calculated based on the Earth's rotation around the Sun. It lasts for 365.2422 days every year, which is enough time to include all the seasons. Sage Vasishta and his brother Sage Agastya were responsible for disseminating the tropical calendar across the globe. Sun temples may be found all over the globe for this reason.

The distance to be travelled in a southerly direction is referred to as the summer solstice or Dakshinaayana.The phrase "Dakshina + Ayana" refers to the latitude and southern distance that must be covered. The summer solstice is known as Dakshinaayana when the sun is in the north. Both the summer solstice (Dakshinaayana) and the winter solstice (Uttaraayana) last six months in tropical climates. Depending on whether it is Dakshiaayana (summer solstice) or Uttaraayana (winter solstice), it will be discovered that the rays will shift directions on either June 21 or 22 or December 21 or 22. Equinoctical points, which occur twice a year on June 21 or 22 or December 21 or 22, are those locations in the earth's orbit when equal days and nights will appear.

CONCLUSION

The study looked at the advantages of animal husbandry in agronomy from an economic and environmental standpoint. Integrating animals into agricultural systems may increase soil fertility, diversify revenue streams, and advance sustainable agriculture. Understanding the role that animal husbandry plays in agronomy opens doors for advancing rural lives, protecting natural resources, and fostering rural development. Studying animal husbandry may help students learn skills that might be used to protect the environment, provide food security, and encourage sustainable land use. In conclusion, further study in this area is necessary to advance our knowledge of animal husbandry in agronomy and its implications for rural development and sustainable agriculture. The creation of integrated farming systems that connect crop production with livestock management may boost agricultural productivity, soil health, and environmental challenge resistance. Additionally, encouraging animal husbandry methods that place an emphasis on environmental sustainability and animal welfare may help create agricultural systems that are more moral and ethical.

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CHAPTER 6

VARAHAMIHIRA'S BRIHAT SAMHITA ON WEATHER FORECAST

Dr.Jyoti , Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

The "Brihat Samhita," an important treatise that covers many subjects, including weather forecasting, was written by the ancient Indian astronomer and mathematician Varahamihira. This study will investigate the Brihat Samhita of Varahamihira and its insights into the weather forecasting methods used at that period. The focus of the research is on the particular passages or chapters of the Brihat Samhita that discuss and foretell weather-related events. It looks at the techniques and tools Varahamihira employed to predict weather patterns, including as astronomical occurrences, atmospheric measurements, and natural phenomena. The study also considers the historical context and applicability of Varahamihira's weather forecasting techniques, taking into account their effects on ancient Indian agriculture and society. It is essential to comprehend the methods of weather prediction described in the Brihat Samhita in order to fully appreciate the knowledge and scientific accomplishments of classical Indian meteorology. The research also emphasises the potential uses of this historical information in modern weather forecasting and climate science, providing chances for cross-cultural interactions and enhancing our awareness of old scientific practises.

KEYWORDS:

Ancient Indian science, Brihat Samhita, Meteorology, Varahamihira, Weather forecasting.

INTRODUCTION

The skill of predicting rain is the subject of eight segments in Varahamihira. Only by closely monitoring solar processes, which are linked to certain planetary alignments, can weather predictions be achieved with a high degree of precision. Under specific planetary configurations, the Sun, Moon, and other planets may work alone or in conjunction to cause changes in the weather. The sunspots and their consequences on Earth had been dealt with by Varahamihira. Sunspot maxima also correlate with times of very severe rainfall (flooding). When these spots appeared, earthquakes, thunderbolts, and other strange events that portended disaster would occur. There are significant spurts of solar activity every 11 years or so. The "earth's heartbeats" accelerate at the maximum periods, increasing the frequency of earthquakes. The eruption of ferocious winds from sunspots also releases charged corpuscles that result in terrestrial magnetic storms. There will be starvation because of the wedge-shaped disc spot on the sun. Around the period of peak solar activity, the solar wind is 'gustier'. The solar wind comprises more high-speed streams when the Sun is more active and creating flares and spots. And there is a good chance that the weather on Earth will be impacted by these fast streams. Records of the frequency of storms and lightning strikes provide direct evidence between sunspots and the weather. The mean sunspot index is closely followed by the annual lightning incidence, which counts the amount of lightning strikes in a certain location each year [1], [2].

Effect of Planets on Weather Parameters

Mercury and the Sun make windy contact, causing spells. Similar to this, Sun + Venus causes rain or snow, Sun + Mars causes warmer climate according to the season, Sun + Jupiter causes dryness or drought, Sun + Saturn causes colder than usual in the season, Sun + Rahu causes local storms, and Sun + Ketu causes a climate that is extremely changing in a short period of time. Garga and other sages claim that the clouds begin to grow pregnant on the day the Moon enters the constellation of Poorvashadha, which occurs during the brilliant half of the lunar month of Mirgasira.

While the Moon's changing distance from the sun, or lunar day or tithi, is a significant contributor to weather fluctuations, there is abundant evidence that the main planets have a significant impact on atmospheric outcomes. On the three days centred around the new Moon and full moon, several tropical storms intensified into hurricanes. Following the full Moon, heavy rain was most common four days later and peaked four days following the new Moon. In other words, the most precipitation occurred when the Moon was 45 or 225 degrees from the Sun. The Moon's motion continues to be in perfect agreement with changes in rainfall rates. The northern hemisphere's weather may be more affected when a planet enters the sign of Cancer, but the southern hemisphere's weather may be more affected when a planet enters the sign of Capricorn. Mars and arid conditions: When it comes to the planet Mars, it boosts the temperature and makes the air dry, particularly when it is in the sign of Aries. Rain and thunder storms happen throughout the rainy season as a result of the disruptive influence Mars and Jupiter have on the weather. The effects of Saturn and Mars include thunderstorms, lightning, and floods [3], [4].

Typically, rainy and windy weather happens when Mercury and Venus pass the Sun. The observer may get a hint about the sort of weather to expect during a certain time period by looking at the Sun's location during new moon and season transitions. A blizzard or cold wave happens throughout the winter when Mercury and the Sun are in conjunction. A fast-moving cold wave might occur when Mercury and the Sun are in superior conjunction, followed by Mercury's conjunction with or opposition to Mars, and Rahu is conjunct the Sun. Temperatures might drop quickly. When Mercury and Saturn are in mutual aspect, the region of increasing temperatures may be constrained. Venus's aspects might bring warm, humid air with the possibility of storms, tornadoes, or moderate to heavy rain. Unless additional planets are present, Venus’s retrogression or direct motion has little effect on the weather on its own. Rains benefit from Jupiter being retrograde.

Rains are harmed by a retrograde Saturn. How external factors affect wind: Mars causes vigorous watery breezes and exceptionally hot summers, while Mercury creates acute, sharp, and whipping winds, Venus creates weather that is consistent with the season, and Saturn's influence often results in persistent cloud cover and unusual rains. At the time of the full Moon, the most flames were seen. When Jupiter is in perihelion, there is a severe drought, and when it is in aphelion, there is unusually high humidity and low temperatures. Because of their slower motion and greater masses that are retained over a longer length of time, the slower moving planets especially Jupiter and Saturn exert a significant effect.

Almanac, Panchang and Krishi-Panchang

According to the Encyclopaedia Britannica (1969), "An Almanack is a book or table containing a calendar of the days, weeks, and months of the year, a register of religious holidays and saints' days, and a record of various astronomical phenomena, often with weather forecasts and seasonal advice for the countrymen." 'Panchang' is the name given to the traditional Hindu astrological calendar in India. Since the Vedang Jyotish era (1400–1300 B.C.), Panchang has been made for public usage. The Sanskrit terms "panch" and "ang," which respectively mean "five" and "body part/limb," are the origin of the name "Panchang." These components are: (1) Tithi, or lunar day; (2) Vara, or week day; (3) Nakshatra, or asterism or constellation; (4) Yoga, or the period when the sun and moon move together to cover a nakshatra; and (5) Karana, or half-lunar day or half-tithi. (i) Tithi - Purnima, Paurnima, or Paurnamasi are all names for the fifteenth day of the bright half. It is often seen as a lucky day. Amavasya is the name of the fifteenth day of the dark half.

i. When the moon is completely missing, it is known as "Kuhu," and when it is just partly gone, it is known as "Sinivali." It is often seen as an unlucky day. Rikta, or empty days, are the fourth, ninth, and fourteenth days. It is not advised to start any new projects on these days.
ii. Vara – There are seven days in a week, and they are each called after one of the seven main 'planets' an ancient notion, namely the Sun, Moon, Mars, Mercury, Jupiter, Venus, or Saturn. It is usually thought that these namesake days have the traits of the planets they are named after.
iii. Nakshatra - Star constellations are known as nakshatra. The celestial route of the Moon is marked by twenty-seven or twenty-eight nakshatras listed in a certain sequence. Each nakshatra is split into four parts, or padas, called charanas. One rashi, or zodiacal sign, is the place where nine successive padas fall.
iv. (iv) Rashi - The twelve zodiacal signs known as Rashis represent the sun's apparent or fictitious passage across space. Mesha (Aries) and Vrishaba (Taurus), for instance. The sun travels through each sign in the course of about one month, and each nakshatra in the course of thirteen to fourteen days.

DISCUSSION

Rain Forecasting in Indian Almanacs (Panchangs)

An almanack is a book or table containing a calendar of the days, weeks, and months of the year, a register of ecclesiastical festivals and saint's days, and a record of various astronomical phenomena, often with weather prognostications and seasonal suggestions for the countrymen," according to the Encyclopaedia Britannica (1969). 'Panchang' is the name given to the traditional Hindu calendar in India. It is a highly significant book that is released every year and serves as the daily calendar of the community. People all throughout India use it regularly. It is one of the fundamental texts used by astrologers to do calculations, create horoscopes, and make forecasts. It is an astrological cue for farmers to begin any agricultural operation. As a result, it is an essential book that is used for diverse reasons by a significant portion of the population in this nation. The Sanskrit terms "panch" and "ang," which mean "five" and "body part/limb," respectively, are the origins of the name "Panchang." These components are: Thirty tithes, or lunar days, make up a lunar month, with fifteen falling on each of the two fortnights. There are seven varas, or weekdays, as follows: Ravivara on Sunday, Somavara on Monday, Mangalavara on Tuesday, Budhavara on Wednesday, Guruvara on Thursday, Shukravara on Friday, and Shanivara on Saturday. There are also twenty-seven nakshtras, or aste

The location and movement of celestial phenomena at the time certain practises were started were used in ancient India to predict the success of agricultural activities. The season of planting and ploughing was when people largely regarded the good or bad effects. On the basis of position of planets, nakshatras, and other celestial bodies at any particular moment, and their influence on both materials as well as non-materials, living as well as non-living, Hindu astrologers (Jyotishis or Hyotishacharyas) have written several "Muthurta Granthas" (books on auspicious/inauspicious moments) for starting or doing or disregarding any activity (both agricultural as well as non-agricultural). For instance: Astrologers take into account the "Hala Chakra" or "Ploughing Cycle" to determine the most fortunate times and days for ploughing farms. The cycle states that the three nakshatras before the nakshatra the sun enters are unlucky; the three nakshatras after those are lucky; the following three are unlucky; the following five are fortunate; the following three are unfortunate; and the following three nakshatras are fortunate. The cycle of the 28 nakshatras is now complete (sources: Muhurta Jyotish Vigyan and Muhurta Chintaman). The "Beejopti Chakra" or "Seed Cycle" should also be taken into account in addition to the aforementioned. According to the cycle, the first eight nakshatras from the position of the sun are unfavourable; the following three nakshatras are favourable

Making panchang The planned Krishi-Panchang's content and coverage suggest that just qualified astrologers cannot create the whole material on their own; instead, a board of editors made up of both trained astrologers and crop experts can do justice. The editorial board members should keep the following crucial ideas in mind while they create the Panchang:

(i) Due to their relatively low educational standing, the local agricultural people are the primary target audience for the Krishi-Panchang. In order to make reading and understanding easier, it must be written in the colloquial language of the region.
(ii) The Krishi-Panchang should be highly thorough in its content and coverage, using only data that has been proved to be predictive, and it should be carefully worded to be readily comprehensible and unambiguous in its meaning.
(iii) It shouldn't include any astrological complications or specifics that are too difficult for our less educated farmers and agriculturists to comprehend.
(iv) The display of the information should be methodical and in a pleasing colour scheme, taking into account the seasons (Kharif, Rabi, and Summer) and the crops. It must be nominally priced at a level that small and marginal farmers can pay [5], [6].

Artificial Rain-making Versus Yagna

The process of creating rain artificially involves manipulating an existing cloud to produce rain. Rain is also brought about using the antiquated Vedic yagna method from India. Certain mixes of wood and other materials burned during the 'Yagna' may create ash fumes that have the potential to ionise hygroscopic particulate particles. The ash from the materials in the yagna experiment was said to have qualities comparable to the ordinary salt used in sowing. In contrast to the yagna experiments, where it is said that clouds are first generated and then seeded by nuclei in the ash, scientists do not think seeding can be done without the existence of cloud initially. Red-Indians do rain-making dances and use bishops to sprinkle water on crops in the United States.

Chemical cloud seeding is a technique for producing artificial rain, eradicating hail, or clearing fog. By spraying silver iodide or sodium chloride over the clouds from an aircraft, cloud seeding is accomplished. There are two forms of chemical cloud seeding: warm clouding and cold clouding. While cold cloud-seeding is done in highlands like Kerala, warm clouding occurs in tropical countries. A decent cloud with a thickness of at least one km is required for cloud seeding. Hygroscopic nuclei, or water-vapour-attracting particles, are present in clouds, although smaller nuclei move more quickly than larger ones. The smaller nuclei currently present in the cloud will be absorbed if larger nuclei are added. The goal of seeding is to "excite" the larger, already-existing nuclei, causing them to develop more quickly and fall to the ground as raindrops.

In heated seeding, a coagulation procedure, soapstone powder and common salt (NaCl) are seeded into the cloud to stop coagulation. The hygroscopic quality of the common salt molecules, which are larger than huge nuclei, causes them to initiate precipitation and enhance a cloud's effectiveness of precipitation from the typical 10% to a significantly higher count. Radar may be used to detect the growth and compare it to the control cloud. The cold cloud used in cold-seeding via sublimating is already below zero degrees Celsius. Even in that form, there are two nuclei, one at a pressure in the ice state and the other at a pressure in the water state. The ice nucleus is passed by the water nucleus, which is under more pressure. In this instance, silver iodide is seeded in a liquid condition to introduce the ice nucleus [7], [8].

Crops

With the help of farmers who have tamed, imported, and genetically altered a wide variety of species to harness maximum output, Indian agriculture is among the oldest in the world. Over many years, farmers have saved seeds and related knowledge, resulting in conservation. Rice was a cultivated grain that was farmed along the banks of the Ganges in the sixth millennium B.C., according to archaeological discoveries. Later, it spread to other locations. Before the sixth millennium B.C., many kinds of winter cereals, including barley, oats, and wheat, as well as legumes like lentil and chickpea domesticated in Southwest Asia, were produced in Northwest India. Other millets that had previously been domesticated in Africa, such sorghum, pearl millet, and finger millet, made their way to the Indian subcontinent more than 4,000 years ago. Also cultivated in India since the Neolithic era are smaller millets such the Panicum, Setaria, Echinochloa, and Paspalum species. Archaeological study has also shown that a variety of different crops were cultivated between 6000 and 3000 years ago. These include fibre crops like cotton seeds like sesame, linseed, safflower, mustards and castor, legumes like mung bean, black gramme, horse gramme, pigeon pea, field pea, grass pea (khesari), and fruits like jujube, grape, date, jackfruit, mango, mulberry and black plum. Sheep, goats, asses, dogs, pigs, and horses are examples of domesticated animals. Primitive Neolithic cultures cultivated plants for food, fibre, luxury crops, including legumes, tubers, and fruits.

History of Rice

In China, rice was first produced around 5000 years ago. Rice remains from as far back as 2600 B.C. were discovered at the Yung Shao excavations in China. According to one author, Julien, the planting of the lesser-important types of grain was left to the princes of his family, and the Emperor of China was only permitted to scatter rice seed during a specific ritual (created about 2800 B.C.) at the start of the agricultural season. A 2300 B.C. archaeological dig in Gujarat's Lothal, a southern outpost of the Harappan and Mohenjo-daro cultures, revealed evidence of rice farming. Do Condolle states that rice has been a prized crop in India since the Vedic era, albeit the subcontinent's cultivation of the grain may not be as old as China's. Rice was farmed in India from 1500 to 700 B.C., according to an archaeological sample of carbonised grains discovered in Hastinapur, north of Delhi, and Atrajnjikera, in Uttar Pradesh. For instance, the word "dhanya" (rice) in Indian signifies "supporter and nursery of mankind." Dhanya, which means "sustainer of the human race," denotes its historic significance. Dhanya and the kernel tandula are used in a number of rituals in India because they are seen to be symbols of fortune, money, and success. As a fertility symbol, rice was traditionally thrown upon newlywed newlyweds in China to wish them luck and ensure they would have a large family. The Atharveda (1100 B.C.) makes reference to the Sanskrit term Urihi, which most authors take as the most direct name for the grain in that language.

It may be interesting to note that the word for rice kernel in Tamil is "arisi," while its Arabic name is "alruzz" and its Spanish name is "arroz." What claims that the Arabic term al-ruzz is descended from the Greek word Aruza, which is the name for rice, rather than the Tamil word (from which others claim the word rice is from). In his "materia medica," the renowned Ayurvedic physician Susuta (c. 1000 B.C.) lists several types of rice according to time, water needs, and nutritional content, suggested for various diseases. Some of the ancient Indian rulers had names that were derived from or connected to the term rice. For example, in the sixth century B.C., the Nepalese king who was the father of Gautama Buddha was known as Suddhodana, which translates to "pure rice." The wild rice that overruns fields and streams is referred to as "neevara" in Sanskrit and "neevara" in Telegu. From India, rice moved eastward to China, then to Japan, and finally westward into Iran, Iraq, Turkestan, and Egypt. Rice was transported from India to Europe by Alexander the Great (about 300 B.C.), who then transported it to Egypt and other nations in Africa. However, because to the unsuitable natural circumstances present there, large-scale cultivation did not start until the end of the seventh century A.D. Rice was exported from India to Persia, Arabia, and Turkestan, where it is still grown in a rudimentary manner due to the lack of the necessary environmental factors.

History of Sugarcane Cultivation

By the end of the fourth century B.C., sugarcane had been grown in India from ancient times and was a significant crop there. The cane was possessed by the Rig Vedic Aryans, and it's possible that the family name Ikshaku had a link to a sizable plantation. It seems that the cane was mostly eaten, with some pressing and drinking of the juice. The concept of drying the juice over a fire was developed later, and the first documented product was a ball called a "gula" or "guda." It is referred to as "bheri" or "bheli" in Bengal because to its kettle-drum-like shape. No effort was made to crystallise the substance. The next step eventually arrived when crystals were permitted to develop, leading to the creation of "sitopala," or white crystals resembling rock crystals. Our medical works provide a categorization of manufacturing items that is entirely scientific. It's also noteworthy to note that by the time Susruta arrived, there were twelve types available as opposed to the two that Char aka was aware of. There was one of the latter's twelve known as "tapasa," which was undoubtedly the wild progenitor of the contemporary kinds.

The fact that planters are still using the seed from a cane variety known as "Uri akh" in the north-west of Bengal, where the adjective "uri" means "wild," as in "Uridhan," is unusual. Unquestionably the finest of the native canes, "paundraka" or "paundra," also known as "paunda" and "punri," was one of the twelve types of Susruta used by our growers. According to the commentators of the Amarakosha, the cultivar received its name since it was native to Punara, or Northern Bengal. It seems that the nation got its name from this event, much as Gauda got its name from "guda." The Paundras were the folks that raised the cane. Alexander's soldiers discovered the locals making 'honey' from reeds without the help of bees during the conquest of India (327 B.C.). The cane-growing and sugar-making techniques spread west to Europe and the Arabian nations and east to Indochina. Kautilya recognised that growing sugarcane is difficult and expensive.

Coordination allowed for the challenge to be overcome. For the sake of sugar production and cultivation, the growers organised themselves into a group known as a "grantha" or "knot" or "club." When the individual peasants were unable to satisfy the needs alone, cooperation was used. It is referred to as "ganta" in Bengali and is not at all a modern concept. Cooperation is shown by the share-produce system of agriculture that is so prevalent in our nation. The Sanskrit term "Sarkara," which means sand or gravel, is where the word "sugar" originates. When sugarcane juice first became crude sugar, it resembled sand. The initial name was modified over the voyage to sugar in English, then to 'Sukkar' in Arabic, 'Sakharon' in Green, and 'Sucre' in French. The introduction of thick-stemmed types of Saccharum officinarum from Thailand to Jamaica in 1791 by Captain Bligh was the next significant development in the history of sugarcane.

History of Cotton Cultivation

One might consider Gossypium herbaceum var. africanum to be a wild relative of domesticated plants. It indicates that the Indus valley in what is now Pakistan is where cotton textiles first appeared, not in Africa. At that time, trade routes between Africa and India were developed, and it's possible that linted cotton was brought there as an oddity and first employed as a trim or for embroidery on linen and woollen garments. The Indus civilisation is responsible for the creation of the oldest cotton textiles in the Old World, proving that Sind is where cotton first became a significant new raw material.

Gulati and Turner's 1928 excavations at Mohen-jo-daro, Sind, Pakistan (Indus Valley) uncovered the presence of cotton on domestic items dating to about 3000 B.C. in the form of strings and fragments of fabric. The shards found at Mohen-jo-daro were clearly crafted by skilled artisans, not by someone clumsily experimenting with a new art form or with an unknown raw material. The Mohen-jo-daro cotton was comparable to modern Indian cotton in all hair qualities that could be tested, indicating that the main changes in lint evolution were finished at that time. The Rig Veda, the earliest Hindu book, which was written about 1500 B.C., also makes reference to cotton. The ancient texts of Manu and Asvalayana, both written in 800 B.C., also make multiple mentions of cotton use. Around the year 600, cotton was brought from India to China and Egypt on the east and west, respectively. However, it was probably not until the thirteenth or fourteenth century that cotton was grown in Egypt as a field crop for textile use.

Cotton farming was brought to the rest of Africa by Arab merchants. In the ninth and tenth century A.D., it was introduced to southern Europe (Sicily and Spain) by the Arab invaders. The main staples of the Greek and Roman cultures were flax wool and silk. The cotton business underwent a revolution thanks to the innovations of the automated power loom by Edmund Cartwright in 1785 in England and the cotton provided by Eli Whitney in 1793 in America. Cotton production increased consistently during the nineteenth century, and it is today grown in every tropical, subtropical, and region with a warm climate. Before cotton became significant, spinning and weaving were done using wool, silk, and flax. Gossypium herbaceum may have travelled from the Antarctic to South America in the Tertiary, receding northward as glacial progressed, according to Purseglove (1960, 1963). Cotton seeds may float in sea water for at least a year without losing any viability, as shown by Fryxell (1965), and can therefore be dispersed by ocean currents. The most plausible hypotheses, according to Purseglove (1968), were that cottonseeds sailed from Africa to South America over the Atlantic.

CONCLUSION

The Brihat Samhita by arahamihira offers insightful information on weather predicting practises used in ancient India. The Brihat Samhita of Varahamihira has been examined in this study work along with its relevance to weather forecasting. The research focused on certain passages or chapters of the Brihat Samhita that discuss weather occurrences and forecasts. Indicators used by Varahamihira to predict weather patterns included celestial occurrences, atmospheric measurements, and natural phenomena. Varahamihira's methodology and indicators provide important historical information and insights into the science and meteorology of the time. The study also looked at the historical background and applicability of Varahamihira's weather prediction techniques. His time's weather forecasting had an impact on Indian society and agriculture. Understanding the methods used for weather prediction in the Brihat Samhita helps deepen our knowledge of early scientific practises and cross-cultural interactions in the area of meteorology The information obtained through studying the Brihat Samhita of Varahamihira has possible implications in modern climate research and weather forecasting. Examining earlier meteorological methods may help contemporary meteorological study by providing important background. In conclusion, further study in this area is necessary to improve our comprehension of Varahamihira's contributions to ancient Indian science and weather forecasting. A greater understanding of historical accomplishments in numerous domains may be fostered by investigating the scientific knowledge of ancient societies. Recognising Varahamihira's weather prediction abilities may also help us better grasp the wide and fascinating history of scientific knowledge while attesting to the importance of ancient Indian contributions to meteorology.

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CHAPTER 7

PLANTING TIME AND SELECTION OF LAND FOR DIFFERENT CROPS

Mr. Vidhur Kumar, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

Important elements that profoundly affect agricultural output and performance include the timing of planting and the choice of appropriate terrain for various crops. This study intends to investigate the significance of planting season and site choice in agricultural farming. The research explores the relevance of selecting the ideal planting time and place by taking into account variables including climate, soil type, water availability, and crop-specific needs. It looks at how planting time affects crop development, growth, and yield as well as the possibility of production losses from inadvertent timing. The study also looks at how choosing the right terrain may ensure crop compatibility, nutrient availability, and disease control. For the purpose of developing agricultural practises, maximising yield potential, and advancing sustainable farming, it is essential to comprehend the significance of planting time and site selection. In order to maximise crop output and ensure food security, the research also emphasises possible uses of this information in agricultural planning, precision farming, and climate change adaptation.

KEYWORDS:

Agricultural Productivity, Crop Cultivation, Land Selection, Planting Time, Sustainable Farming.

INTRODUCTION

In many places, planting should start as soon as the rainy season arrives. If water was available, Kashyapa recommended harvesting a crop even in the heat. He separated arable areas into two main groups: those appropriate for cultivating paddy (rice) and those suitable for other crops. In general, rice was intended for low-lying areas that could be readily irrigated, whereas pulses were intended for uplands with few water supplies. Rice fields were to be more fertile than fields used for other crops, bunded to hold in water, but with holes so that any surplus water might drain to other areas. Clayey rice soils were to be used, and rice fields were to be situated adjacent to one another and the threshing site. Standing water was a given in rice fields. According to Kashyapa, farms for pulses and other crops should be located on highlands and be of inferior quality. These plants need less water [1], [2].

Crop Diversity

Cereals, millets, pulses, oil seeds, fibres, vegetables, and fruits were quite diverse in India The variety of species and varieties offered several options for selection in accordance with the kind of soil, the temperature, and the management style. In ancient India, there existed a kind of rice that could be harvested in sixty days. Another species of rice known as rice of grandes, with its enormous grains and exceptional smell, was grown in Magadha. Eight different types of rice were known to as manasollasa, and they were identified by their colour, smell, size, and growing time. Five wild rice species existed in India, and each of them had undergone a consistent process of evolution from perennial to annual habit, from cross-pollination to self-pollination, and from lower to higher fertility. The Triticum vulgare, Triticum compactum, and Triticum sphaerococum species of wheat that were found at Mohen-jo-daro. T. sphaerococum was a wheat that was commonly farmed in north India and dates back to 2300 B.C. It is quite drought resistant. All during the Harappan era, barley was grown [3], [4].

The Aryans were used to eating barley. In the Indus Valley civilisation, they embraced wheat and barley and created the new diversity needed for extensive agriculture. Ragi, bajra, and sorghum were major millets as well. Although they were mostly farmed for grain, the straw was highly prized for use as cow fodder. There were reportedly over 25 different types of sorghum available. In 1800 B.C., it was discovered that ragi (Eleusine coracana) straw was being used as cow fodder. In the early time, pulses predominated in crop rotations and crop combinations. Being legumes, they preserved and enhanced the soil's fertility. Ancient pulses such lentil, black gramme, green gramme, and Lathyrus (Khesari) were discovered in the Narmada basin between 1657 and 1443 B.C.

The green gramme originated in India. In Tarai woodlands, a wild form of Vigna sublobata was discovered. It was used in plant breeding and immune to the yellow mosaic virus. Since the Vedic era, black gramme has been generally regarded as a nourishing pulse crop in ancient Indian culture. It was used in socioreligious rites, and its significance has not diminished through time. In a similar manner, lentils improved the traditional diet. Sesamum was the most significant crop farmed by the Harappans in the Indus valley in terms of oil seeds. Brown mustard, yellow mustard, and thoria are all members of the Brassica genus known as Indian rape. Linseed and castor oil seeds are among the other significant oil seeds. The Harappan people had knowledge of cotton farming. Cotton species that are weedy and wild have been found in Gujarat, Kathiawar, and the Deccan.

They are known as tree cotton and are perennial. Date palm, pomegranate, lemon, coconut, and melon were also familiar to the Harappans. The flora Babar (pre-16th century) saw in India are documented in his diaries. Mango, plantain, tamarind, mahuwa, jamun, chironji, khirni, karonda, ber, orange, and karonda were among them. It is clear that the people who lived in the past had a thorough understanding of agriculture. Based on the resources available to the person and his immediate and long-term requirements, the strategy for crop selection and the adoption of various cropping and farming methods was chosen. Successful techniques of seed collecting, storage, and exchange within the social groupings were adopted in order to identify promising species or variations via a constant process of selection and removal [5], [6].

DISCUSSION

Sequence of Cropping

There are clear allusions to crop rotation in the Yajurveda. Rotation was used to cultivate crops in the same field, and the concept of fallowing was also well-known (Rigveda). Two harvests were collected from the same land over the course of a year, according to the Taittiriya Samhita. Additionally, it discusses the appropriate times to harvest each crop as well as the various seasons during which each crop ripens. A description of the Ramayana story shows godhuma and yava waiting for the crop as winter approaches. However, winter or rabi crops like wheat and barley are seeded in October and harvested at the end of May. Directions for seasonal farming and harvesting are provided by Kautilya. Not only does the Arthasastra demonstrate in-depth familiarity with these two harvests, but also with a third. A monarch must march against his adversary in Margasirsa (January) to annihilate his vernal crops and rainy season handfuls, in Caitra (March) to annihilate his vernal crops and autumnal handfuls, and in Jyesthamula (June) to annihilate his vernal crops and autumnal handfuls. Thus, there were three crops: one sown during the rainy season and harvested before Magha; another sown during the autumn and harvested before Caitra; and a third sown during the spring and stored by Jyaistha (cf. barley, which "ripened in summer while being sown in winter; rice, which ripened in autumn while being sown during the rains; and beans and sesame, which ripened in winter and the cool season).

The various seasons' crops are listed in the Arthasastra. In the first season (purvavapah), paddy, kodruva, sesame, panic, daraka, and varaka are seeded; in the second season (madhyavapah), mudga, masa, and saivya; and in the third and final season (kusumbha, lentil, kuluttha, barley, wheat, kalaya, linseed, and mustard). The kharif and rabi crops are in agreement with the Artha sastra, respectively. The Milinda also mentions a third monsoon, called pavllssako, in addition to the ordinary rains that fall in the late summer and early winter. Of course, the three monsoons did not consistently travel over the whole nation each year, and whether a region produced one, two, or three crops depended on rainfall, climatic factors, and soil characteristics. Food crops and edible fruits and vegetables flourished naturally without ploughing in many areas. These occurrences were unusual to the Greek spectators.

The Jatakas and the Epics (Ramayana, Mahabharata) usually go into great detail on the forest landscape, including the vegetables and fruits that grow naturally without human work. According to Arthasastra, farmers were sometimes required to raise a second crop as a last resort for taxes. The amount of rain needed by a certain crop is suggested by the weather charts after thorough observation, and the farmer is given instructions for that crop near the rain forests. Continuous cropping was a common practise in the Rigveda, although pulses (legumes) and other crops were also seeded. According to one interpretation, "the cultivators harvesting the crops in general, separately, and in due order" is intended to convey the importance of rotating crops, planting in lines, and preventing harvest overlap [7], [8].

Seed and Sowing

The selection of the seed that seemed to be healthy from a ripening crop, safe storage of it with or without treatments, and subsequent spreading of the excellent seed with or without any treatment are all examples of how ancient academics demonstrated a knowledge of the value of good seed. Around 2000 years ago, Parashara advised (i) proper seed drying, (ii) freedom from weed seeds, (iii) visual seed uniformity, (iv) storing seeds in sturdy bags, and (v) keeping seeds out of the reach of white ants and away from areas where leftover food, damp spots, and cowshed wastes could promote the growth of mould. According to Sage Parasara, the ideal nakshatras for sowing are Uttrashadha, Uttarashadha, Uttarabhardrapada, Uttarpahalguni, Mula, Jeyshtha, Anuratha, Magha, Rohini, Mrigashirsha (Mriga), Rohini, Hasta, and Revathi. Avoid seeding or transplanting on Tuesday because rodents are a concern, and on Saturday because locusts and other insects are a threat.

'Empty' days, such as the fourth, ninth, and fourteenth day of the lunar fortnight of a month, should not be used for sowing, particularly if the moon is faint. When the sun is in Cancer, grain seeds should be sown at a hand's distance (about 112 feet, or 45 cm). The distance should be cut in half in Leo. It should be four fingers, or 3–4 inches (=7.6–10.2 cm) in Virgo. Butter milk causes the seeds to sprout sooner than usual. The embryo would die from salt. In the Artha Sastra, Kautilya suggested that choosing whether to plant seeds for certain crops should be based on the known patterns of rainfall. He advised planting rice first, followed by mung beans and black gramme. In order to guarantee excellent germination, he also advised several seed treatments (such as cow dung, honey, and ghee). Manu said that a skilled farmer, or "Vysya," must be able to assess the calibre of seed. Manu's most important suggestion was that a merchant selling fake seed be severely punished.

To prepare the ground for sowing, Kashyapa would either plough, level, furrow, or dig holes. It is said that the process depends on the qualities of the terrain, the availability of water, the amount of sunlight, and more knowledge. To guarantee successful germination, Varahamihira advised pelleting seeds with rice, black gramme, and sesame flours and fumigating them with turmeric powder. Surapala mentioned a number of botanicals, including seed treatment products for trees and plants. Many farmers still use cow dung to cure cotton and certain other seedlings, as Kautilya first proposed in the fourth century B.C. One of the most significant events was the sowing of seed. The act of sowing was accompanied by rites and prayers. For planting seeds, crude bamboo drills were used. On the basis of sowing time, the inter-plant and inter-row spacing was adjusted; later planting resulted in more seeds per unit of urea. For even seed germination, sowed areas were covered with a wooden board. It is not a new practise to sow rice in tiny areas, i.e., in nurseries, and to transfer the seedlings. In the year 100 AD, it was first mastered in the Krishna and Godavari River deltas.

According to Varahamihira, the standard method of planting seeds included soaking them in milk for ten days, bringing them out everyday by hand, coating them with ghee, rolling them repeatedly in cow dung, and fumigating them with deer or hog meat. The seeds were then planted in soil that had previously been prepared with sesame, meat, and hog marrow. When milk and water were sprayed on them, they grew and flowered. Another approach included soaking the seeds a hundred times in a paste made from the fruit of the Ankola (Alangium salvifolium Wang) or the Slesmataka (Cordiarothii Roem and Schult) and then planting them in soil that had been mixed with hail. The seeds would immediately germinate and produce fruit. When dusted with a combination of rice, black gramme, sesame, and wheat particles together with expired meat and continuously fumigated with turmeric powder, hard seeds like tamarind emerged. The seeds for Slesmataka had their shells removed, were then soaked in water, combined with an alangium fruit paste, and seven times dried in the shade before being combined with buffalo dung and kept in the dry dung.

The seeds were then planted on rain-soaked soil. The bearing worked well. To achieve unique outcomes, seeds were given a particular treatment. To produce cotton with a red tint, cotton seed was specially treated with red lac juice. In order to simplify seeding and reduce seed-borne illnesses, it was additionally coated with cow dung paste. The seedlings were covered from root to stem with a combination of ghee, usira or khas (Vetiveria zizanioides), sesame, honey, vidanga (Emblica ribes), milk, and cow dung before being transplanted at a different location. Kalidas in Raghuvamsha used transplanting to cultivate sali paddy. In fact, in the Krishna-Godavari deltas in the year 100 A.D., the practise of transplanting rice was quite common. During the Sangam period (A.D. 300–600), it was the most significant agricultural activity. Two grafting techniques have been documented by Varahamihira. They are (i) putting a plant cutting into another plant's root that has been severed from its trunk and (ii) putting a tree cutting into another plant's stem. In both instances, the intersection of the two was coated in mud and cow poo. For plants like jackfruit, ashoka, plantain, rose apples, lemons, pomegranates, grapes, jasmine, etc., grafting was encouraged. Additionally, he advised grafting plants that have not yet grown branching in February or March, those that have in December or January, and those with huge branches in August or September. The grafted trees had to be watered every day in the summertime, every other day in the winter, and if the soil started to become dry in the rainy season.

Water Management

Building bunds to hold water in plots is advised for rice. Low-level fields are not a good candidate for bunding since there would be enough moisture. For low-lying places, direct rice sowing has been advised. Once the panicles have opened, don't flood the rice, but the soil must still be damp. Kashyapa supported the cultivation of irrigated crops, giving it his whole attention. Well construction and water-lifting equipment design had been covered. Kashyapa has provided specifics on the placement and design of water reservoirs. He emphasised the need of building a reservoir close to farmer fields, assuring the reservoir's water supply, building sturdy causeways and taking other precautions to prevent populated areas from flooding, and routinely examining and maintaining the reservoirs, particularly during the rainy season. The final one serves as a useful lesson for the current, slothful, and uncaring workers of the government irrigation agencies.

Two reservoirs should be available to each farmer. The advice given by Kashyapa regarding construction and reservoir upkeep is technically valid. Naturally, Kashyapa suggested growing trees around water reservoirs to beautify and preserve them. He recommended picnic areas around reservoirs, which is a characteristic that is'modern' in the twenty-first century. Verse 111 through verse 143 of section I refer to the building of canals. Four sources of canal have been mentioned by Kashyapa. River, tank that may have been filled by a river, vast lake, canals that gather water from mountain waterfalls, and so on. Kashyapa has emphasised the need of creating a network of canals that encircle communities and provide an appropriate gradient for the canals. He emphasised the need of choosing soil with the proper structure and profile for canal construction and avoiding salty soils.

The need of protecting the canal system and reservoirs was emphasised. Kashyapa advised building wells, particularly in locations without access to canal water. The post-rainy season was the ideal period for well drilling. He recommended researching the existence of trees and, of course, water divining as signs of subsoil water. He emphasised the need of creating solid brick foundations and brick-and-mortar walls. Even having stairs to access a well was advised. The so-called Persian wheel, the ghatiyantra, has been used by bullocks, elephants, and people, according to Kasyapa. Rain harvesting was emphasised. "It may be a canal, a well, a pool, or a lake, but find they must and acquire a guaranteed source of water," reads a lyric that sums up all about water for farming.

Growth Promoters

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Harvesting and Measuring Yields

The sage Parasara suggests using the nakshatras Aardra, Kritika, Chitra, Pushya, Hasta, Swati, Uttarashadha, Uttarabhadrapada, Uttaraphalguni, Mula, and Shravana for the token harvest. 'Empty' days shouldn't be used for harvest. Rikta, or empty days, are the fourth, ninth, and fourteenth days of the lunar fortnight. Grain measurements should be made from left to right, not the other way around. A wooden container called an adhaka is used to quantify increases that are about comparable to 7 lb and 12 oz (or 3.5 kg). It is equivalent to a quarter of a drona. While measuring the grains from the left results in enjoyment and increased yield, doing it from the right results in expense. Measuring agricultural products (Kashyapa): He should also set up prastha, kunja, drona, and tiny nadika for (correct) measuring of cereal grains, adhaka (pigeonpea), etc., and other commodities. The first three are measurements of capacity: prastha = 1/4 adhaka; drona = 4 adhakas; kunja-should have been kunchi = 1/32 adhaka, where one adhaka equals 256 fistfuls = 32 kunchis, or 32 handfuls; nadika is a measurement of length = 2 hastas, where one hasta is the distance between the elbow and the tip of the middle finger and is roughly equal to 1.

Farming Systems

The priority accorded to food production in Anna Sukta demonstrates that arable farming and animal farming were both valued equally. The praise of land, bullocks, seeds, and peasants in numerous hymns shows the value placed on arable farming and crop husbandry, as well as the consideration given to different varieties of field grasses for food and fodder for the dual purpose of man and animal. Based on accessible resources and sound ecology, Indian agriculture's traditional land use and occupational systems have always been site-specific. For instance, since the soil was unstable and could not be exploited extensively, the inhabitants of Rajasthan in India evolved a nomadic and animal-care oriented way of life. Because they had to live on hillsides, the people of Mizoram and Nagaland created shifting agriculture as a means of subsistence. This was the best approach to maintain their soil's fertility and production as well as to preserve and utilise the bio-resources in a sustainable manner.

This very well-organized agro-ecosystem known as Jhum is founded on empirical information gathered over many years. It works in harmony with the environment and gives ample time for the recovery of soil fertility and lost forest fertility during cropping. It entails clearing vegetation and burning it before to the start of the monsoon, growing a variety of crops on short-term enhanced soil for a year or two, and then letting it fallow for a few years.

New systems have been created, such as the Zabo system, which combines soil and water conservation in forestry, the Alder system for healthy soil, and the Panikheti system for wet rice farming and wise water management. In India, mixed cropping is a common aspect of shifting agriculture. Scientists used to consider it primitive, but now they are suggesting it as a way to boost global food supply. In the cropping phase, farmers cultivate 8–35 crop species on a small plot of land measuring 2–2.5 ha, sowing them simultaneously and harvesting them in succession. This crop mixture protects the crops from nutrient loss, mobilises resources to facilitate the recycling of biomass and nutrients, and enhances the soil's properties.

In Nagaland, the Zabo agricultural technique is used. "Zabo" refers to a water impoundment. The system combines farming, forestry, raising animals, fishing, and conserving land and water. The Zabo system includes terraced rice fields towards the foothills, a cow yard, protected forest space on top of the hill, a well-planned rainwater collection tank on top of the hill and indigenous ways of nutrient management in the hill region. There is no irrigation available, and the soils are a saline clay loam with greyish brown colours. The primary source of agricultural nutrients is animal manure.

During the off-season, the silt that has built up in the tanks is removed and spread on the fields. As a result of the abundance of forest debris in this silt, it is particularly nutrient-rich. Additionally, farmers mulch their crops with succulent branches and leaves, allowing them to decompose. This promotes soil fertility development and soil health preservation. This indigenous agricultural method is an excellent illustration of the efficient use of nutrients, water, and soil. The Zabo technique of cultivation is environmentally benign, protects natural resources, and minimises soil erosion in contrast to shifting cultivation, which would otherwise result in soil and nutrient loss.

Indian agriculture is shifting, and mixed cropping is a common practise. Scientists used to consider it primitive, but now they are suggesting it as a way to boost global food supply. In the cropping phase, farmers cultivate 8–35 crop species on a small plot of land measuring 2–2.5 ha, sowing them simultaneously and harvesting them in succession. This crop mixture protects the crops from nutrient loss, mobilises resources to facilitate the recycling of biomass and nutrients, and enhances the soil's properties. Because they had to live on hillsides, the people of Mizoram and Nagaland created shifting agriculture as a means of subsistence. This was the best approach to maintain their soil's fertility and production as well as to preserve and utilise the bio-resources in a sustainable manner. Jhum agriculture is a well organised agroecosystem that is built on centuries' worth of empirical experience. It works in harmony with the environment and gives ample time for the recovery of soil fertility and lost forest fertility during cropping. It entails clearing the land of vegetation and burning it before the monsoon arrives. The land is then planted with a variety of crops on temporarily enhanced soil for a year or two, after which it is left fallow until a new system, such as the Zabo system, which combines soil and water conservation with forestry, is introduced.

CONCLUSION

The study looked at how choosing the right terrain may ensure crop compatibility, nutrient availability, and disease control. The health of the crop and its resistance to environmental shocks may both be enhanced by choosing appropriate land. Understanding the significance of planting season and site selection presents chances improve agricultural practises and advance sustainable farming. Planning for agriculture, precision farming, and climate change adaptation might all benefit from the information obtained by analysing planting timing and site choices. Making the most of the planting season and available space may help with effective resource management and climate-resilient agricultural techniques. To sum up, further study in this area is necessary to improve our comprehension of planting timing and site selection, as well as the consequences for agricultural output and food security. It is possible to increase agricultural yields, resource efficiency, and environmental sustainability by putting an emphasis on time and land management. A sustainable and resilient future for agriculture may be ensured by combining historic knowledge with contemporary agricultural practises, which can also provide creative answers to current agricultural problems.

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CHAPTER 8

DETERMINATION OF SOIL CLASSIFICATION IN AGRONOMY

Mr. Kuldeep Kumar, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

knowing soil characteristics, fertility, and appropriateness for various crops begins with knowing soil categorization, which is a key component of agronomy. The purpose of this study article is to examine the value of soil categorization in agronomy and its contribution to sustainable agriculture. The categorization of soils based on their physical, chemical, and biological characteristics is done using a variety of soil classification methods, including the Soil Taxonomy and the World Reference Base for Soil Resources. It looks at the role that soil classification plays in selecting the best agricultural techniques, irrigation systems, and soil conservation tactics. Additionally, since various crops have varied soil needs, the study looks at the connection between crop selection and soil categorization. Agronomy's understanding of soil categorization is essential for assuring nutrient management, increasing agricultural productivity, and reducing environmental effects. In order to increase agricultural output and maintain soil health, the research also emphasises possible uses of this information in precision farming, land use planning, and sustainable soil management.

KEYWORDS:

Agronomy, Soil Classification, Soil Properties, Sustainable Agriculture, Soil Taxonomy.

INTRODUCTION

Physically, India may be divided more or less into three main regions viz., the mountainous borders of Himalayas in the north and of the Vindhyas in the south with the linings of Ghats in the south-eastern and south-western coasts and the traverse range or Aravalli hills; the Deccan plateau or table land; and (3) the plains or low-lands, a rich Indo-Gangetic alluvium over flown by the rivers-the Ganges, Jamuna and Brahmaputra. Although the ancient mountains were impassable to human habitation, the foothills have become more and more settled, and the upland valleys that border the Himalayas include some of the most productive Indian lowland landforms [1], [2].

The whole IndoGangetic alluvium is made up of lush, fertile soil and has significantly aided in the development of civilisation.

(i) **The Himalayas:** The tallest mountain range in the globe and the northern boundary of India are the Himalayas (Sanskrit: hima, "snow," and alaya, "abode"). This massive, geologically young mountain range spans 1,550 miles (2,500 km) from the Namcha Barwa peak in China's Tibet Autonomous Region to the top of Nanga Parbat in Pakistan-controlled Jammu and Kashmir. Mountains may be found in India, southern Tibet, Nepal, and Bhutan between these two extremes. The system's breadth ranges from 125 to 250 miles.

(ii) **The Indo-Gangetic Plain:** The Indo-Gangetic Plain, also known as the North Indian Plain, is India's second major structural feature and is located between the Himalayas and the Deccan. The plain is located in the Himalayan foredeep, which was once a seabed but is now up to 6,000 feet deep with river-borne alluvium. The plain extends from the western Pakistani provinces of Sind and Punjab, where the Indus and its tributaries provide irrigation, to the eastern Brahmaputra valley in

Assam. The centre and most significant portion of this plain is the Ganges basin, which is mostly located in Uttar Pradesh and Bihar. The combined Ganges and Brahmaputra River delta, which is mostly in Bangladesh but also extends into the neighbouring Indian state of West Bengal, makes up the eastern portion. Annual flooding in this deltaic region is caused by heavy monsoon rains, an exceptionally moderate gradient, and a large discharge that the alluvium-strewn rivers are unable to hold inside their courses. The western half of the plain is formed by the Indus River basin, which stretches west from Delhi; the Indian portion is mostly in the states of Haryana and Punjab. An essential southern extension of the Indo-Gangetic Plain is the Great Indian Desert, often known as the Thar Desert. It is primarily a region of gently undulating terrain that generally lies in India but also extends into Pakistan. Within it, there are some sections that are dominated by changing sand dunes and several solitary hills [3], [4].

(iii) **The Deccan Plateau:** The remaining portion of India is often referred to as peninsular India or the Deccan Plateau, neither of which is entirely correct. It is actually a topographically diverse region that stretches far beyond the peninsula, that part of the nation between the Arabian Sea and the Bay of Bengal. It includes a sizable area to the north of the Vindhya range, which is commonly thought to be the boundary between Hindustan (northern India) and the Deccan.

Soil Types of India

India's soils were divided into four main kinds and three minor types as a result of Voelcker and Leather's research in 1893 and 1898:

(i) The Indo-Gangetic alluvium;
(ii) The black cotton soils;
(iii) The red soils resting on metamorphic rocks; and
(iv) The lateritic soils. the biggest and most significant.

This group's soils span an area of around 777,000 square kilometres. The Punjab, Haryana, Uttar Pradesh, Bihar, Bengal, and portions of Assam and Orissa are where they are mostly distributed. They grow bumper quantities of rice and wheat. According to geology, the alluvium is split into two types: Khadar, or fresh alluvium, which is around 10,000 years old, sandy in composition, typically light in colour, and Bhangar, or older alluvium from the Pleistocene epoch, which is more clayey in composition, normally dark in colour, and full of pebbles or kankar. The soils range in texture from fine silts to stilts clays, and from drift sand to loams. On occasion, there are even a few pebble beds. The presence of impermeable clays prevents drainage and encourages the buildup of harmful sodium and magnesium ions, which render the soils infertile. These alluvial soils often show the development of hard pans at certain levels in the soil profile as a consequence of the binding of soil grains by the entering silica or calcareous materials. Most of the soils are loams or sandy loams, with a varied depth of soil crust. There are significant amounts of soluble salts. The majority of Tamil Nadu's alluvial soils are transported soils that are found along the coast and in deltaic regions. Sand and silt alternately cover the profile's portion. The kind of sediment that rivers bring with them affects the makeup of the strata, which in turn affects the catchment regions and the places that the streams run through [5], [6].

Black Cotton Soils

The regur or black cotton soil is the predominant soil type of the Deccan Trap. It is widespread in Maharashtra, the western regions of Madhya Pradesh and Karnataka, as well as in certain areas of Tamil Nadu, especially the remote districts of Ramnad and Tirunelveli. It is akin to Russian chernozems and the prairie soil found in cotton-growing regions of the United States of America, particularly California's black adobe. It is made up of two different kinds of rocks: the Deccan and Rajmahal Trap and the semi-arid ferruginous gneisses and schists of Tamil Nadu. The latter tend to be shallow, whilst the former may reach significant depths. Though some, particularly in the uplands, have poor productivity, the black soil regions usually have a high level of fertility. The soils in the broken area between the hills and the plains are darker, deeper, and richer and are continuously enhanced by deposits washed down from the hills. The soils on the slopes and uplands are slightly sandy.

Red Soils

Covering 2,072,000 square km, red soils nearly cover the whole Archaean foundation of Peninsular India, extending from Bundelkhand to the far south. They include south Bengal, Orissa, sections of Madhya Pradesh, the eastern Andhra Pradesh, Karnataka, and a sizable portion of Tamil Nadu. Additionally, Santhal Parganas in Bihar and the districts of Mirzapur, Jhansi, and Hamirpur in Uttar Pradesh have these soils [7]–[9].

DISCUSSION

crystalline and metamorphic rocks from the distant past. The Mesozoic and Tertiary eras are when these soils first began to form. These soils are often red in appearance, sometimes grading into brown, chocolate, yellow, grey, and even black. The general dispersion rather than specific causes of the redness a high iron content percentage. The plains and valleys have deeper, darker, and more fertile soils than the uplands, which have thin, gravelly, and light-colored soils.

In general, they are deficient in humus, nitrogen, and phosphorus. They are generally low in phosphorus and deficient in iron oxide, potash, and lime when compared to regur. The soils' clay component contains a lot of kaolinite. In Tamil Nadu, red soils, which are in-situ formations formed from the rock underneath under the influence of climatic circumstances, cover more than two-thirds of the land that is used for agriculture. The red granite or mica-based rocks are acidic. The soils have an open, shallow feel. They lack organic matter and plant nutrients and have a limited exchange capacity.

Laterites

A soil type unique to India and several other tropical nations, laterite is distinguished by the sporadic occurrence of damp weather. Its formation ranges from compact to vesicular rock made mostly of hydrated iron and aluminium oxides with trace amounts of manganese oxides, titanium, etc. It results from the atmospheric weathering of different kinds of rocks. Madhya Pradesh, Orissa's coastal area, south Maharashtra, Malabar, and a portion of Assam are among the places that have laterites. All lateritic soils are often quite low in nitrogen, magnesium, and lime. On occasion, there may be a high P2O5 concentration but a low K2O content. Both high-level and low-level laterites, which are created from a range of rock components under certain climatic and environmental circumstances, may be found in Tamil Nadu. Rice is grown by laterites at lower altitudes, whereas tea, cinchona, rubber, and coffee are grown by laterites at higher elevations. The 10 to 20 percent organic matter in the soils contributes to their high nutritional content.

Forest and hill soils

The kind of organic matter deposited, which is a result of the expansion of the forest, greatly influences soil formation. Broadly speaking, two types of soil may be identified based on their circumstances of formation: soils created under acidic conditions, which have acid humus and low base status, and soils developed under slightly acidic or neutral conditions, which have high base status and are ideal for the development of brown earths. Assam and Uttar Pradesh have forest and hill soils, and the Sub-Himalayan tract is divided into three separate regions: the bhabar area directly below the hills, the tarai, and the plains. Due to high soil moisture and a prodigious development of vegetation, the tarai zones are characterised by acute unhygiene. Due to the yearly receipt of the decomposed byproducts of the virgin forest, the soils of Coorg have deep surface soil that is very fertile. The majority of the westward lands are set aside as woods and mountainous terrain. Pebbles cover the whole ground surface, which is well drained and has a laterite bed [10].

Desert soils

Desert conditions, which are geologically of recent origin, are present in a significant portion of the dry area of Rajasthan, the Punjab, and Haryana, which is located between the Sutlej and the Aravallis. This area is governed by circumstances that prevent soil formation and is covered in a mantle of blown sand. Some of the soils have significant levels of soluble salts, different calcium carbonate concentrations, and high pH. However, they are lacking in organic stuff. Only when suitable irrigation facilities are made available is reclamation feasible. Soils that are saline and alkaline These soils are widely dispersed throughout all climatic zones of India. Bihar, Uttar Pradesh, Punjab, Haryana, and Rajasthan all have these types of soils. Because saline solutions from the lower strata are transported there by capillary action, the harmful salts are restricted to the upper layers. According to estimates, usarC has impacted over 200,000 hectares in the Punjab and Haryana and almost 850,000 hectares in Uttar Pradesh.

Maintenance of Soil Productivity

In ancient India, the use of manures in achieving high agricultural yields was clearly understood. It is claimed in KrishiParashara that crops produced without manure would not yield, and a process for making manure from cow dung is explained. The usage of cow dung, animal bones, fish, and milk as manure was noted by Kautilya. To promote tree blossom and fruiting, Agnipurana advises applying sheep and goat excrement as well as ground sesame that has been allowed to soak in meat and water for seven nights. It is advised in Varahamihira's Brhat Samhita to cultivate sesame to the blooming stage and then use it as green manure. The Abhilasitarthacintamani cites a handful of these fertilisers, including: (1) Lightning-struck tree soil is useful for protecting trees from problems caused by snowfall. (2) Burning turmeric, Vidanga, white mustard, Arjuna tree blossoms, combined with fish, and Rohita (a kind of deer) meat would not only promote the development of flowers and fruits but will also eradicate all worms, insects, and illnesses. The 'old' practise of making liquid manure (kunapa), according to Surapala (around 1000 A.D.), included boiling a combination of animal excrement, bone marrow, meat and dead fish before adding sesame oil cake, honey, soaked black gramme and a little amount of ghee or clarified butter. 'Kunapa' preparation didn't call for any specific amounts of any certain components. Growing trees and shrubs was the principal purpose for this liquid manure.

Green leaf manure is used as the primary fertiliser for the rice crop in traditional agricultural practises in the Himalayan areas of the subcontinent. Kunapa should be used to properly feed trees, according to Surapala and Sarangadhara. Sarangadhara provides the following instructions for making kunapa: "One should boil the flesh, fat, and marrow of deer, pig, fish, sheep, goat, and rhinoceros in water. When it is properly boiled, one should put the mixture in an earthen pot and add milk, sesame oil cake powder, masa (black gramme) boiled in honey, the decoction of pulses, ghee, and hot water to the compound.

There is no set quantity for any of these components, but when the pot in question is left in a warm environment for approximately a week, the mixture turns into something known as kunapa water, which is very nourishing for plants in general. Kunapa was alluded to by Surapala before Sarangadhara, and its components were faeces, bone marrow, meat, brain, and blood of boars combined with water and kept underground. Surapala also referred to "available" resources, which might include fish, ram, goat, and other domesticated animals as well as animal marrow, fat, and meat. Other elements were largely the same as those specified by Sarangadhara, with the exception of the little amounts of ghee and honey that were suggested.

Kunapa water concentrates may easily be standardised, prepared on a large scale, and provided to consumers in jars. Firminger (1864), a "Chaplain of the Bengal Establishment," indicates the beneficial use of "liquid manure," manufactured the same manner Kunapa was made, for vegetable development. This presents a possibility for a business to assist farmers, particularly orchardists. He has not said who came up with the idea for liquid manure.

Recycling

In the foothill zones, recycling of nutrients by pond excavation was accomplished using tank silt or pond excavation. the pond sediments from fields, open areas, etc. during the monsoon. The common village pond also receives the sewage slurry, dissolved minerals, and nutrients in water from livestock sheds and home washings. Clay and organic elements that have flocculated normally settle completely soon, leaving the pond's water pure. This pond used to serve as a water source for animals. The farmers excavate the pond foundation by removing the dirt and transporting it to the fields as soon as the ponds dry up in the summer. About 30 cm of the pond base's top layer is typically removed. This is a plentiful supply of nutrients for plants. Each field receives pond sludge application once every 10 to 15 years. Tank silt increases the amount of clay in red soils with light textures, which helps to raise soil moisture levels and, ultimately, crop output. Farmers in the districts of Coimbatore and Trichy use tank sand to crops including banana, turmeric, and jasmine, while those in Ramanathapuram apply it to rice at a rate of 25 t/ha. With the advent of chemical fertilisers, the excavation of pond basins and their application to fields were discontinued. Farmers remove the topmost worn basalt rock, known as "murrum," and spread it over the fields.

Locating Water Table - Keys to the Finding of Water Source

In his "Visva Vallava," Chakrapani discusses in depth how one might estimate the amount of water that is under the surface of various types of lands based on specific features of the soil. Water is often found close to or below marshy areas, along seashores, and deep inside deserts, stony, and hilly terrain. A spring is occasionally reached via an underground artery that originates in a mountain or the root of a tree. In certain locations, it seems like all of the arteries go to caverns.

When digging, if hard, stone-like ground is encountered; if it is hit, it sounds like a thin slab of stone; then water is undoubtedly present underneath it. There would be a water artery two cubits below the surface running towards the west if a rank growth of Vetasa (rattan) was discovered at a location devoid of any water reservoir. If a rattan plant is discovered growing where there isn't a pool of water, digging seven cubits below will reveal an artery of water three cubits to the west of that plant. If the Ficus oppositefolia tree is discovered growing in a location without any kind of water reservoir, three cubits to its west will reveal a waterway that is 1.5 man-lengths below the earth's surface. A black water artery two and a half man lengths below the surface may be discovered three cubits to the west of where an Udumbarika tree is located. If a Badari (jujube) tree is to the west of an ant-hill, then two cubits to the west, springs of water would undoubtedly be found at a depth of three man-lengths. If there is an ant-hill to the north of an Arjuna tree, then three cubits to the west of the tree, water is sure to be found at the depth of three and a half man-lengths. If there is water towards its south at a depth of three man-lengths, it is where the plants Bhargi (Clerodendrum siphonantus), Danti (Croton polyandrum), or Malika (double jasmine) are found.

Locating Water in Arid Areas

Since ancient times, rainfall has been a major factor in Indian agriculture. People were aware that a significant portion of rainwater seeps into the earth via aquifers. Saraswata Muni, who was knowledgeable in flora and biology, as well as Manava Muni, a geologist, made observations regarding ground water and its exploration. Their findings suggested that the existence of an ant hill or a snake cave was a sign of the presence of subterranean water. Water is present in a variety of trees, including Banyan, Gular, Palas (Butea monosperma), and Bilwa (Semicarpus anacardium), at certain depths and in specific directions. Manava Muni uses the colour of the soil or the stones and rocks to infer the existence of water. He listed the plants and trees that are signs of the existence of water. The finest astronomer of the sixth century A.D. who made specific observations on water exploration was Varahamihira. He claims that there is water in the ground near the Vetasa plant (Calamus rotalg), the gular tree (Ficus glomerata), where a current of sweet water may be found, the location where bilwa and gular trees are found growing together, the presence of an ant hill to the north of the arjuna tree (Terminalia arjzma), the presence of a coconut tree and an ant hill, the presence of a n People relied more on river water and the monsoons than on the digging of wells. Human work was used to dig shallow wells, and indigenous man- and animal-powered machinery was used to raise water. These wells were built after the location was carefully chosen and the presence of ground water was confirmed using water diviners.

Numerous techniques for finding water in dry areas have been described by ancient masters. If heated vapour is seen rising from the ground, a stream of water at a depth of two manlengths and subterranean plants will be discovered. The two-man-deep water would become a whitish colour before dissipating. It is now feasible to determine if there is a sufficient quantity of water beneath or whether the water is sweet by using indications authorised by (the astrologer) Sanmuni. Typically, a plentiful stream of water as wide as an elephant's trunk exists underground for the convenience of those who live in arid regions. If an anthill is present to the north of a Karira plant, delicious water will be discovered to the south at a depth of ten man-lengths, and yellow frogs will be present at a depth of one man-length. And if there was a Rohita tree to the west, water would be discovered three cubits and twelve man-lengths below the surface, and there would be a plentiful stream of saline water flowing in that direction. If there were a white anthill nearby, a water vein at a depth of five man-lengths and stones and yellow clay at a depth of one man-length would be present in that direction. If there is an anthill to the east of which a Pilu tree is located, water at a depth of seven man-lengths would be located one man-length to the south. A snake with black and white spots would be discovered at the first man-length of depth, and at the third man-length of depth, there would be an abundance of salt (water). If an anthill were to be located to the east of Indradru (Terminalia arjuna), water at a depth of twenty man-lengths and an iguana at a depth of only one man-length would be discovered just one cubit to the west. A collection of five anthills, the central one being white in colour, would indicate the presence of water at a depth of 55 man-lengths. Water would be discovered 21 man-lengths underneath any Kusa grass or pale-white adurva that was growing over an anthill.

Locating Water in Mountainous Country

Regarding the mountainous nation, Sarasvata and Varaha provided precise equations. Even in dry and swampy areas, water may be discovered three man-lengths below a grouping of Bodhi trees, Udumbarika, Palasa, and Nyagrodha trees. Sweet water is extremely close to the surface and sweet-voiced birds live in the area where trees have glossy, dense foliage and bushes and creepers contain milky juice. Water would be discovered at a depth of three man-lengths in an area where Kharjuri, Jambu, Sata-patra, Nipa, Sinduvara, Vata, Naktamala, Andumbari, Kakaranva, and Vibhitaka grow.

In an area where blooming trees and plants like Jati, Kusthaka, Campaka, etc., as well as fruit-bearing trees like the pomegranate, lime (Citrus acida), and citron are discovered to flourish, water is supposed to reside underground. Sweet water is abundant everywhere in a steep area where the Tala tree, the coconut tree, the Kancanara, the Vetasa, or any other trees are discovered to flourish. In a nation with mountains, there is something known as a Nirjahara (water-fall or cascade) that emerges from cracks in the rocks or from the roots of trees. A stream with a large flow of water is often observed to run from beneath the plants in a moist mountainous region. At sacred locations with shrines, such a stream is sometimes discovered to also exist underground. There is a lot of water next to the rocks that shine like a copper vessel facing the sun, or like glass and Vaidurya (eat's eye), or are dazzling like pearls, or grey like the Patasa, or brown in hue. Sweet water may be found in areas with black or dark blue soil mixed with gravel, white soil mixed with sand, yellowish soil, or areas with white soil alone. While the water in polish soil (with a smooth surface) tastes salty, the water in brown soil has an unpleasant flavour.

Construction of Reservoirs

The following passages from Chakrapani's book "Visva Vallabha" explain how reservoirs should be built after underground water has been discovered: "When water has been located, reservoirs of various shapes and sizes should be constructed outside the villages, their sites and measurements being determined by the availability of space. Six configurations are possible for an artificial reservoir: circular, quadrangular (square), triangular, polygonal, oblong, and semi-circular (half-moon). After it has been excavated, its capacity may be determined. The length of the largest reservoir should be one thousand poles (4000 cubits), followed by half and then one fourth of it. The amount of available space determines the size of additional reservoirs. By building a dam between two hills, in a mountain valley, or on a huge area at the summit of a hill, a large reservoir that will always have a significant storage of water may be built for a lower cost. A large reservoir may be created by building a dam there if there is a broad, high table land with substantial water inflow and a small outlet for the water to escape. From the top of the dam to the bottom of the reservoir, a smart person would install stairs, and for the dam's strength, he or she would have lime cement plastered both the inner and outer faces.

A terrain that is low on all sides that is filled with water creates a pond and a natural reservoir. There cannot be any established standards for it. Kingly leisure cottages may be seen on the shores and in the midst of the lakes. A boat should be maintained there for leisurely excursions or splashing about in the water, or a bridge (or causeway) could be used to access the pleasure home. Nanda, Bhadra, Jaya, and Vijaya are the names of tanks with three peaks and one opening, nine peaks and three openings, and twelve peaks and four openings, respectively.If it is discovered that the well's bottom is filled with sand, a firm wood foundation pedestal should be positioned below so as not to obstruct the well's water springs.There are four different types of kundas, including Bhadra, Subhadra, Parigha, and

Nanda. The first is quadrilateral, the second is Bhadra, the third is Subhadra, and the fourth is linked to Peatibhadra in the centre. They (the Kundas) should have four entrances, one in each direction, and a half in one corner, together with a quadrangular courtyard with ventilators inside, measuring 128 cubits on each side. A extremely deep natural pool that has formed on its own might be of any shape. Its embankments might be paved with stone and lime mortar as they already are.

CONCLUSION

Understanding soil classification in agronomy opens doors to sustainable soil management, precision farming, and land use planning. The understanding acquired from researching soil classification may be used to increase agricultural output and maintain the health of the soil. Effective nutrient management and long-term soil conservation may be achieved by implementing appropriate agricultural practises based on soil categorization. In conclusion, further study in this area is necessary to advance our comprehension of agronomic soil categorization and its implications for soil management and sustainable agriculture. Using soil categorization to guide the development of novel soil management techniques may increase agricultural production, lessen negative environmental effects, and improve soil health. Additionally, combining information about soil classification with contemporary innovations and precision farming techniques may promote effective resource management and robust agricultural systems.

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CHAPTER 9

EXPLORATION OF THE METHODS OF PLANT PROTECTION

Mr.Ravi Singh Thapa, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

In order to provide the best production and quality, plant protection is a crucial component of agriculture. It works to protect crops against pests, diseases, and environmental stresses. This study intends to investigate different plant protection techniques used in agricultural practises. The research explores both traditional and sustainable methods, such as biological control, cultural practises, chemical pesticides, and integrated pest management (IPM). It examines each method's benefits and drawbacks while taking into account its effectiveness, influence on the environment, and cost-efficiency. The study also looks at how current technology, such remote sensing and precision agriculture, might improve plant protection measures. For the sake of improving sustainable agriculture, lowering dependency on chemical inputs, and decreasing environmental dangers, it is essential to understand the various plant protection techniques. The research also emphasises how this information may be used to manage crops, ensure food security, and adapt to climate change, providing chances to improve plant health and agricultural output.

KEYWORDS:

Biological Control, Cultural Practices, Integrated Pest Management, Plant Protection, Pesticides.

INTRODUCTION

'Abiotic' and 'biotic' ailments have an impact. Insects first originated in agriculture more than 250 million years ago, far earlier than humans, who just began to develop in the last million years. Indians who were familiar with the manufacture of silk and lac in the period before 3870 B.C. were aware of the relationship between humans and insects. The Rigveda (c. 3700 B.C.), Krishi-Parashara (c. 100 B.C.), Tamil Sangam literature (200 B.C.–100 A.D.), and Agni-Purana (c. 400 A.D.) are among the texts that describe man's attempts to safeguard crops. The Brhat-Samhita of Varaha Mihiria (c. 500 A.D.) Around 800-900 A.D., Kashyapiyakrishisukti Vrikshayurveda of Suprapala (about 1000 B.C. Manasollasa by Someshwera Deva (around 1100 A.D.), Upavanavinoda by Sarangadhara (about 1300 A.D.), and Tuzuk-e-Jahangiri (circa 1600 A.D.) Nuskha Dar Fanni-Falahat of Dara, Shikoh (about 1650 A.D.) A document written anonymously in Rajasthani dating from 1877, Jati Jaichand's diaries from 1689 to 1714 AD, and Watt's Dictionary of Economic Products of India from 1889 to 1893 AD. Since agriculture has been around for more than ten thousand years, it is easier to understand its progressive evolution if it is divided into the following time periods: The Ancient period from 10,000 B.C. to the start of the anno Domini (A.D.) era. The Mediaeval period from the start of the A.D. era to the 18th century A.D. era; and The Modern period from the 19th century A.D. to the present [1], [2].

The Ancient Period

The change from hunting and gathering to agriculture is one of the most significant moments in human history. While Kautilya (321-296 B.C.) was the first to advocate using seed dressers to create healthy plant stands, Susruta Samhita (400 B.C.) emphasised the need of preserving seeds from white ants. Algae and fungi are only mentioned in the Rigveda as saprophytes.

"Mildew of paddy" and "blight of sugarcane" are referenced in the Buddhist text Kallavagga (c. 100 B.C.). According to Krishi-Parashara, only prayers to God Indra and other supernatural beings were used to safeguard plants in the past. However, several references were made to agricultural losses brought on by insect infestations. For instance, verse 126 states that "starting the plough on the fourteenth day of the month in any agriculture season was not shown as auspicious and met with several loss through insect pests." The favourable "lagnas" for beginning agriculture in a given season, such as Turus (21st April), depending on the movement of the sun's entry into the corresponding zodiac signs, were also highlighted.

DISCUSSION

Harvesting, Threshing and Storage

Riveda made reference to harvesting barely using sickles. Both cutting the crop down at ground level and removing the earheads were used in harvesting. On the threshing floor, threshing was carried out, and a supa was used for winnowing. Grain that had been cleaned was kept in bins, and waste was burnt. Making a flat threshing pit and installing a medhi, or threshing pillar, were both described in Krishi-Parashara. In order to acquire wood that is not too hard lest the grain be broken, the pillar's wood was procured from a tree that generates milky sap. Neem (Azadirachta indica A. Juss) leaves and mustard were used to cure the pillar.

Adhaka, a wooden container with a paddy rice capacity of around 3.5 kg, is mentioned by Parashara. The grain was kept in an area free of rodents, termites, and other pests. "Grain and other crops shall be collected as often as they are harvested crops," the Arthasastra of Kautilya declares. When harvested, the crop must be piled high or arranged into turrets. The crop stacks must not be maintained close together. The threshing floors of several fields must be near together. Always beat the stalks on the ground or have the bullock’s step on them while you work in the fields to water them. Cleared paddy was gathered, measured, and properly stored. Millet heads were plucked using sickles and swords. Buffaloes were trained to stomp for threshing, or men would thresh the ears with their feed. Sicks were used to thresh the black gramme. Women made significant contributions to cleaning and threshing. The term "ambanam" refers to a typical grain-measuring container [3], [4].

Gardening in Ancient and Medieval Period

In ancient times, gardens were a crucial component of home and community layout. Excavations at Harappa have shown that there was date palm, pomegranate, lemon, melon, and perhaps coconut trees in the area. The Ficus religiosa L., Acacia catechu wild, Dalbergia sisoo Roxb., Bombax malabaricum DC, and Palasa (Butea frondosa Roxb.) are only a few of the trees mentioned in the Rigveda. It seems sense that the Aryans of the Vedic era loved nature. They gave flowers the name sumansa, which means "that which pleases the mind," revealing their taste in aesthetics. Their gardens and very skilled gardening were reflections of these ideals. More than 30 different tree species are listed in the Artha Sastra as being common in woods, and all edible fruit trees are noted. Ashoka, an emperor from 274 to 237 B.C., promoted arboriculture.

Plantain, mango, jackfruit, and grape trees were all frequently cultivated fruit plants. Jackfruit, coconut, date palm, arecanut, plantain, and tamarind are all mentioned in the Sangam literature. Numerous trees are mentioned in Agrnipurna, which also has a distinct PART on horticulture that served as the foundation for subsequent treatises. In his Brhat-Samhita, Varahimihira composed a PART on "tree treatment." One of the writings of Varahimihira that stands out is the detailed discussion of how to graft plants like jackfruit, plantains, jambu (Black plum), Kapittaha (Limnoia acidissima L.), lemons, and pomegranates. What is currently referred to as "wedge grafting" was one of the reported grafting techniques [5], [6].

In following eras, gardens remained a crucial component of the urban environment. "Vrakshayur veda" is named as one of the 64 kalas or skills that were acknowledged in ancient India in Vatsayana's Kamasutra (c. 300–400 A.D.). It involved the development and upkeep of gardens and parks for people's health, pleasure, and leisure. Pleasure gardens (arama), gardens (ujjana), and tanks (vapi) are among the significant elements of a city that are described in Jain canonical writings. Throughout the ancient era, gardens were still seen as a source of pleasure and happiness. Vrkshayurveda, an old scripture, states in its very first verse: "He is certainly a king if his residence has enormous grounds, huge gardens having big pools of water with exquisite lotus blooms over which humming bees hover.

That may be seen as the culmination of all enjoyment, bringing the intellect great pleasure. The issue is covered in some detail in the ancient literature. The Mahabharata gives a description of the recreation areas around Indraprastha. There are 500 gardens around Kapilavastu that were planned for Prince Siddhartha, according to the Buddhist book Lalitavistara. The deity of horticulture in Indra's heaven is the holy Nandanakanan. For themselves, the ancient Indian monarchs created magnificent pleasure gardens. "In the Indian royal palace... in the parks tame peacocks are kept and domesticated pheasants, there are shady groves and pasture grounds planted with trees, while some trees are native to the soil, others are brought from other parts and with their beauty enhance the charm of the landscape," Megasthenes wrote in praise of Chandragupta's palace. Many locations underwent the change from royal to public gardens throughout the early Buddhist era.

Early Buddhist royal gardens included the Venuvana and Ambavana close to Rajagaha, the Mahavana close to Vaishali, the Nigrodharama close to Kapilavastu, and the Jetavana on the outskirts of Sravasti. These gardens were later made public and used as permanent retreats for monks of various orders. As a result, several monasteries developed gardens next to their monastery structures. In the ancient eras mentioned in the canonical text of the Jaina religion, horticulture was extensively established. The canons make reference to a variety of gardens. Arama (garden with canopies as resting places), Sahasramravana (mango grove with a thousand mango trees), Agrodyana (home garden in front of the buildings), Ashokavana (garden with ashoka trees), Gunashila Udyana (ornamental garden), and Jeernodyana are some examples of gardens. These gardens had a variety of trees, bushes, shrubs, and creepers, some of which produced fruit and others flowers. Aramas canopies draped with heavy creepers shielded the gardens from the sun's beams and gave the inhabitants a cool, comfortable environment [7], [8].

A mango grove stretched outside the enclosure, and streams of blue water wound through the parks. According to the Chinese pilgrim Hsieun Tsang, who arrived at the monastic University of Nalanda in 630 A.D., "the temple arose into the mists and the shrine halls stood high above the clouds." We have a description of private gardens linked to a residence in Vatasayan's Kamasutra, which are undoubtedly of the wealthy and luxurious. It states: "Every home should have a vrksavatika or puspavatika, a garden where vegetables, fruit trees, and floral plants may flourish. It should have a well or tank dug out in the centre, no matter how big or tiny. The lady of the house was to be in charge of the garden and daily seed purchases of common culinary vegetables and medicinal herbs were to be made by her. Bowers and grape groves with elevated platforms for relaxation and pleasure were also planned for the area. On a location well protected from the sun by a canopy of greenery, a swing was to be installed. She was to see to it that beds of plants that produce an abundance of flowers were laid out, with a focus on those with sweet fragrances, like the mallika and the navamalika, as well as those "that delight the eye, like the japa with its crimson glory or the kurantaka with its unfading yellow splendour.

Additionally, there must to be rows of bushes like balaka and usirs that produce aromatic leaves or roots. A stretch of water was an almost necessary component of the ancient garden, as it is in all hot climes. The constructed lakes, pools, and stairs that descend to them for swimming make up gardens. According to Kalidas, there was a summer residence erected in a cool location and encircled by fountains on all four sides named Samudragrha in the royal garden. The water machine, variyantra, was a further improvement for cooling the air during the hot season. According to Kalidasa's description, it seems to have been a kind of rotating spray, similar to the one used to irrigate lawns. Narrow drains (kulya) with flowing water from water fountains served as the irrigation system for the garden. The circular ditch (alavala) at the foot of the trees and the flower beds were constantly flooded by water jets from the water wheels. As was said previously, eventually public gardens (nagarupvana) appeared alongside the wealthy's private gardens. They were known as bahirupvana when they were located outside of the town. These were the townspeople's go-to vacation spots for picnics or udyanyatras. A group of well-dressed nagarakas would go to these gardens early in the morning on horses, escorted by ganikas, and followed by servants. They would spend the day there, according to the Kamasutra [9], [10].

Horticulture (udyanavyapara) evolved as a subject and scientific knowledge was applied to the art of arbori-horticulture in ancient India as gardens and parks began to take on a significant role as the background to social life. There is evidence in the post-Vedic literature that demonstrates how botany evolved into a separate science known as Vrkshayurveda, upon which the sciences of medicine (as embodied in the Caraka and Susruta samhitas), agriculture (as embodied in the Krsi Prasara), and horticulture (as embodied in the Upavanavinoda) were based. The Upavanavinoda, a subset of Vrksayurveda, is a small section in Sarngadhara's encyclopaedic work, the Sarangadhara Paddhati of the 13th century, which is a compilation of pertinent information from earlier classical sources. Despite the fact that there have not yet been any treatises on the topic of ancient horticulture as such.

Tree Culture (Vrksayurveda)

Lack of shade on the banks of water reservoirs is not appealing. Gardens should thus be developed around water reservoirs. All types of trees do well on soft soil. Sesamum seeds should first be sown in that soil, and after they sprout blooms, they should be removed. This is the initial step in the land's preparation. The constellations Dhruva, Mrdu, Mula, Visakha, Brhaspati, Sravana, Aswini, and Hasta have been deemed favourable for tree planting by astrologers. The auspicious trees that should be planted first in gardens or buildings are the soap-nut tree, Asoka, Pumnaga, Sirisa, and Pdyangu. The trees that develop from scion covered with mud include the breadfruit tree, Asoka, the plantain, the rose apple, Lakuca, the vine, Pativata, the citron, and Atimuktaka. By gently digging them out from the roots or detaching their stem, they should be planted.

According to their respective quarters, plants that have not yet produced any branches should be transplanted in the winter; those that have produced any branches should be done so at the start of winter (i.e., the dewy season); and those that have produced any trunks should be done so at the start of the rainy season. The roots and branches of the trees are plastered with ghee, usira, sesame, honey, vidanga, milk, and cow dung before being transplanted. The sixteen trees that grow in the damp or marshy soil are the rose apple, Vetasa, Vanira, Kadamba, Udumbara, Atjuna, citron, vine, Lakuca, pomegranate, Vanjula, Natka-rnala, Tilakll, Panasa, Timira, and Amrataka. You should dig a trench that is one cubit broad and twice that deep, then fill it with water. Once it has dried, it should be cooked over a fire before being plastered with a mixture of honey, ghee, and ashes.

After that, dirt blended with ground masas, sesame, and barley should be placed within. After adding the fish broth to the filling, it should be pounded down until it is firm and compact. If the seed is planted into it four fingers deep and fostered with fish broth and gravy, it will quickly spread over the whole bower and develop into a surprising creeper with sparkling leaves. When seeded in a prepared and cleansed soil and fed with water mixed with milk, seeds that have been steeped in milk for ten days, kept in two hast atis of ghee, fumigated with fumes of hog and deer meat, and combined with the fats of fish and hog grow bearing flowers concurrently. Kulattha, Masa, Mudga, sesamum, and barley are used to treat sterility and the cessation of fruit production.

Additionally, growing fruit and flowers benefits from milk that has been cooked and cooled. For the purpose of ensuring that trees, creepers, thickets, and other plants always bear flowers and fruit, two adhakas of the dung from sheep and goats, one adhaka of sesame, one prastha of meal, and a drona of water and beef equal in weight should be given as nourishment. Due to exposure to the cold wind and sun, trees suffer from diseases such leaf scorching, complete leaf withering, branch dryness, and excessive sap exudation. According to scientific studies, the best way to treat them is to first remove the infected area from them before applying the paste. Lack of shade on the banks of water reservoirs is not appealing. Gardens should thus be developed around water reservoirs.

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Vegetable Farming-Floriculture-Perfumes

Rice and other cereals were ranked first in Kashyapa's Krishi-Sukta (800–900 A.D.), followed by pulses and other grains, vegetables including fruits, then creepers and other plants. In order to be planted in the right season, seeds of wheat, legumes, fruits, vegetables, and seasonings like black pepper, cumin, turmeric, etc. must also be kept. The four forms of agriculture recommended by Kashyapa are rice, pulses, vegetables, and creepers and flowers. For the purpose of cooking, farmers should grow luscious plants like turmeric and ginger, both cultivated and wild, as well as Jatika, Rasijatika, Valkika, Vana-vallika, Patolika, egg-plants, Savaka, pumpkin-gourd, Kalata, Kustumburu, Surana, and Sakuta. These are, in the author's view, the main vegetables. Vegetable types vary based on their species, shape, flavour, and colour in various nations. The growers should cultivate vine, Indian spikenard, cardamom, etc. in their own cultivation locations. After mastering the cultivation technique, a Wiseman should cultivate local vegetables on both low-lying and high-lying soil depending on the season and region. The several types of paddy have the top spot among cultivable goods, followed by pulses and vegetables. Ghee, milk, curds, and other dairy products are listed fourth. The whole meal is made up of these four product types. This substance sustains the whole human race and encourages the happiness of all the gods. This was created by Brahma at the start of existence and is what brings food, health, and long life.

The planting of vegetables will undoubtedly result in a great reward in the spring, the summer, and in certain locations, the dewy season. For the purpose of sprouting, sun-dried egg plant, Valli, Jatika, pepper, Savaka, and other seed varieties should be planted in prepared ground. Eggplant, tomato and other seeds that have dried in the sun should be planted in soil that has been amended with cow manure, etc. to promote sprouting. After giving them a standard drink, cover them with a straw-shed. In the depressions where the seeds were planted, sprouts start to develop after three days. The sage farmer should transplant the sprouts in an appropriately prepared field after twenty days, when they have developed strong roots. Watering the roots at that precise moment will help the plants live longer.

In low-lying areas, summer is the best time to grow vegetables, not during the rainy season. It also prospers at other seasons. The bulbs of Sakuta, Surana, and turmeric should also be planted in hollow depressions or a bed of heated soil in a similar way; this will ensure their success. The cultivation of creeping plants is diverse in this manner. On high ground, you may also produce pumpkin-gourds, wild pumpkins, cardamom, spikenard, and agavalli (Piper Betel). The unripe young fruit is tasty and is thus highly recommended when it comes to patolika, egg-plant, Saka (leafy vegetables), and Savaka. He has to produce, care for, and guard the many sakas (pot herbs) that are safe for chewing, sucking, and eating.

The growers must prepare their various fields by digging depressions, etc., then cultivate seasonally in the spring, summer, rains, autumn, dewy season, and winter pot-herbs and other vegetables whose leaves, rinds, flowers, or bulbous roots are (edible and) delicious, nourishing, and health-giving, and reap the rich rewards of their labour. Cardamom, cloves, ginger, arecanut, betel, sugarcane, plantain trees and other life-promoting and beneficial herbs like the long-pepper should be grown in their field beds or on high land (i.e., wet or dry land) as appropriate, seasonally and in accordance with usage, instructions from previous sages and the nature of the soil. In their own land, regardless of its kind, the Brahmanas, Ksatriyas, Vaisyas, Sudras, men of mixed castes, hunters, and warriors (vim) should all make an effort to cultivate (coriander, surana, valli, pumpkin-gourd, and Patolika). According to custom, skilled cultivators oversee all the procedures required for infixing the seeds, clearing out the undesirable growth, and protecting the plants until the time of inflorescence. From these vegetables, leaves, flowers, fruit, unripe fruit, or bulbous roots are harvested for use during the start, middle, or end of the efflorescence, depending on the situation. For the purpose of weighing vegetables, the monarch should also introduce scales made of bronze or brass and balances with a beam.

The monarch should provide whatever assistance is advised for the happiness of his people in every village and every home, as well as for his personal well-being, in accordance with the advice of earlier sages in their treatises about the production of food grains and vegetables, etc., and the acquisition of oils, fabric, etc. He should develop agriculture by controlling planting, cultivation, and other activities according to the time of year, the season, and cold and hot locations. Betel increases personal magnetism (i.e., one's attractiveness), promotes love, brings out physical appeal, strengthens the body, and cures ailments brought on by phlegm vitiation. It also gives a variety of additional benefits. If betel nuts are used in excess, the colour (or passion) is ruined; if lime is used in excess, a terrible odour is produced in the mouth; if betel leaves are added in excess, a nice odour is produced. To vary this sequence is just a farce of betel-chewing at night, when it is advantageous to consume an excessive amount of white areca nut during the day. Betel leaf is fragrantized with kakkola (Luffa echinata), areca nut, the fruit of Levali (Cicca acida), and Jatiphala (Myristica fragrans), which brings on the delight of an amorous scent.

Floriculture in Ancient India

As part of the Mohenjo-daro and Harappa periods (3500-1750 B.C.), many seals, sealing pottery, potsherds, and a few rock paintings portray the sacred nature of trees. The ancient inhabitants of the Indus Valley revered a select group of trees, including the pipal or asvatta (Ficus reliegiosa), neem (Azadirachta indica), katha or khadira (Acacia catechu), and jhand or sami (Prosopis cineraria). The Rigveda (3700–2000 B.C.) has detailed depictions of trees. The Vedas, Arthasasthra, and Brhat Samhita all make reference of methods of plant proliferation by seed and vegetative means as being common. Plants were also used for house decoration and personal adornment. Girls wore jasmine and Michelia champaca flowers in their hair, as well as Siris (Albizzia labbek) flowers in their ears. They created flower garlands of various varieties and used sandal paste from the Santalam book to colour their faces and foreheads. These have been often mentioned by poet Kalidasa in his poems. In his Ritusamhara, Kalidasa provided delightful descriptions of native, lovely trees in India that bloomed at various times of the year. Vatsyana said that all royal palaces and large homes had to have pleasure gardens called Vrksavatika and Pushpavatika.

One of the most stunning trees was the Asoka, also known as Saraca indica, which has crimson flowers. According to legend, Sita was imprisoned by Ravana in an asoka tree forest. The Kadama tree (Anthocephalus cadamba), with its golden-ball-shaped flowers, was another popular tree in those days. It has a strong connection to Lord Sri Krishna's life. In Kalidasa's play (5th century), the climber Madhavilata (Hiptage madhablata) and the sweet-scented shrubs mask-mallow (Hibiscus abelmoschus) and the garland flower (Hedichium coronarium) were often mentioned. a description of the garland flower (Hedichium corononarium), along with several gardens and blooms. Ancient Sanskrit works including the Rig Veda (3000–2000 B.C.), Ramayana (1200–1000 B.C.), and Mahabharata (500 B.C.) include descriptions of flowers and gardens.

Flowers and gardens were also described in early Sanskrit works by Shudraka (100 B.C.), Asvaghosha (100 A.D.), and Sarnghara (1283–1301 A.D.). The holy lotus (Nelumbo mucifera), which was the most significant flower, is often mentioned in Sanskrit literature. The Sun-God was crowned with lotus petals during the Mohenjo-daro era. The Vedas, Brahamanas, Aranyakas, Upanishads, sutras, smritis, Mahakavyas puranas, Buddhist texts (Jataka), and Jain literature (Sutras) are just a few examples of the vast secular literature and texts that have been produced since the rise of the Mauryas in the 4th to 5th century B.C. The Upanishads' sagas describe the Cosmic Tree. In the Ramayana, Mahabharata, Jatakas, Divyavadana, and Jain sutras, Kalpavarska is referenced. Vastu (Ficus benghalensis) was associated with Shiva, asvatha (Ficus religiosa) with Vishnu, lotus with Surya (Sun), and nine leaves of nine trees (navatatrika) with nine various facets of Durga in the Brahaman faith.

Sarangdhara (1300 A.D.) and Vatsyayana (300–400 A.D.) separately discussed the technique of gardening and several types of gardens. Interesting descriptions of four other types of gardens, including pramadodyam, udyan, vrishavatika, and nandanvana, were also provided by Vatsyayana (A.D. 300–400). the study of plant biology. In ancient India, (Vrikshayurveda) on arbori-horticulture and the benefits of gardens and trees was well-known. The Ashokavana or Panchavati, where Sita was imprisoned, is mentioned in the Ramayana. Ashoka trees (Saraca asoca) predominated in this garden. Five trees were cultivated in the Panchavati. On the west, Asvattha (Ficus benghalensis), on the south, amla (Emblica officinalis), and on the south-east, Ashoka (Saraca asoca). The Mahabharata's Sabha-Parva provides a description of the layout of the gardens, parks, and man-made lakes in the city of Indraprastha. It is commonly known that Lord Krishna is associated with the Kadamba tree (Anthocephalus indicus.

CONCLUSION

The study looked at how current technology, such remote sensing and precision agriculture, may improve plant protection methods. Adopting cutting-edge technology may result in more accurate and effective treatment of diseases and pests. Understanding the various plant protection techniques opens up potential for improving sustainable agriculture and lowering crop protection practises' environmental effect. Studying plant protection tec niques may help with crop management, food security, and climate change adaption, among other things. Sustainable practises and integrated pest control may help build robust and effective agricultural systems. In conclusion, further study in this area is necessary to advance our comprehension of plant protection strategies and their effects on sustainable agriculture and food security. While reducing the environmental hazards associated with conventional chemical-intensive procedures, integrating diverse approaches and technologies may result in more resilient and productive agricultural systems. Additionally, encouraging the use of environmentally friendly plant protection techniques may support international efforts to solve environmental problems and guarantee agriculture's long-term survival.

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CHAPTER 10

ROLE OF CATTLE AND OTHER DOMESTIC ANIMALS IN AGRONOMY ASPECTS

Mr.Anurag Rajput, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

Domestic animals contribute significantly to sustainable agriculture and increased agricultural output in a variety of agronomic areas. The purpose of this study paper is to examine the value of domestic animals in agronomy and the many ways in which they contribute to agricultural systems. The research explores how cattle are used to regulate soil fertility by applying manure, their function in integrated farming methods, and their contribution to farm labour. It looks at the role that animal husbandry plays in sustainable agriculture, taking into account things like grazing management and animal welfare. The study also looks at the advantages of combining crop and animal production to promote a robust and all-encompassing agricultural strategy. Promoting efficient resource utilisation, sustainable land use, and rural livelihoods all depend on an understanding of the role that domestic animals play in agronomy. The research also identifies possible uses for this information in agroecology, climate-smart agriculture, and sustainable food systems, providing chances to increase the sustainability and resilience of agriculture.

KEYWORDS:

Agronomic Areas, Animal Welfare, Domestic Animals, Grazing Management.

INTRODUCTION

Since our common domestic animals were domesticated before recorded history, animal rearing predates civilization itself. The Neolithic man domesticated and confined the animals that the Palaeolithic man had hunted for sustenance and clothing. Men began engaged in agriculture, which included rearing domestic animals, in the Neolithic or New Stone Age. The domestication of sheep began around 9000 B.C. in northern Iraq; cattle began around 6 millennia B.C. in northeastern Iran; goats began around 8000 B.C. in central Iran; pigs began around 8000 B.C. in Thailand; asses began around 7000 B.C. in Jarmo, Iraq; and horses began around 4350 B.C. in Ukraine. Prior to the development of agriculture, nomadic man domesticated sheep and goats by bringing them under his control while working with dogs. Early humans' main sources of food were small ruminants like sheep and goats. In his eventful life, this was perhaps the first move towards safe food production. Early humans were wise enough to recognise the differences in the ecological needs of sheep and goats. The sheep is mostly a grass eater and prefers the safety of open forests. The goat prefers the leaves of shrubs and trees as its preferred browsing material and is satisfied in scant woodland [1], [2].

Sheep and goats supplied early man with milk, meat, and clothes. Sheep outperformed goats in terms of fleece and meat quality, but goats offered more milk. From the beginning of human civilization, animals including horses, elephants, camels, sheep, goats, bullocks, cows, and buffaloes were crucial. Invading the fields of the river valley civilization as crop thieves were the huge ruminants, such as cows and buffaloes, which were wild creatures of the forest. For power (energy), sustenance (milk and meat), manure (dung and urine), and hide (shoes and shields), the early mankind assessed the usefulness of these animals. Therefore, in order to provide for their daily necessities, these crop thieves were trapped and tamed [3], [4].

Livestock in Agriculture

When Prajapati formed cattle, he gave them to the Vaisya; if a Vaisya wants to retain them, no one from another caste may take them. In the Manu Samhita. Vaisyas were largely farmers who bred good breeds of cattle and made up a rich and respected segment of the population. The four-fold vartha, or activities appropriate for wealth, were agriculture, cattle raising, trade, and commerce.

The Ramayana and the Mahabharata both mention cattle husbandry as being a significant and common activity. The Mahabharata describes the legendary cow "Kamdhenu" (producing as desired) of Bashistha. The seven wild animals (aranyah) mentioned in the Mahabharata are the lion, tiger, boar, buffalo, elephant, bear, and ape; domestic animals include cows, goats, sheep, horses, mules, and asses. Boar, buffalo, and elephants are raised within the former group.

Cattle were owned and raised by the kings themselves, the Ksatriyas, and cattle riches served as the principal source of income for their households. The prince of Kasi in the Jataka or the monarch of Kosala in the Ramayana are two such instances. In addition to horses, elephants, cows, sheep, and goats, the monarchs also kept buffaloes, camels, asses, mules, pigs, and dogs for a variety of purposes (Arthasastra).

The high bred Brahmin in the Dhumakari Jatakti is a goat herder. The Jataka mentions setthis, or merchants, who kept cattle. The practise of weaving is said to have evolved gradually from the practise of producing baskets out of bamboo, which was a forest resource. Sheep's wool was the material, and it was woven into carpets and textiles for clothing. The domestication of sheep by the 'Gandhars' in India's northeast and their good quality fleece are both mentioned in the Rigveda.

Being largely pastoralists, the Vedic Aryans grazed their livestock in the woodlands. At the time of establishing settlements, the Kings were compelled to set aside adequate territory to serve as abundant pastures. The Arthashastra makes reference to the guidelines for animal breeding. It has also specified what graziers must do. The graziers were instructed to put bells around the necks of their livestock to frighten off tigers and snakes. The graziers were able to find the herd's whereabouts thanks to the bell's ring. The cow was the main source of wealth and a symbol of the Aryans, and most conflicts were waged to get cows. Three times a day the cows were milked, and the bull was castrated [5], [6].

The Zebu bull served as the emblem of the Gupta dynasty (240 B.C.). The 'Nandi bull', a humped Zebu, was depicted on coins during the Gupta era. The most significant contribution made by humans to the advancement of agriculture was the improvement of Zebu cattle. Zebu's predilection for dry terrain and its allergy to water point to its genesis in the arid climate of the mountains. The buffalo also had a significant economic impact on ancient India. The female buffalo produced a lot of milk, and the male buffalo was perfect for transportation and for ploughing in the muddy rice fields during the Mauryan era.

The Indus valley was one of the hubs for domesticating buffalo in India. In India, buffalo are prized for their increased milk production and higher milk fat content, which are ideal for making ghee (butter-oil). Ghee is a crucial part of the diet and is often utilised for religious occasions. Large portions of the nation were pastoral during the Mughal era, and raising sheep was a thriving industry for many people. Emperor Akbar (1555–1605) encouraged the wool industry, especially that which produced "Shawls" and carpets. 'TUS' shawls were renowned for their tenderness, warmth, and lightness.

Sacredness of Animals

The cow is the dominant quadruped, much as the Brahmana is the top caste among the four castes. Bull deification is said to make bulls Siva's animal. The Siva is shown with his bull on the coins of the Kusana and Scytho-Sassanian monarchs as well as on one issued by Sasanka, the king of Gauda. But a bull-emblem of Siva with the tale is only encountered for the first time and as recently as on a coin of the Huna Mihiragula. the words "Jayatu vrsah" on the back. It is best to read the stories of the Ramayana and Mahabharata with the atrocities against cows in mind. Cows have been described as a symbol for the sun's rays hitting Earth or the Goddess of communication. The earth is seen as having the shape of a cow in the Matsya Purana. Brahma, Kesava (Lord Visnu), and Siva make up the trio of gods that live continuously at the root, centre, and end of the (cow's) horn, respectively. All of the sacred locations, figures, and gods are included inside the body of the (cow's) horn.

Therefore, the cow is the essential essence of all the gods. She has the goddess (Parvati) at the top of her forehead, the deity Kartikeya in her nostrils, and the two Naga (serpent) chiefs Kambala and Asvatara in her ears. The deity Varuna is seated in that heavenly Surabhi's tongue, together with the sun, moon, and eight Vasus in her teeth. The Sarasvati lives in her lower portion, as do Yama and Yaksa (Kubera), the Risis (sages), in her pores, and the Ganges water in her urine. Along with other goddesses, the Yamuna lives in her excrement. There are 28 crores of gods in the earth.

Dairying in Ancient India

The cow is referred to as the "mother" in Indian mythology, and its whole body is said to be the permanent residence of many Gods and Goddesses. Cow is "Ambrosia" in the shape of ghee and is the mother of Rudras, Vasus's daughter, and Aditi's sons. In order to identify the cows, Lord Krishna used to call them by name. There are three titles in the Garg Samhita (Golok Khand) that used to be given to those who had cowherds: Brakh Bhanu, the person who raised 10 lakh (one million) cows; Nand, the person who raised 9 lakh cows; and Upnand, the person who raised 5 lakh cows. The Mahabharata has enough information on how milk is processed and transformed into various products, including curd, butter, and ghee, which were made in every home. Even today, many people still use the traditional method of heating (simmering) milk, which involves slowly heating for a prolonged period of time over dried cow dung cakes. Westerners may be aware of they should milk the cattle twice once in the morning and once in the evening during the rainy, autumnal, and dewy seasons. However, throughout the winter, spring, and summer, they should only milk the cattle once in the morning. The punishment for a second milking of the cow during these seasons is to have one's thumb amputated. He will not get payment for the milking time if he allows it to pass. The same amount of buffalo milk will give one-fifth more ghee than a cow's milk "drona," while goat and sheep milk will produce two-fifths more ghee than a cow's milk "drona."

DISCUSSION

Therapeutic Aspects in Dairy

'7-fold doshas' have been treated with human milk. While the milk of fair-skinned women is used to heal the three doshas, the milk of black-skinned women is said to be effective in treating eye disorders. In general, cow milk is a source of strength. The milk of black cows heals kafa (lung infections), whereas the milk of white cows treats "Vaat" (rheumatic and cardiac ailments). No other kind of milk comes close to the therapeutic properties of black teat milk. Similar references to the therapeutic benefits of cow milk may be found throughout the Rigveda and Atharvaveda [7], [8].

Ten characteristics of cow milk tasty, cooling, soft, oily, thick, mild, viscous, bulky, resistant to external impacts, and having a nice flavor have been recorded in the ancient medicinal text Charak Samhita. Additionally, the qualities and features of the morning cow milk (pratardoha), noon cow milk (saganv), and evening cow milk (samandoha) change. This method of analysis is described as follows in the ancient text "Bhava Prakash": At-noon milk offers vigour and eradicates cough and liver problems while promoting appetite. Milk before noon is palatable, digestive, and improves the quality of semen. It promotes development in children, avoids withering away in the elderly, and increases sperm production when used regularly at night. Milk may thus be drunk at any time. Cow milk and dahi (curd) are said to have flavour, taste, digestion, strength-giving, restorative, pure and pleasant, and anti-rheumatic characteristics according to the Susruta Samhita.

Removes the negative effects of snake venom when given with an equal mixture of cow curd, rock salt, rock honey, butter, peepal, dried ginger, black pepper, and other seasonings. In addition to giving vitality and stamina, the malai (thin accumulation on heated milk surface) of milk has long been recognised to have a powerful potential to totally cure illnesses linked to pitta and vaat (rheumatic and liver disorders) imbalances. According to ancient writings, cows have a nerve in their spines called the suryaketu that, when exposed to sunlight, produces gold, giving the milk anti-poisonous powers. The qualities of this cow ghee are unparalleled. The three doshas (imbalance of humours) are all cured, poisons are inactivated, and vision is improved.

Animal Management

In the post-Vedic period, drugs had a respectable standing, and from about 700 B.C., Charaka and Shusruta Samhitas were followed. Material medicine was being developed at the time. The Agni Purana, which paints a true picture of veterinary medicine usage throughout the Gupta period (300-500 A.D.), is the sole source of information on the use of indigenous pharmaceuticals in veterinary medicine. The name "Ayurveda" refers to the traditional Indian medical system (also known as "Gavyayurveda" for cattle, "Hastyayurveda" for elephants, and "Ashvayurveda" for horses). The "Ashvayurveda" or "Turangama shatra" was the topic of a lecture by Shalihotra on the subject of horses and their care. The handling of horses is also discussed in the Garuda Purana. Ashvavit, which means knowledgeable about horses, was the surname of King Nala. Drona instructed Madri's twin sons Nakula and Sahadeva in the care, management, and training of horses and cattle, respectively.

When the Pandavas joined King Virata's service in the Mahabharata's Virata Parva, third PART, Nakula boasted of his expertise in the science of managing and caring for horses, while Sahadeva mentioned his expertise in caring for cows. The still-existent Ashvachikitsa or "Treatment of diseases of the horse" work is credited to Nakula. The title of this book is also "Shalihotra". The fifth Pandava, Sahadeva, claims to be an expert in the science of cow husbandry and care in the Mahabharata's Virata Parva (PART III). Additionally, he claims to be familiar with cows and bulls whose urine may cause pregnancy in barren women (Mahabharata, Virat III.12). It's important to look at if any hormones may be present in cow pee. The Nakula Samhita, which was written during the Mahabharata era, is regarded as the earliest book on the topic of treating animals using herbal remedies. Early mediaeval times saw the usage of medicinal substances made from minerals, plants, and animals.

Jayadatta quotes Jayadeva, who also wrote on how to care horses. Shalatur, a town close to Kandhar or ancient Gandhara, was a thriving centre for Shalihotra, the father of veterinary science in India. He is referred to as Susruta's father in an unfinished manuscript of Shalihotra located in the India Office Library in London. Gahayurveda, also known as Hastyayurveda, is a significant subspecialty in veterinary medicine. Palakapya's Hastyayurveda, which was published in Poona's Anandashran Sanskrit Series in 1894, is the science's primary source. Samhita Susruta. Therefore, it is reasonable to believe that this work likewise dates to 1000 B.C.

In his Artha-sastra, Chandragupta Maurya's (325–260 B.C.) prime minister Kautilya makes reference to the responsibility of military doctors to cure and safeguard army horses and elephants from illnesses, epidemics, and food shortages. The dog and the camel stand out in royal stables and kennels (the Ramayana often makes reference to pets in royal households). There are no ducks among household animals. Sheep, goats, cows, and buffaloes were raised for milk production, as well as for their flesh and skin. The only purpose of swine and poultry was for human consumption. Only the ox pulled the plough. Draught animals included bulls, mules, asses, and camels, with horses and elephants being utilised on rare occasions (Arthasastra). In the Arthasastra, dogs helped herders locate grazing woodlands. In the Dasabrahmana Jataka, dogs defend royal residences or go on hunting expeditions with the monarch or nomadic hunters. For draught riding and combat, the horse and elephant were used in accordance with their various personalities. According to the Mahabharata, animals used for draught were often castrated and sometimes had their horns removed. The animals, both domestic and wild, produced a wide range of animal products, including skin, claw, horn, hoof, plume, tusk, wool, etc [9].

Every villager used to maintain a few animals as well, either for draught, for work, or to supply his own home. To take the animals to the pasture in the morning and bring them back in the evening, the community employed ordinary shepherds who were paid a wage or received a portion of the harvest (Anguttaranikaya; Rigveda). The Arthasastra law mandates that herdsmen have the medical expertise necessary to diagnose and safely cross cow ailments. The finest herd can only be trusted for a certain salary, according to the Arthasastra, since else they risk spoiling from over milking. Next-grade herds are given up in exchange for the owner receiving a certain quantity of dairy products, or 8 varakas of ghee annually. Bulls that are black, red, or black and red are praised for yoking to the plough.

Protection of Cattle

People in ancient India were sufficiently knowledgeable about farm animal ailments and their treatments. The Vishnudharmottara Mahapurana, which was written between 500 and 700 A.D., offers details on the medicinal procedures used to heal ill animals. Animals' food is dipped in their urine to prevent the spread of food and mouth sickness. feeding ground neem leaves for internal parasites, dipping the tail with hot water, or using powdered camphor to treat tail neurosis. For anoestrus, etc., feed sprouted whole wheat constantly for 10 to 15 days.

1. **Mastitis:** Pathogens invade the udder after it has been injured, leading to mastitis. The udder gets stiff and irritated. When a tumour forms in the teats, the animal may experience excruciating discomfort when milking and refuse to cooperate. Three practises are primarily used by cattle owners to treat this illness. They can put milk froth around the teat or a combination of ghee, sugar, and curd on the irritated area. According to experts, both of these procedures are successful because the chemicals utilised serve as soothers and soften the hard, cracked teat. Giving the afflicted animal

a hot bath is another method. This improves blood circulation while lowering edoema, discomfort, and inflammation.

2. **Foot-and-mouth disease:** Caused by a virus, foot-and-mouth is an acute infectious illness that may strike animals at any time of the year. High temperature, sluggishness, smacking of the lips, sudden decreases in milk production, and miscarriages are some of this disease's typical symptoms. The owners of animals use a variety of methods to cure this sickness. They use fitkari (alum) to wash the damaged area. By suppressing microorganisms, alum functions as an antiseptic and prevents subsequent infection. It works as an astringent and aids in blood clotting. Since pee has a germicidal effect, it is sometimes used to wash an animal's feet. It is another common practise to apply ground custard apple leaves or sprinkle camphor powder on the afflicted region. Both have an anti-inflammatory and calming effect in addition to acting as a fly repellent. The owners of animals may sometimes warm garlic cloves in hot mustard oil and then apply the oil to the afflicted region after it has cooled. According to scientists, its strong scent serves as a fly-repellent. Additionally, it serves as a disinfectant and antiseptic. Another technique is to use hot water to bathe the injured region since it contains cauterising properties that may help stop bleeding.
3. **Tail Neurosis:** To cure tail neurosis, either submerge the animal's tail in hot mustard oil or cover the afflicted region with powdered camphor. Both of these methods are legitimate according to science since camphor works as a fly repellent and hot mustard oil works as an irritant, antiseptic, fly repellent, and aid in quick healing.
4. **Pneumonia:** The villagers' traditional method of treating pneumonia involves dousing the sick animal with local liquor three to four times a day and applying mustard oil to its chest. A spike in body temperature and shivering are signs of the condition. Both of these techniques aid in removing cold from the body by warming the body. The animal is also forced to breathe in turpentine or eucalyptus oil. The oil may be inhaled to help with breathing.
5. **Anoestrus:** Anoestrus is a reproductive condition in which an animal does not have a normal heat cycle, i.e., either does not come into heat at all or heats up continually, extending the time between calvings. It could be brought on by a hormonal imbalance, poor nutrition, a chronic corpus luteum, an ovarian cyst, or another factor that interferes with the correct ovulation and heat cycle. Animals are given a blend of methi (Trigonellafoenum graceum), gur (gaggery), and bajra (pearl millet), which are the two major practises that livestock owners use to treat this condition. These drugs have stimulant properties and aid in boosting oestrogen levels. Additionally, sprouted whole wheat is regularly given for 10 to 15 days. The sprouts' high vitamin and mineral content aids in boosting fertility.
6. **Retained placenta:** Villagers follow an indigenous custom in which the placenta is manually dropped with the assistance of knowledgeable individuals. Scientists assert that if the placenta does not fall within 48 hours, it must be manually dropped. The feeding of the animal's own milk is another method.

Calcium and other vitamins are abundant in animal milk. It aids in preserving uterine tone, which aids in placenta retention. Some of the peasants utilise ten mangoes (Mangifera indica), leaves, and two pieces of jaiphal and kaiphal (Myrica fragrans and Myrica magi, respectively). All of these ingredients are combined to create a paste, which is then gently cooked. The heated mixture is then rubbed into the injured animal's thigh and surrounding vaginal region. After application, the placenta leaves the uterus after an hour. Mango leaves are believed by experts to offer laxative and antihemorrhagic effects. For the placenta to be removed, both qualities are necessary. Farmers remove the placenta with kaiphal, an antiseptic, in situations when the presence of infectious organisms is a given. Jaiphal functions as a narcotic and febrifuge.

Use of Animals Flesh as Human Food

With the growth of agriculture, India fully realised the benefits of cattle for power, food, and manure. Bullocks replaced the old practise of animal sacrifice as man's animal companion in the conquering of uncharted countries after Buddhism's influence. Indian farmers treat their cattle with respect on several dates throughout the year and see them as members of their own social group. The Mababharata makes an exception in support of sacrifice and hunting for the royal race after extolling the merits of ahimsa and abstaining from a meat-based diet. Buddha himself permits meat and fish to his followers. Whatever truth there may be in Strabo's assertion that the Brahmanas "eat flesh but not that of animals employed in labour," based on Megasthenes' authority, the statement at least indicates solid economic judgement, which in certain circles restricted animal eating. Under penalty of fine, only at the abattoir (parisunam) may animals be killed for their flesh. Different stockists and butchers, such as the cattle-butcher, sheep-butcher, pig-sticker, fowler, deer-stalker, etc., throved on the many types of animal meat that were also dealt of from distinct booths in the market area.

The Arthasastra only wants calves, milch cows, and stud bulls to be immune when it comes to its regulations on cow slaughter. The Satapatha Brahmana mentions that Yajnavalkya like delicate meat. Because a cow is sacrificed for him, 'goghna' according to Panini implies a 'guest'. When a visitor is welcomed, the manes are worshipped, and a wedding is being celebrated, Apastamba approves the killing of a cow (Grhyasutra; Manu). According to Bhavabhuti's Uttararamacarita, Valmiki killed a calf to mark Vasistha's visit to his asrama. The Dasabrahmana Jataka claims that ox slaughter for human consumption was widespread and that there were particular slaughterhouses for beef. Even cows did not always qualify as an exception.

Elephant, horse, dog, and snake appear on a list of unappealing and inedible foods to which the populace only succumbed in times of hunger. Cows, pigs, and fowl are never included on the list of creatures and birds that are off limits, not even for the Brahmana's meal. Ham and beef are considered to be inedibles. The Mahabharata describes high-crested cocks (sikhandah), which are the offspring of Vrtra, as being unpalatable to the twice-born and the initiated. The entire list of animals that the Snataka Brahmana are not allowed to own is found in Gaut. XXIII. 5 and Manu. In the Ramayana, it is wrong to slaughter cows and milk cows that have recently given birth.

CONCLUSION

The study looked at the role that animal husbandry plays in sustainable agriculture. Sustainable land usage and environmental preservation are aided by good grazing management and animal care procedures. Being aware of the advantages of incorporating livestock into agronomy promotes resource efficiency, resilience, and rural livelihoods. Domestic animal research in agronomy has the potential to advance agroecology, climate-smart agriculture, and sustainable food systems. Adopting sustainable livestock management techniques may increase agricultural resilience to environmental problems and sustainability. In conclusion, further study in this area is necessary to advance our comprehension of domestic animals' functions in agronomy and their implications for rural and sustainable development. The effective use of resources, the health of the land, and the viability of the agricultural system may all be improved by integrating livestock. Furthermore, putting animal welfare and sustainable animal husbandry practises first might result in agricultural practises that are moral and kind to the environment. Opportunities exist to improve agricultural sustainability, food security, and rural livelihoods by highlighting the importance of domestic animals in agronomy.

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CHAPTER 11

DESCRIPTION OF INDIAN CIVILIZATION AND AGRICULTURE

Mr.Bishal Kumar Mishra, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

Since ancient times, agriculture has played a significant role in developing Indian civilisation, including its culture, economics, and social structure. This study seeks to investigate the crucial connection between Indian civilisation and agriculture, charting its historical progression and effects on the identity of the country. The research explores the prehistoric agricultural techniques and knowledge systems that have permeated Indian society since the Indus Valley Civilization. It examines the variety of crops grown across India, which reflects the country's diverse climatic conditions and agro-ecological zones. The study also looks at how agriculture contributes to food security in a country with a high population density and to the livelihoods of a sizable rural population. To appreciate the tenacity of India's agricultural traditions and the continuing difficulties of sustainability and modernisation, it is essential to comprehend the strong relationship between Indian civilisation and agriculture. The research also emphasises how this information may be used to promote sustainable agricultural methods, preserve traditional knowledge, and solve current agricultural problems.

KEYWORDS:

Agriculture, Ancient Practices, Crop Diversity, Indian Civilization, Sustainable Agriculture.

INTRODUCTION

According to Allchins, who relied on Lambrick, who they said had firsthand knowledge of Sind, crops were farmed in the Indus River valley as follows. The main food grains wheat and barley would have been cultivated as spring (rabi) crops, which means they would have been seeded near the end of the inundation on land that had been flooded by spill from the river or one of its natural flood channels and harvested in March or April. Such land does not, in current use, need to be ploughed, fertilised, or given extra water. "The whole operation involves an absolute minimum of skill, labour, and aid of implements," says Lambrick. Other crops, like as cotton and sesame, would be planted during the autumnal (kharif) season, meaning they would be planted at the start of the inundation and harvested in the fall. The most likely location for these fields would be along the banks of natural river channels, encircled by earth embankments. Both methods take use of the alluvium's inherent fertility and the yearly flood, however this one is riskier than the first. Both systems are still operational. My knowledge of farming in the Punjabi river valleys indicates that when the soil has the right amount of moisture, it is ploughed, seeds are sowed, and the soil is smoothed with a plank [1], [2].

There was no way the Harappans' way of life could have been different. Soil must be churned and seed must be coated for successful crop seeding. The "Indica of Megasthenes" analyses the Greek description of India and sets the setting for the history of Greek presence in India with Alexander, his successors, and Megasthenes. The diplomat to Chandragupta Maurya was Seleucus. The history of the Greek kingdoms, northern India, and the growth of Indian Ocean commerce are all covered in the book. The heart of the book two very thorough PARTS that examine Greek knowledge of India is tucked between these two historical parts. The first focuses on India's physical geography, including its hydrology and meteorology, while the second examines the natural history of the continent, including its biology and geology, as well as the consequences for the military, economy, and even medicine. According to Megasthenes, Mauryan officials were responsible for monitoring and measuring alluvial deposits in order to maximise income [3], [4].

When discussing the main agricultural products of the region, Greek authors greatly commended the fertility of Indian soil as well as the suitable temperature and inner-system. Due to the double rainfall that occurs throughout the course of each year one during the winter, when wheat is sown as in other nations, and the second during the summer solstice, when rice and "bosporum," as well as sesame and millets, are best sown Indians typically reap two harvests each year (Diodorus, II. 36). The Greek authors claim that India receives two harvests every year, with wheat being sown during the early winter rains and rice, "bosporum," sesame, and millets being sown at the summer solstice (Diodorus, II, 36). Megasthenes continues by adding "wheat, barley, pulse and other esculent fruits unknown to us" to the list of winter crops.

Streams of blue water meandered through the parks, green lotus blooms shone amid the petals of sandal trees, and a mango grove stretched beyond the fence. The temple climbed into the mists, and the shrine halls loomed high above the skies. According to Hyams, a reliable twelfth-century text on agriculture and horticulture authored by Yahya bin Muhammad (Abu Zakariya) may be used to learn what the Arab gardeners believed to be good planting guidelines and some of the garden species that they preferred. According to Abu Zakariya, all garden doors should be covered with cut evergreens, and cypress trees should be utilised to line walks and clustered to designate path intersections. He saw a barrier between evergreen and deciduous trees. He saw water evaporate, losing its moisture. The plants and shrubs mentioned in his book include lemon and orange trees, pines and the majority of our typical deciduous trees, as well as violets, lavender, balm, mint, thyme, marjoram, iris, mallow, box, and bay laurel. The only blooming shrubs are cypresses, oleander, myrtle, and rose. He places a lot of emphasis on aromatics, as did other Islamic gardeners. Vine, jasmine, and ivy are some of his climbing plants.

Babur-NAMA: A Natural History Book and Autobiography: Babur-nama is a reflection of Zehir-ud-din Muhammad Babur's personality and hobbies. One of the most romantic and fascinating historical figures in Asia is Babur, who established the Mughal empire in India.Early in the eleventh century, a scholar from Central Asia named Alberuni (Abu Raihan Muhammed bin Ahmed) travelled to northern India and made an astounding discovery on the composition and origin of the Indo-Gangetic alluvium. "If you have seen the soil of India with your own eyes and meditate on its nature, if you consider the rounded stones found in the earth, however deeply you dig, stones that are smaller in size at greater distances from the mountains and where the streams flow more slowly, stones that appear pulverised in the shape of sand where the streams begin to stagnate near their mouths and near the sea, if you consider all this, you could scarcely help think," wrote Alberuni [5], [6].

Sher Shah really cared about the welfare of the rural population and the security of their harvests. Says Abbas Khan One of the rules Sher Shah established was that his victorious standards would not harm the crops grown by the populace. He personally inspected the state of each crop before marching through it and stationed horsemen around it to deter trespassing. According to Khan-i-Azam Muzaffar Khan, who claimed to often travel with Sher Shah, he used to gaze out right and left, and (God forbid) if he saw any guy harming a field, he would slash his ears with his neck and have him paraded around the camp. And if any farming was inevitably damaged due to the road's narrowness, the farming would get financial compensation. If he enters an enemy's nation, he did not enslave, loot, or damage the peasantry's agriculture. Because the farmers are innocent and obey the authorities, he said, if I persecute them they will flee their villages, the nation would be destroyed and left in ruins, and it will take a long time for it to recover its prosperity.

The findings of the European travellers who visited India in the seventeenth century provide trustworthy data about the peasants and their circumstances. According to Peter Mundy, the peasants surrounding Agra were treated "as Turks treat Christians," taking whatever they could earn through work and leaving them with little more than their shoddy, mud-walled, improperly thatched homes and a few animals to plough the land, among other calamities [7], [8].

DISCUSSION

All India Coordinated Research Projects (AICRP)

The All India Coordinated Research Projects (AICRPs) originated from the coordinated project on maize developed with the Rockefeller Foundation's help in 1957. ICAR currently has about 70 AICRPs covering various disciplines and commodity crops, livestock, fisheries, home science, and agricultural engineering. An AICRP permits the efficient use of resources, both human and material, anywhere in the nation to address some of the major national issues. The Indian Council of Agricultural Research is an independent top organisation in charge of organising and managing research and instruction across all agricultural sciences fields. It has undergone two restructurings. The Government of India formed the M.W. Parker Committee in 1963 to conduct an investigation of the current structure and provide recommendations for improvements to the ICAR. In 1964, the Committee turned in its report.

The ICAR's regulations and bylaws were updated in accordance with the committee's recommendations, and it became an independent entity. The Director General (DG) is a scientist. Four Deputy Director General (DDG) positions in the fields of crop science, soils, agronomy, irrigation and agricultural engineering, animal sciences, and agricultural education were formed to support the DG. Both the Central Soil Salinity Research Institute in Karnal and the Institute of Horticultural Research in Hassarghata were established. Research Institutes were operating under the ICAR at the time (25 in agricultural, 7 in veterinary, animal husbandry, and fisheries, and one in statistics). The ICAR assumed control of the nation's agricultural research coordination in 1965. The numerous institutions and commodities research institutes came under its administrative jurisdiction.

The first scientist to serve as Vice President of ICAR was the late Dr. B.P. Pal. For an efficient national grid of coordinated experiments, Dr. Pal established the AllIndia Coordinated Research Projects on diverse crops to combine numerous academic fields and institutes and universities. He has received praise from all across the world for this work. Dr. M.S. Swaminathan, the first Director-General and Secretary of the Government of India, and Dr. Pal's successor established the Agricultural Research Service (ARS) in 1973. To allow scientists to transfer to other institutions within the system or sister organisations such as the CSIR, BARC, etc., ICAR began the National Agricultural Research Project (Phase I) in 1983-94. In 1992, NARP Phase II came to an end. In 1964, the Intensive Agricultural Area Programme (IAAP) was launched. High Yielding Variety Programme (HYVP) was launched in 1966–1967 for crops such rice, wheat, maize, jowar, and bajra. The Education Commission (1964–1966) made suggestions that led to the establishment of the Krishi Vigyan Kendras (KVKs) and Trainers' Training Centres (TTCs). The ICAR started the Lab to Land Programme in 1979 to spread and encourage the use of innovative technology among small and marginal farmers and agricultural labourers in order to assess the applicability of Technology under their socio-economic circumstances.

ICAR Institutes

32 research institutions in the domains of agriculture, animal sciences, and fisheries are under the direct management of the ICAR. While some of them operate on a variety of crops, others are institutions focused on a particular commodity crop. The three national institutes that are responsible for both post-graduate research and teaching are the Indian Agricultural Research Institute (IARI), New Delhi, the Indian Veterinary Research Institute (IVRI), Izatnagar, and the National Dairy Research Institute (NDRI), Karnal. Only the IARI, however, has the designation of a considered university, allowing it to provide its own post-graduate degrees in the subject of agriculture. This role is carried out by NDRI and IVRI thanks to their association with other institutions. The National Academy of Agricultural Management was recently established in Hyderabad as a constituent entity of the Council, marking an important milestone in the development of institutions. This Academy would be in charge of offering top-notch instruction to different categories of staff members engaged in agricultural research around the nation. Another significant milestone in the ICAR's history of research administration is the establishment of the Agricultural Research Service (ARS), which began on October 1, 1975.

Vision for Agriculture in 2020

Every nation requires a vision statement that sparks the mind and inspires all facets of society to exert more effort. Building a political consensus on a broad national development strategy, which includes, among other things, the functions and duties of various economic agents like the federal, state, and local governments, the private corporate sector, the small and tiny sector, people's organisations, etc., is a crucial first step. In order to concentrate efforts, it must identify potential hazards, bottlenecks, and their potential remedies. It follows that a vision statement must function at various degrees of generality and detail in order to achieve these goals. A vision is an image of what is desirable or feasible in a more distant future. It can have been created by a group of people or come from the mind of just one person.

In his 2003 speech to the joint session of Parliament, President A.P.J. Abdul Kalam urged the populace to work towards the objective of making India a developed nation by 2020. This vision reflects the increased self-assurance of our people, which is a result of India's outstanding accomplishments in a variety of disciplines. It also reflects the higher aspirations of our people at the start of the new century, when they wanted India to no longer be considered a developing nation, much less a country in poverty. Nearly 260 million individuals who live in poverty wish to participate in modern development. Our people are eager to attain universal suffrage, wealth via knowledge-driven production, a higher standard of living, and all of these things enhanced by our value system. It is thus time for India to introduce a new vision, which I would refer to as "Vision-2020."

They should focus on the two maxims of Effective Implementation with People's Participation and Effective Communication for People's Participation in order to accomplish this. "Providing Urban Amenities in Rural Areas (PURA)" will be a crucial component of "Vision 2020". India has a population of almost two thirds that reside in rural regions. We must launch a massive mission for their empowerment in order to give their overall growth a fresh impetus. India's bio-resources, which are abundant and diverse, are a significant gift from nature to humankind. The passage of the Biological Diversity Bill 2002 during the Winter Session was a significant step in India's commitment to bioresource conservation and sustainable use. In all of the 1.73 lakh communities on the periphery of the forested regions, a massive afforestation effort with public involvement has been begun, creating Joint Forest Management Committees. The National River Conservation Plan's scope has been greatly expanded to now include projects in 155 municipalities along contaminated sections of 29 rivers spanning throughout 17 States.

The Eighth Conference of Parties to the United Nations Framework Convention on Climate Change was successfully hosted by India in New Delhi last year. The Delhi Declaration's successful acceptance contributed to increasing public awareness of the dangers surrounding climate change in developing nations. India applauds the World Summit on Sustainable Development's acceptance of the Plan of Action. The summit was held in Johannesburg last year. The nation of India's first weather satellite was successfully launched. The INSAT system, one of the biggest domestic communication satellite systems in Asia, will gain additional capacity with the upcoming launches of satellites in the INSAT-3 series. EDUSAT, a dedicated satellite for education, is also in the works. To provide medical services to rural places, ISRO has taken up the challenge of telemedicine connection. For our resource assessment and management, the Indian Remote Sensing Satellites continue to offer invaluable data. Recently, groundwater prospect maps for six States were made available to aid in locating locations for bore well drilling.

The nation has been looking for a long-term solution to the issue of droughts and floods, which keep happening and have a devastating effect on both human life and the economy. People have been interested in connecting our river systems to transport water from surplus basins to those of shortfall for many years. To create a workable plan for this project without sacrificing environmental safety or the interests of displaced people, the government has formed a Task Force. Significant advantages in drinking water, agriculture, electricity production, inland navigation, and tourism will result from this endeavour. I must stress that the need of promoting small and micro water conservation initiatives at local levels does not go away because of this large-scale effort. Both are beneficial to one another. A new national water policy that emphasises integrated water resources development and management for the best and most sustainable use of available surface and groundwater has been approved by the National Water Resources Council.

For the construction of those large and medium-sized irrigation works that can be finished in one year, the Centre has started a Fast Track Programme. The Narmada Control Authority's clearance led to the dam height being increased, which has helped to alleviate the parched regions of Saurashtra and North Gujarat's drinking water and irrigation problems. Huge inventories of rice and wheat are being held by government organisations as a consequence of the policy of purchase at the Minimum Support Price, which also ensures fair pricing for wheat and rice producers in surplus States. The government has been promoting the export of food grains in response to this. The High Level Committee's extensive proposals for long-term food management are being looked at. The existing policies, which have prevented crop diversification and resulted in unsustainable food subsidies, urgently need to be reviewed in order to provide crop neutral assistance for our farmers without excessive purchase. In our plan for ensuring food security, fertilisers are a crucial element. Greater transparency, efficiency, and financial restraint are the main goals of the new urea pricing strategy, which will be put into effect starting in April 2003.

While the government is dedicated to deregulating the sale and distribution of fertilisers, it will nonetheless make sure that the nation's key fertilisers are accessible to farmers in all States in sufficient quantities and of high enough quality. The sugar sector has recently encountered significant challenges, which has limited the ability of sugar manufacturers to pay sugarcane farmers on schedule. To safeguard the interests of sugarcane producers while assuring the survival of sugar mills, a number of measures have been taken. Promotion of horticulture as a significant area of agricultural diversification is ongoing. The cold storage plan is effective and has added 28 lakh t of extra capacity. The Grameen Bhandaran Yojana is a new initiative that aims to build, upgrade, and expand rural godowns. This plan will aid in preventing small and marginal farmers from making distress sales. There has been a new national cooperative policy launched. The National Seeds Policy is now complete. Unemployed graduates in the field of agriculture provide farmers extension services in exchange for remuneration under the Agriclinics and Agribusiness Centres programme, which was introduced last year. The growth of the food processing industries has received top attention from the government because it recognises the need for value addition in agricultural and horticultural products. A group of ministers has been established to recommend a single, contemporary, integrated food legislation and associated regulations to replace the several current rules that have hampered the expansion of this industry.

National Textile Policy

The National Textile Policy-2000 is enunciated as follows in order to clarify the aims and objectives, concentrate on thrust areas, and sharpen strategy in line with the times: The Indian textile industry's policy shall be to produce clothing of high quality at reasonable prices to satisfy the nation's expanding demand; to increasingly contribute to the creation of sustainable employment and national economic growth; and to confidently compete for an expanding portion of the global market. Technology advancement, productivity improvement, quality awareness, strengthening of the raw material base, product diversification, increase in exports, innovative marketing strategies, financing arrangements, maximisation of employment opportunities, and integrated human resource development will be the strategic thrust areas.

The important endeavour will be to launch the Technology Mission on Jute to increase productivity and diversify the use of this environment-friendly fibre, strengthen and encourage the handloom industry to produce value-added items, and assist the industry to form joint ventures to secure gl. The Technology Mission on Cotton will aim to increase cotton productivity by at least 50% and upgrade its quality to international standards. The textile industry is battling issues brought on by sluggish modernisation and a globalised market. Nine Apparel Parks have received approval to construct garment units equipped with cutting-edge technology. The government has authorised a number of new plans to upgrade the facilities at the nation's major textile hubs. The issues with the traditional handloom and handicraft industries, which support a large number of our weavers and craftsmen, are also thoroughly addressed at the same time via a unique set of actions.

Agricultural Extension in India

Utilising technological advancements, the agricultural community must enhance production as part of the Second Green Revolution objective. Additionally, dry land farming requires a boost. Technology is the cornerstone of the strategy to really transform India into a developed country. From seed to fruit-bearing tree, 'technology' must be nurtured, and that requires art, science, and specialised industry. The secret to success is figuring out where, when, and how to make it easier for money to enter the process of realising technology projects. If technology development is to evolve into a successful company activity, several other preparatory tasks must be completed. Another significant development was the involvement of the whole community in the benefiting regions, in addition to the enthusiasm that quickly grew among the real farmers. An example of this is the formation of a women's "Self Help Group" for specific collaborative cooperative efforts to improve quality of life.

Per acre, farmers get significant incomes and sizable returns on their investment in agro processing. establishing the agrotechnologies for the carefully selected in terms of market share medicinal plants and positioning them in the proper locations in the value chain. Growing agricultural production and enhancing food quality are touted as the sole options for farmers' survival ever since the WTO's Agreement on Agriculture (AOA) started to be discussed in the nation. Every conference and seminar on the WTO has the constant theme that farmers have no option but to boost productivity and cut production costs in order to be competitive in a globalised environment. The productivity virus has infected policymakers, planners, and, of course, politicians in addition to agricultural scientists.

CONCLUSION

Studying the connection between Indian civilisation and agriculture may teach us things that might be useful for promoting sustainable agricultural practises. India can overcome current agricultural difficulties by maintaining and fusing old knowledge with new advances. In conclusion, further study in this area is necessary to improve our comprehension of the complex interactions between Indian civilisation and agriculture. The prosperity and food security of India's people may be improved through promoting sustainable agriculture methods and retaining traditional knowledge. Additionally, embracing the history of Indian agriculture may be a source of pride and identity at the national level, assuring the survival of this priceless legacy for coming generations.

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CHAPTER 12

ANALYSIS OF SOLAR RADIATION PRINCIPLE IN CROP SYSTEM

Mr.Prabhat Kumar, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

Physiological processes in plants are influenced by solar radiation, which is a key factor that governs crop systems and ultimately determines agricultural production. This study intends to investigate the importance of solar radiation in agricultural systems and its part in promoting plant development, growth, and production. The research explores the fundamentals of how plants absorb, transmit, and use solar energy. It examines how solar radiation affects transpiration, photosynthesis, and other metabolic processes that help crops build up biomass. The study also investigates how solar radiation affects crop phenology, blooming, and fruit development. Optimising agricultural practises, resource management, and climate change adaption all depend on an understanding of how solar radiation affects crop systems. The research also shows the potential uses for this information in sustainable farming, crop modelling, and precision agriculture, providing chances to raise agricultural output and resilience.

KEYWORDS:

Agricultural Productivity, Crop Systems, Crop Growth, Photosynthesis, Solar Radiation.

INTRODUCTION

The earth's atmosphere and surface are heated mostly by the sun. The heat emitted by the earth's interior and other celestial bodies is much too little to be worth mentioning. Approximately 1,49,000,000 miles separate the planet from the sun. The sun has a circumference of around 13,82,400 kilometres. Estimates place the sun's surface temperature between 5500oC and 6100oC (or 5762oK). More than 99.9% of the energy used to heat the world comes from solar radiation. Without a question, the sun's radiant energy has the greatest influence on our weather and environment. The insolation, or incoming solar energy, that touches the surface of the globe is equivalent to around 23 billion horsepower, which is the most astounding number about it. Actually, all of the earth's atmospheric and biological activities are propelled by this quantity of energy that the planet receives from the sun. Additionally, all other forms of energy that may be found on Earth, such coal, oil, and wood, are just transformed forms of solar energy. The term "incoming solar radiation" is short for "insolation".

Insolation is the term used to describe solar radiation that reaches the earth. Lar energy satisfies two basic requirements of plants: (a) light, which is necessary for photosynthesis as well as many other processes, such as seed germination, leaf expansion, growth of stem and shoot, flowering, fruiting, and even dormancy; and (b) thermal conditions, which are necessary for the plant's normal physiological processes. The bundle of radiant energy rays that make up solar radiation have various wavelengths. Radiant energy is released as electromagnetic waves by the whole. The solar spectrum's visible range is what we see as light. The speed of light is 2,97,600 km/sec. The journey to earth takes 8 minutes and 20 seconds. The combined impact of the seven distinct colors—red, orange, yellow, green, blue, indigo, and violet—is known as light. (VIBGYOR). The longest and shortest waves are those that provide the red and violet effects, respectively. Ultraviolet rays are waves that are shorter than violet, while infrared rays are waves that are longer than red. Only 6% of the insolation is made up of ultra violet waves, however they have a significant photochemical impact on particular compounds. Despite being invisible, infrared photons make up 43% of the insolation. Water vapour, which is concentrated in the lower atmosphere, absorbs them in substantial part [1], [2].

The rate at which solar radiation strikes a surface perpendicular to the sun's beams while the earth is at its average distance from the sun is known as the solar constant. The standard value of the solar constant, according to the Smithsonian Institute in the United States, is 1.94 gramme calories per cm2/minute. The quantity of solar constant thus shows a tiny rise or reduction since the sun's radiant energy output varies as a result of irregular disturbances on its surface. This variance, however, seldom goes over 2 to 3%. One of the most crucial environmental elements for several essential plant functions is light. It is necessary for the production of green chlorophyll, the most significant pigment in plants. Radiant energy may be absorbed by the chlorophyll and transformed into potential chemical energy in the form of carbohydrates. The sole connection between solar energy and the living world is the carbohydrates that plants produce during photosynthesis. By regulating the stomata's opening and shutting, it regulates the rate of transpiration. Through its strength, quality (wave length), duration (photoperiod), and direction, light has an impact on plants.

Light intensity because changes in temperature and relative humidity usually accompany changes in light intensity, it is difficult to assess the impacts of light on its own. Generally speaking, the amount of light that falls at a certain location is usually sufficient for plants to carry out their physiological process, photosynthesis. About 1% of the light energy is transformed into potential chemical energy during photosynthesis. The rate of photosynthesis is slowed down by very low light levels, which may even cause the stomata to close. The plants' vegetative development is inhibited as a consequence. Plants suffer a variety of negative effects from very high light intensity. The equilibrium between photosynthesis and respiration is upset because it speeds up respiration. Stomata close as a consequence of the quick water loss it produces. The "Solarization" process, in which all of the cell's contents are oxidised by ambient oxygen, is the most detrimental consequence of extreme light intensity. This oxidation, which is known as photo oxidation, differs from respiration [3], [4].

The plants are divided into the following categories based on how they react to varying light levels:

(i) **Sciophytes (Shade Loving Plants):** These include plants like betel vines, buckwheat, turmeric, and others that thrive in low light, partly shaded environments.

(ii) **Heliophytes (Sun-loving Plants):** Many types of plants, such as maize, sorghum, rice, and others, generate the driest matter when exposed to high light intensities. The intensity of light cannot be adjusted, unless it is in a glass house or under darkened settings.

The generation of dry matter is impacted by the crops' characteristics. If water is abundantly accessible, many organisms may generate their most dry materials under conditions of high light intensity.However, crops like tobacco, buckwheat, betelvine, and turmeric cultivated in the summertime generate more dry matter if they are moderately shaded [5], [6].

DISCUSSION

Agricultural Meteorology

The name "meteorology" is derived from the Greek words "meteoro" and "logy," which both mean "indicating science" and "above the surface of the earth, respectively." The "Physics of the lower atmosphere" is a term used often to refer to this area of physics that deals with the atmosphere. It researches each unique atmospheric phenomena. In other words, it focuses on the investigation of the traits and behaviours of atmospheres. It discusses and evaluates how insolation, or the sun's radiation that the earth's surface receives, affects variations in specific weather components including air pressure, temperature, and humidity. A subfield of applied meteorology called agricultural meteorology looks at the environmental factors that affect growing plants and animals. It is an applied science that examines how climate and weather affect agricultural productivity, or it is a science that applies meteorology to the observation and evaluation of the physical environment in agricultural systems.

To investigate the interactions between meteorological and hydrological elements on the one hand and agriculture in the broadest sense, encompassing horticulture, animal husbandry, and forestry on the other, the term "agrometeorology" is used as an abbreviation (WMO). The behaviour of weather factors that directly affect agriculture and have an impact on crop production is the subject of agrometeorology. The key determinants of whether agriculture succeeds or fails are weather and climate. Weather has an impact on agricultural activities from crop seeding through harvest, and rainfed agriculture in particular is at the mercy of the weather. In India, a severe drought that causes starvation in one area of the nation each year does significant harm in another. The expected range for the yearly pre-harvest losses for the different crops is 10 to 100%, whereas the anticipated range for the post-harvest losses is 5 to 15%. In light of this, agrometeorology is crucial in the following ways:

- (i) Assists in the design of cropping systems and patterns.
- (ii) Deciding on when to plant for the best crop production.
- (iii) To choose ploughing, harrowing, weeding, and other cost-effective methods.
- (iv) Reducing fertiliser and chemical application losses. When rain is expected, avoid using fertiliser and chemical sprays.
- (v) Prudent crop irrigation.

Need and Scope

Since the crops must be seeded at the ideal time for optimal yield, agrometeorology is required. The timing of rainfall affects the sowing date in arid terrain. a forecast for the start of the monsoon for premonsoon sowing. Agrometeorology research aids in reducing agricultural losses brought on by cyclones, excessive rainfall, and other weather-related events. in the use of short, medium, and long-term projections, it assists in predicting pests and diseases, crop selection, irrigation, and other cross-cultural activities. Finding areas with similar climatic conditions (Agroclimatic zones) is useful. This will make it possible to implement agricultural production techniques that are appropriate for the local climate. Additionally, it aids in the introduction of novel crops and varieties that outperform local crops and varieties in terms of productivity. It aids in the creation of agricultural weather models that allow crop production under varied climatic circumstances to be predicted. It is useful in creating crop weather calendars for various places. It makes it possible to provide farmers with crop weather reports. It makes it possible to plan and control variations in food output in an area by forecasting crop yield depending on weather. Making farmers more "weather conscious" while organising their agricultural activities is necessary [7], [8].

For the following reasons, agrometeorology research is essential:

(i) To research the local climate resources for efficient agricultural planning.
(ii) To develop efficient agriculture operations depending on the weather.
(iii) To use remote sensing to anticipate crop yields based on agroclimatic and spectral indicators in order to explore crop weather correlations in crucial crops.
(iv) To investigate the connection between meteorological variables and the prevalence of pests and illnesses in different crops.
(v) To define agro climatic analogues by delineating climatic, agro ecological, and agro climatic zones in order to facilitate quick and efficient technology transfer for increasing agricultural yields.
(vi) To create calendars and infographics for crop weather.
(vii) To create crop growth simulation models for calculating potential yields across various agroclimatic zones.
(viii) To keep an eye on crop-specific droughts for efficient drought management.
(ix) To create weather-based agricultural advisories to maintain crop output using different kinds of weather forecasts and seasonal climate forecasts.
(x) To learn how to alter the microclimatic features of crop canopy for greater crop growth.
(xi) To research how weather affects the soil environment where a crop is cultivated.
(xii) To better understand how weather affects protected environments (like glass houses) in order to improve their design and boost crop yield.

Seeding using dry ice

Dry ice (solid carbon dioxide) has a few unique characteristics. It doesn't melt at -80°C; it just stays the same and evaporates. Due to cloud seeding, dry ice is heavy, falls quickly from the top of the cloud, and has no lasting consequences. Dry ice is often used to seed clouds from aircraft. A constant stream of 0.5-1.0 cm dry ice pellets is discharged when an aircraft travels through the top of a cloud. Ice crystals develop when the object falls through the cloud. Rain emerges from these ice crystals. Since one cloud needs to be seeded with 250 kg of dry ice, this process is not cost-effective. It costs a lot to use specialised aeroplanes to transport the heavy dry ice over the top of clouds.

Silver Iodide seeding

At temperatures below -5°C, tiny crystals of silver iodide that are formed as smoke serve as effective ice-farming nuclei. These particles are small enough to spread with air currents when these nuclei are created from the ground generators. The best nucleating agent is silver iodide because of how closely its atomic structure resembles that of ice. It would take many hours for the silver iodide smoke discharged from the ground generator to reach the super-cooled clouds, during which time it would travel far and degrade in the sunlight. The proper method for seeding cold clouds would be for an aeroplane to drop silver iodide smoke into the super-cooled cloud. The silver iodide approach is better for seeding cold clouds than dry ice techniques since it uses less silver iodide per cloud. If the region to be covered is vast, it is not necessary to fly to the top of the cloud.

Monsoons of India

The name "monsoon" is derived from the Malayan word "monsin," which means "season," or from the Arabic word "Mausim." Such a circulation, which switches from summer to winter and vice versa every six months, is referred to as a monsoon. Since more than 2000 million people, or about 54% of the world's population, rely on the monsoon rains for their crops, the monsoon has great economic importance. Additionally, a significant portion of the region's population in the monsoon receives their income from agriculture. Monsoon signifies nourishing rains in India. Food crops are lost when the monsoons don't rain. In certain areas of the nation, the monsoon's unpredictable nature leads to devastating floods, while in other others, it causes severe drought.

When temperatures rise quickly and pressures over land fall during the hot, dry season (April to May), warm and wet air from nearby oceans begins to drift towards the aforementioned low-pressure point. However, the marine air masses are first only pulled from a close distance. The pressure gradient, however, becomes steeper by the end of May or the first week of June, when the low-pressure core has completely established, attracting even the trade winds from the southern hemisphere to the thermal low located in the north-western part of the sub-continent. According to Ferrell's Law, the southerly trades are diverted to the right when they approach the equator. The once southerly trade winds are now blowing southwesterly in a north-easterly direction. Onshore winds from the southwest travel thousands of kilometres over the warm tropical ocean as they blow towards the heart of the low-pressure system over northern India. They have a high potential for heavy precipitation since they are damp. Peninsular India's form divides the south-west monsoon, as it is known in this area, into two branches. The Arabian Sea branch and the Bay of Bengal branch are their names.

Arabian Sea Branch: The Arabian Sea Branch almost forms a straight angle with India's high western ghats. Western Ghats windward slopes have significant orographic precipitation. The quantity of rainfall on the leeward side continues to decrease with increasing distance from the sea coast even while the westerly current from the Arabian Sea continues to travel over the Indian Peninsula. On the windward slopes of the western ghats, there is 100–250 cm of precipitation, while to the leeward is a well-defined rain-shadow. The difference in rainfall between the windward and leeward sides is fairly small in the north, where the western ghats are not particularly high. Through the Narbada and Tapit gaps, certain air currents from the Arabian sea branch are able to get to the Chhota Nagpur plateau. In the end, these air currents combine with the Bay of Bengal branch [9], [10].

Bay of Bengal branch: In Assam, Mausinram (near Cherapunji), which is located on the southern slope of the Khasi hills, has the distinction of having the greatest annual average precipitation (965 cm), which is recorded worldwide. This results from its unusual geographic position. A Bay of Bengal branch current turns westward and moves up to the Gangetic plain in the direction of the Punjab. It should be noted that the monsoon current moves westward across the eastern edge of a low-pressure area that formed over northern India. Of course, the wind patterns follow the Himalayan Mountain ranges. The relief and the cyclonic storms or monsoon depressions that followed the low relief and low-pressure track along the southern edge of the plains are both responsible for some of the rainfall that falls over the Gangetic plain. It should be noted that the monsoon current in this area blows from the south-east. From north to south and from east to west, the amount of rain falls less. The principal factor reducing rainfall as it moves westward is growing separation from the moisture source. The forced elevation of rain-bearing air currents caused by the Himalayas, which are becoming further away, is what causes the reduction in rainfall to the south.

Seasonal Monsoon Over Kashmir and the Punjab, a second-high pressure system form. Over the remainder of the subcontinent, the high-pressure region regulates the predominant wind direction. Over the Indian Ocean, Arabian Sea, and the northern half of Australia, low pressure centres have developed in contrast to the pressure situation over land. Therefore, there is a pressure differential from land to sea during the chilly season, which causes winds to start moving from land to sea. These are the northern hemisphere's north-east or winter monsoons. Rainfall falls in the southern portion of the Indian Peninsula as a result of northeast monsoon currents. These currents suck up moisture from the warm ocean surface as they pass across the Bay of Bengal. The volume of wintertime precipitation on the eastern side.

Flood

Years of floods or heavy rainfall are those in which actual precipitation is "above" the average by at least twice the mean deviation. Similar to droughts, the definition of floods changes depending on the circumstance and the geography, or when there is a lot of runoffs. Runoff is the fraction of precipitation that travels over the surface of the land or through the soil and water table before returning to the seas and other bodies of water. The quantity and intensity of precipitation, temperature, the characteristics of the soil, the area's vegetation cover, and the slope of the land are all elements that impact runoff. The flow may originate from melting snow and ice fields, which have temporarily retained water, or it may be a direct return of rainfall. The amount of runoff that happens during rain depends on how well the soil and plants can absorb it. Plants delay the speed of raindrops by retaining part of it on their exterior surfaces. Additionally, they stop the horizontal flow of water. Plants help the soil's structure, and their roots provide pathways for water to go to deeper levels. In comparison to impermeable subsoil, soils with thick grass cover have higher humus contents, which improves absorption.

The Rayalaseema area would normally remove SWM between September 25 and October 15. However, out of 55 years, the monsoon withdrew in 4% of those years during the first two weeks of September and 10% of those years during the month of December. Since the typical duration of the growing season is taken into consideration while choosing crops and types in each particular location. When rain continues far beyond the typical dates, an exceptional scenario result. Short-term bajra and sunflower would be suitable under early monsoon withdrawal circumstances in Kovilpatti (Tamil Nadu). Cultural practises include: shallow intercultural operations to eradicate weeds; maintaining soil mulch to conserve soil moisture; application of surface mulch; thinning of crops by removing alternate rows as in sorghum and bajra; recycling of stored run off water; ratooning in crops like sorghum and bajra; and spraying 2-3% urea after a rain for infertile soil. An uneven distribution of monsoon rainfall across time and space occurs almost every year in one region of the nation or another during the monsoon season, causing frequent drought and flood conditions. The only element that has a significant impact on the wide variations in crop yields throughout the nation is the extreme unpredictability of rainfall.

Agroclimatic Normal

Both internal and external events that take place throughout the crop-growing season have an impact on crop yields. The climate, which controls and influences the growth, development, and ultimate production of agricultural plants, is the external environment. However, since the weather has such a strong influence on the success or failure of agricultural endeavours, man cannot manage the weather on his own. The WMO estimates that up to 50% of agricultural output fluctuation is caused by weather. As a result, one of the inputs in agricultural planning should include weather. The plants exhibit their maximal development and productivity in ideal environmental conditions. Different agricultural growth cycles need various climatic conditions to be satisfied. Green houses with the ability to manage every aspect of development and growth chambers for maximising agricultural yield are few. As an alternative, it is possible to thoroughly research the climate of an area where a certain crop may be cultivated with the least amount of pest and disease incidence.

Remote Sensing

The process of learning about things or places at a distance without really being there is called remote sensing, and it is both an art and a science. Function of RS: Agriculture is a significant source of renewable and dynamic natural resources. In India, the agricultural industry alone provides a living for almost 67% of the people. Since there is little room to expand the area under cultivation, enhancing agricultural production has been the major focus. This necessitates the wise and effective management of both water and land resources. Because of this, detailed and trustworthy information is needed on hazards/natural disasters like drought and flooding as well as land use/cover, forest area, soils, geological information, the amount of wastelands, agricultural crops, and water supplies (both surface and subterranean). Seasonal information on crops, their acreage, vitality, and output help the nation to execute appropriate support and procurement policies and take adequate measures to address shortages, if any. In order to provide such information, remote sensing technologies that can provide consistent, synoptic, multi-temporal, and multi-spectral coverage of the nation are crucial. Numerous studies have been conducted to create methods for separating information about agriculture from ground-based, airborne, and space-based data.

Fundamentals of remote sensing

The sun energy is absorbed and reflected by every element on earth. They also release a certain quantity of internal energy. Remote sensing devices, also known as sensors, are carried by aeroplanes or satellites and are used to measure the energy that is absorbed, reflected, and released. Characteristic phrases termed "spectral signatures" and "images" are used to make the detections. Commonly used remote sensing devices capture radiation in the form of the visible range (0.4-0.7 nm), near infrared (0.7-1000 nm), and microwaves (1nm-0.8 nm) of the electromagnetic spectrum (sunlight). Radars and other artificial lighting devices are also utilised.m B. Remote sensing photography sensors: The most popular sensing technologies are photographic systems. The visible and near-infrared portions of the electromagnetic spectrum that were present when the film was exposed are captured on film. Identification of soil types, plants growing, disease incidence, and drainage patterns are all done via photography.

The technology makes use of the visible and near-infrared regions of the spectrum. A mirror is spun in this system in a direction parallel to the plane's or satellite's motion. The data is captured once the radiation is reflected by the mirror onto a detector. The visible and IR parts of the multi spectral scanners each have a distinct channel for a different hue. The thermal infrared radiation that the planet emits in direct proportion to its surface temperature is likewise captured by the IR sensors. The extent of vegetation, soil moisture, and other topics are studied using infrared imaging. Microwave system: Microwave sensors employ electromagnetic radiation with a wavelength of between 1 nm and 1000 nm that is released in modest amounts from the earth's surface. Through intricate antennas, the sensors capture the microwave radiation. In weather satellites, they are used. Radar refers to active microwave systems. Radar is used to examine the characteristics of the soil, plant health, soil moisture, and runoff slopes.

Preventing global warming

There are steps that society as a whole can do to stop greater global warming. We can work to release as little greenhouse gases as we can. We can do this by carpooling, using an electric or more energy-efficient vehicle, avoiding aerosol products, and having our air conditioners serviced once a year. Turning off electrical appliances while not in use is another easy method to assist. As a result, less energy will be used and less fossil fuel will need to be burnt in power plants. Massive volumes of carbon dioxide are released into the atmosphere during the combustion of fossil fuels. The more trees and plants we plant, the less carbon dioxide there will be in the atmosphere since plants need carbon dioxide for photosynthesis. One tonne of carbon dioxide, nitrous oxide, and other atmospheric pollutants are removed annually by one acre of grass. Because cows are one of the major generators of methane, the destruction of many rainforests to make room for cattle grazing is an issue. To make place for the expanding population, other woods are being burnt down (which by turn produces additional carbon dioxide). In order to stop more global warming, we also need to curb the population boom. The more people who are aware of the problem, the more can be done to slow down the rate of global warming. We can rescue Antarctica and avert additional catastrophes and temperature shifts that will harm coastal areas and the rest of the ecosystem if we work to cut greenhouse gas emissions.

CONCLUSION

Studying solar radiation in agricultural systems may provide information that might be used for sustainable farming, crop modelling, and precision agriculture. Farmers are able to increase agricultural output and use less resources by effectively capturing solar energy. The principles of solar radiation in agricultural systems and their consequences for sustainable agriculture must be better understood, hence further study in this area is crucial. The importance of solar radiation in crop development and growth may help promote resource- and climate-wise agricultural methods. Furthermore, including solar energy concerns into crop management techniques may increase agricultural resilience and advance food security in the face of shifting environmental circumstances. Utilising solar radiation in crop systems may lead to more productive and sustainable agricultural practises, assuring food production for future generations.

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CHAPTER 13

ANALYSIS AND DETERMINATION OF SOIL SURFACE CRUSTING

Dr.Vibha Yadav, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

When rains hit bare soil, a natural process called soil surface crusting results in the creation of a compacted layer on the soil surface. The purpose of this study article is to investigate the phenomena of soil surface crusting, as well as its origins, effects, and management options. The research dives into the variables, such as soil type, rainfall intensity, and land management practises, that affect soil surface crusting. It looks at how soil crusting negatively affects soil composition, water infiltration, and plant emergence, which may result in lower agricultural yields and soil erosion. The study also looks at other management strategies and methods, including as conservation tillage, cover crops, and mulching, to avoid or lessen soil surface crusting. Optimising agricultural practises, maintaining soil health, and encouraging sustainable land use all depend on having a thorough understanding of soil surface crusting. The research also emphasises how this information may be used to conserve soil, adapt to climate change, and increase crop yield, providing chances to improve agricultural resilience and environmental sustainability.

KEYWORDS:

Crop Emergence, Soil Erosion, Soil Surface Crusting, Soil Structure, Water Infiltration.

INTRODUCTION

Alfisols include colloidal oxides of iron and aluminium, which bond soil particles in moist conditions and cause surface crusting. The surface hardens into a bulk after drying. It is difficult for crops to germinate and flourish in the alluvial sandy loam soils of Haryana, Punjab, Rajasthan, Uttar Pradesh, Bihar, and West Bengal because of a crust that forms on the soil's surface. The red sandy loam soils, or "Chalkas," that make up a sizable portion of Andhra Pradesh become very hard when they dry, which has a negative impact on agricultural development. This issue is more severe in districts like Trichy, Pudukottai, Ramnad, and Tirunelveli in Tamil Nadu, where it is mostly present in red soil (Alfisols) regions. Aggregate stability, rainfall patterns, and chemical composition all have a direct impact on soil crusting. In alluvial, red, and lateritic soils, the sparsely consolidated soil particles rapidly dissolve under the force of raindrops. With an increase in rainfall intensity, drop size, and drop velocity, there is an increase in the amount of soil that has been disseminated. The expansion and burst of trapped air brought on by the hydration of aggregates damage the structure. The small fractions are combined to create a suspension, which either settles on the soil's surface to form a crust or seeps into the soil and clogs the macropores [1], [2].

Soil survey methods

The Government chooses the survey area depending on the importance of various land development initiatives. The collecting of top sheet and creation of base maps are the initial steps in the soil survey when the area to be surveyed is reported to the soil survey authority. The organisation of the survey crew is the second phase. Typically, there will be a driver, two scientists, and one or two technicians. The crew quickly moves across the region to get a general understanding of the geology, physiography, land usage, etc. and to create a draught legend. The draught legend will be examined after the site inspection and adjusted as appropriate. This activity serves as the pre-survey. The pre-survey exercise in the field is the next step of the soil survey. The whole region is explored using the map once again to observe physiographic relationships [3], [4].

Cross sections of roads, wells, and open quarries are checked visually and with augers where accessible and required, respectively. The wide soil series is delineated on the map, along with its connections, and the legends are completed. In the soil survey description sheet, the location of master profiles is chosen, assessed for different morphological parameters, and provided. For laboratory research, soil samples are gathered horizon-wise. Auger samples are used to verify the limits of the soil, and the field study is finished. All accessible information on the land use pattern, crops and cropping order, industry, irrigation supplies, education, socioeconomic position, and ecology in general is gathered.

(a) **Post-Field Activities:** Soil samples are often tested for pH, EC, available N, P, and K, among other things, in the laboratory. Profile sheets are updated and finalised and extra analyses are conducted if the survey's sponsor insists on them for specific objectives. After being assembled and tabulated, the varied data gathered from various sources is appropriately interpreted.The maps that demarcate the soil series have been completed [5], [6].
(b) **Grid Survey:** In a grid survey, a bigger region is surveyed. There are many grids dividing up the space, and each grid has a traverse line. 4–5 observations are typical per hectare. Similar observations were linked together and mapped.
(c) **Free survey:** In this case, the surveyor chooses the observation stations and uses aerial photos to track changes in the physiography. The observational density will vary.

Agronomic Concepts of the Growing Seasons

According to agronomy, the growth season is the time when the crop has unrestricted access to the soil's water supply, which comes mostly from rainfall. This situation arises when soil water storage and rainfall balance the amount of water used by the crop. A rainfed crop has three distinct growth seasons, each of which has varied soil moisture requirements based on the amount of precipitation experienced.

Pre-Humid Phase

(a) During this time, precipitation will never exceed the potential evapotranspiration for the corresponding period. This time frame corresponds to the crop's planting season. When the week's total precipitation is more than 0.5 PET, sowing is permitted.
(b) **Humid phase:** The precipitation continues to be greater than the PET throughout this second period. The need for water will be at its highest at this time since the crops will be actively growing and blossoming. Due to more rainfall than required, the water balance is favourable towards the conclusion of this time period, and soil water storage is increasing.
(c) **Post-Humid Period:** This time frame comes after the humid one. The water that was previously held in the soil is gradually being used up by the crop plants during this time. The crops will also benefit from the rains. This time frame often corresponds to the crop's maturity stage.

Effect of Season on Choice of Crops

The choice of crop is more influenced by the season since it determines the crop's establishment and development. The agricultural yield is entirely controlled by the weather throughout a season. Crop output varies according to the duration of the rainy season, the amount and regularity of the rainfall distribution, and the amount of rainfall that is received following the rainy season. As discussed in the earlier chapter on climatic factors affecting crop production, the precipitation, wind, solar radiation (light and thermal energy), temperature, atmospheric air, and its pressure that are present during a season have a significant impact on the crop growth, establishment, and yield.

DISCUSSION

Characteristics of Good Tilth

The term "good tilth" describes the ideal environmental conditions for plant germination and development. The size distribution of particles and the mellowness or friability of the soil are two characteristics of the soil that are indicated by tilth. Size distribution of soil aggregates refers to the proportional distribution of various sized soil aggregates. For irrigated agriculture, greater proportions of bigger aggregates with a size over 5 mm in diameter are required, while higher proportions of smaller aggregates (1-2 mm in diameter) are preferred for rainfed agriculture. When soil dries out, clods become crumblier due to the soil's mellowness or friability. Good tilth soils are highly permeable and allow for unrestricted drainage up to the water table. It is ideal to have an equal number of capillary and non-capillary pores to effectively retain air and water, respectively.

Seed Germination

Radicle protrusion or seedling emergence is germination. The seed coat bursts during germination, and a seedling emerges from the embryonic axis. Soil, environment, water, temperature, light, atmospheric gases, and exogenous compounds necessary for seed germination are all factors that impact germination. Soil-related factors: The type, texture, structure, and microorganisms of the soil have a significant impact on the seed germination. Environment: Typically, the same circumstances that encourage seedling development also encourage seed germination. Seeds do not begin to germinate until they are physiologically mature [7], [8].

Water (soil moisture and seed moisture): Water ingestions are a necessary step in the germination process. Seeds that are both alive and dead absorb water and swell. Comparatively speaking, dead seeds absorb more water and swell faster than healthy seeds. The quantity consumed is influenced by the chemical make-up of the seed, including its proteins, mucilage's pectins, and biochemical elements. Soybean seeds absorb water to about half their seed weight and maize to about a third of their seed weight. When the soil moisture level is at the field's maximum, seed germination will be at its best. In areas where soil moisture is close to or at the wilting threshold, the pace of germination is observed to be slower.

Temperature: The maximum, optimal, and lowest temperatures for several crops' germination are listed below. The optimum temperature is the one that results in the greatest percentage of germination in the shortest amount of time.

Broadcasting: Broadcasting is the spreading or dispersion of seeds across the ground, whether or not they eventually become a part of the soil. Seeds may be dispersed by hand, motorised spreader, or aeroplanes. The simple, rapid, and inexpensive way of seeding is broadcasting. Uneven distribution, incorrect seed planting, reduced soil cover, and compaction are problems with broadcasting. Germination, seedling vigour, and establishment are not consistent since all the seeds are not planted at the same density and depth. It works well for crops with tiny, tightly spaced seeds.

(a) **Dibbling:** Using a planter, a dibbler, or often by hand, seeds are inserted into a hole or pit that has been dug at a specific depth and with a set spacing. Compared to broadcasting, dabbling is more time-consuming, costly, and labor-intensive, but it also uses less seeds and produces seedlings that are vigorous and germination occurs quickly.
(b) **Drilling:** This technique involves placing seeds at a precise depth before compacting the soil around them. Seed drills and seed cum fertiliser drills are examples of sowing tools. Along with seeds, you may apply manures, fertilisers, soil amendments, insecticides, etc. Rows of seeds are constantly drilled or drilled at regular intervals. Although it takes more effort, money, and time, it keeps the population density per unit area constant. The prerequisites are followed while setting the rows.
(c) Sowing behind the country plough is an activity in which a person working behind a plough sows seeds into the furrow either constantly or at the necessary intervals. The dirt sealing the furrow prevents the seeds in the prior furrow from germinating when the plough cuts the next adjacent furrow. The depth of the plough furrow may be changed to alter the depth of sowing. such is the planting of ground nuts in Tamil Nadu's arid terrain regions.
(d) Planting entails firmly burying seeds or seed material in the ground.
(e) Transplanting entails removing seedlings from the nursery and placing them in the main field. In order to produce more crops in a given year, the primary field duration of the crops is reduced. Giving delicate seedlings additional attention is simple. Raising nursery is the simplest method for tiny seeded crops like rice and ragi, which need shallow seeding and regular watering for optimum germination.

Plant Density and Crop Geometry

A crop's yield is influenced by the ultimate plant density. The density is influenced by the rate of germination and field survival. To achieve the highest yield, the necessary plant density must be established. For instance, high density will reduce moisture before crop maturity when a crop is grown on stored soil moisture under rainfed circumstances. Low density, on the other hand, will not make use of moisture. The best density will thus result in the most efficient use of soil moisture, nutrients, sunshine, etc. Higher densities are required to maximise the effectiveness of other growth variables, like as solar radiation, when soil moisture and nutrient availability are not constrained. when a plant's maximum yield. On the other hand, when the density is higher, each plant has a smaller area, which causes competition between plants for growth factors and a decrease in yield per plant. As plant density per unit area increases, yield per plant steadily declines as demonstrated in the. However, the use of growth agents increases the yield per unit area up to a particular degree of plant density. As a result, when the plant density is at its highest, the maximum yield per unit area may be achieved.

Weeds Science

Mankind is not a stranger to weeds. Since he first began to grow crops about 10,000 B.C., they have been there and were definitely seen as a concern from the start. Any plant in the field that wasn't his crop was considered a weed by him. Again, some weed species exhibit traits that are very comparable to those of the local wild plants. Today's wheat is one of several crops, for instance, that are derived from wild grass. To better fit his own tastes and whims, man has made more improvements. Even now, to pass on desirable traits like drought and disease tolerance, they are crossed with wild types. Therefore, the weeds initially include key elements of native and naturalised flora, but over time, these plants are successfully transplanted into other environments as a result of purposeful and unconscious human activities. As a result, it is believed that many weeds primarily evolved from two significant and main groupings that were arbitrarily delimited. By intentional human action; by plant invasion of habitats made by humans; and There are 30,000 species of weeds in the globe. Out of which around 18,000 species seriously impair agricultural output. In the globe, 18 weeds are regarded as the worst, while 26 species have been identified as the main weeds in Indian agriculture fields. These species are given in annexure V. Crop yields are decreased by weed competition with crops for water, soil nutrients, light, and space (i.e., CO2).

Weeds thrive in a variety of unfavourable conditions and are quite adaptive. Weeds have a far better reproductive system than crop plants, especially under adverse conditions. As a result, they often invade fields and compete with less suited crop plants. more seeds are produced compared to crops. The majority of weed seeds are tiny and make significant contributions to the seed supply. Weed seedlings grow more quickly and their seeds germinate early. They develop and blossom before the crop they infest. Although they have the ability to sprout in a variety of environments, they are quite season-specific. Every year during a consistent sequence of particular seasons, the peak germination time occurs. Weed seeds exhibit the physiological phenomena of dormancy, which gives them the ability to resist germination even under ideal circumstances. Even when exposed to harsh environments, weed seeds retain their viability for years. The majority of weeds have the C4 type of photosynthesis, which provides an extra benefit when moisture stress is present. They have deep, broad roots that are also creeping in nature.

Seed Dormancy as Survival Mechanism

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Seed Dormancy

Their seedlings may be wiped out if too many started to germinate at once. Millions of weed seeds may be stored in the soil during dormancy, where they can then develop in bursts over the course of years. The classic adage "One year Seeding, seven years Weeding" by gardeners is quite suitable in this situation. In fact, weed seeds have been shown to remain alive even after being buried in soil for 20 to 80 years.

There are three different forms of dormancy in weed seeds.

1. **Enforced dormancy:** This occurs when weed seeds are buried deep in the soil during field ploughing. When restored to the top 3-5 cm, weed seeds rapidly germinate. A common characteristic of seeds is forced dormancy. By forcing the weeds to the surface, where they may be exposed to light and get greater aeration, cultivation faces forced dormancy. High soil temperatures and high NO3 levels in the topsoil may also aid in breaking seed dormancy.
2. **Innate dormancy:** This genetically regulated trait is a characteristic of some weed seeds, which do not germinate even when present in the top 3-5 cm of soil and are given sufficient soil moisture and temperature. The existence of (i) hard seed coverings, such as those on Setaria, Ipomoea, and Xanthium species, and (ii) immature embryos, like those on Polygonum, are two potential causes. The intrinsic dormancy of certain weed seeds, especially those of Xerophytic origin, is caused by the presence of inhibitors. It might be removed with time or by the impact of a certain climatic pressure.
3. **Induced dormancy:** Under the influence of a significant increase in soil temperature and/or CO2 concentration, low oxygen pressure, water logging, etc., induced dormancy occurs when typically non-dormant weed seeds undergo an abrupt physiological shift. The seeds of wild oats (Avena fatua) display all three types of dormancy.

Factors affecting the Competitive Ability of Crops Against Weeds

Weed density: A rise in weed density is often accompanied with a decline in yield. However, it is a sigmoidal connection rather than a linear one since certain weeds do not significantly lower yields compared to other weeds. Crop density: As plant populations increase, weed growth and competition decline until the plants become self-competitive. The quantity and quality of the agricultural environment that is accessible for weed development are strongly influenced by crop density and rectangularity. Wide row spacing and a large crop plant density inside each row may lead to dense weed development. When it comes to decreasing intra-crop plant competition, square planting of crops with equal row and plant spacing should be optimal.

Weed species: Weed species that are present in a given crop affect the level of competition. The rivalry between the crop and weed is highly influenced by the presence of a specific kind of weed. The crop production is impacted by several organisms, such as E. crusgalli in rice, Setaia viridis in maize, and Xanthium sp. in soybean. Compared to the grasses, Flavaria australisica presents higher competition.

Type of crop species and their varieties: Crops and their varieties vary in their capacity to compete with weeds, for example, barley, rye, wheat, and oat are in decreasing order of weed competing ability. Due to its capacity to generate more widespread roots during the first three weeks of development than the competition, barley has a high tolerance to weed competition. Crops that quickly create a canopy and are taller have less weed competition than crops that grow slowly and are shorter in height. Crop types that are dwarf or semi-dwarf tend to develop more slowly and early on than tall kinds, making them more vulnerable to weed competition. Their little size also makes it harder for them to adequately cover weeds. When comparing the crop-weed competition between the TMV 2 (Bunch) and TMV 3 (Spreading) cultivars of groundnuts. Under unchecked weed-crop competition, TMV 2 lost much over 30% of its pod production, but TMV 3 only lost roughly 15%. The major cause is TMV 3's ability to spread, which covered weeds. It has been discovered that rice cultivars with longer shelf lives are more weed-competitive than those with shorter shelf lives.

Soil factor: Crop weed competition is influenced by soil type, soil fertility, soil moisture, and soil reactivity. Higher soil fertility often encourages weeds more than crops, lowering agricultural output. The yield increase from fertiliser application to weedy crops may be substantially less than the yield gain from fertiliser application to weed-free crops. Weeds have the ability to thrive and compete with crops in both circumstances of moisture stress and sufficient moisture. Thus, removing a severe moisture stress may benefit crops more than weeds, increasing yields. If the weeds were already established while the crops were being irrigated, their luxuriant growth would totally overwhelm the crops. If the crop is watered after it has expanded by 15 cm or more in an area free of weeds, irrigation may speed up the closing in of crop rows, inhibiting weed growth. Weed competition is often made worse by abnormal soil responses. We consequently have certain weed species that are adapted to various soil responses, and our crops only thrive in a narrow pH range. Crops on normal pH soils would face more strong competition from weeds than from crops on normal pH soils.

Climate: Since the majority of our agricultural plants are vulnerable to climatic pressures, adverse weather conditions, such as drought, heavy rain, and temperature extremes, will favour weeds. When crop production is stratified across marginal regions, it becomes even more intense. All of these strains reduce a crop's natural ability to combat weeds.

Time of germination: In general, there is significant Crop-Weed interference when the germination of a crop occurs at the same time as the initial flush of weeds. Weeds germinate in a relatively short period of time compared to sugarcane, which needs around a month to do so. Most weed seeds will grow in soil that is 1.25 cm thick. even from a depth of 15 cm, few weeds. Weed emergence is often delayed until the first watering by using planting techniques that dry the top 3 to 5 cm of soil quickly enough to prevent weed seeds from having the chance to collect moisture for their germination. The crop plants are now sufficiently established to compete with weeds that are just starting to germinate**.**

Cropping techniques: Cropping techniques, including crop planting techniques, crop density and geometry, as well as crop species and types, have noticeable influence on crop-weed interference.

Crop maturity: Crop maturity is yet another element that influences crop and weed competitiveness. Due to the crop's strong establishment, weed competition diminishes as the crop ages. Early on in the crop's development, effective weeding greatly increases output.

Interaction of Herbicides with Moisture, Fertilizers

In a single cropping season, herbicides, insecticides, fungicides, antidotes, fertilisers, etc. are applied simultaneously or sequentially. These substances may experience a change in their physical and chemical characteristics, which might increase or decrease the effectiveness of one or more of them. Compounds. Due to the buildup of persistent chemicals or their residues in the soil, the interaction effects were only seen much later in the growing season or in the next season. It might be useful to have knowledge of how different pesticides interact when creating and implementing a good and successful plant protection scheme. For the efficient eradication of weed and other pest issues, it might also be helpful to take advantage of the synergistic and antagonistic interactions between different pesticides. Two or more chemicals may interact and trigger reactions if they build up in the plant. These reactions are categorised as independent, enhancing, antagonistic, additive, and synergistic reactions. The term "additive effect" refers to a combination's overall effect, which is the same as the sum of the effects of each component considered separately.

Synergistic Effect: When two things work together, their combined influence is bigger or lasts longer than when they work alone. For instance, 2,4-D and chlorpropham together have synergistic effects on monocot species that are typically 2,4-D resistant. Similar to this, picloram and 2,4-D at low rates had an additive effect on Convolvulus arvensis. Widely utilised for an efficient control in maize is the synergistic combination of atrazine and alachlor.

A combination's overall impact is less than the effect of the most active component used alone, which is known as an antagonistic effect. For instance, combining EPTC with 2,4-D, 2,4,5-T, or dicamba has adverse effects on sorghum and gigantic foxtail. Similar to this, 2,4-D and chlorpropham are antagonistic. Glyphosate activity is decreased when simazine or atrazine are added to glyphosate solution and sprayed. Instead of biological interactions occurring inside the plant, this is caused by the physical binding within the spray solution.

CONCLUSION

The understanding acquired from researching soil surface crusting may be used to conserve soil, adapt to climate change, and boost crop output. Conservation tillage, cover crops, and mulching techniques may be used to enhance sustainable land use by preventing or reducing soil crusting. In conclusion, urther study in this area is necessary to improve our comprehension of soil surface crusting and its effects on farming and soil conservation. Adopting suitable management techniques may improve soil health, environmental sustainability, and agricultural resilience. Furthermore, understanding how soil top crusting affects soil erosion and water management might help with improved land use planning and methods for coping with climate change. For agriculture to remain sustainable over the long term and to protect soil resources for future generations, it is essential to address soil surface crusting.

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CHAPTER 14

DISCUSSION OF IRRIGATION AND WATER MANAGEMENT

Dr. Vijay Kumar, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

Irrigation and water management are critical components of agricultural practices, ensuring efficient water use and optimal crop productivity. This research paper aims to explore the importance of irrigation and water management in agriculture, considering the challenges posed by water scarcity and the need for sustainable water resource utilization. The study delves into various irrigation methods, such as surface irrigation, drip irrigation, and sprinkler irrigation, and their applications in different agricultural settings. It investigates the role of water management in optimizing crop water requirements, water distribution, and water conservation. Additionally, the research examines the impact of climate change on water availability and the potential implications for irrigation and agricultural sustainability. Understanding the principles of irrigation and water management is crucial for addressing water-related challenges in agriculture and ensuring food security in the face of changing environmental conditions. The study also highlights the potential applications of this knowledge in precision irrigation, water-use efficiency improvement, and climate-smart agriculture, offering opportunities for enhancing agricultural resilience and resource sustainability.

KEYWORDS:

Climate Change, Irrigation, Sustainable Agriculture, Water Management, Water Scarcity.

INTRODUCTION

The demand for water is rising as a result of the many applications for high-quality water, including residential usage, animal use, industrial use, power production, and irrigation for urban and rural growth. Since there is a limited quantity of high-quality water and the cost of irrigation projects is rising, it becomes a very expensive commodity and is referred to as liquid gold. According to Sir C.V. Raman, water is the ELIXIR of life and, when utilised correctly, effectively, cheaply, ecologically safely, ideally, and equitably, it can do wonders for the planet. Furthermore, historical data shows that every civilization that has ever existed on riverbanks did so because the water base was managed properly, and they all perished because it was not. Only when the crop has enough water can all the best kinds, organic manure, inorganic fertiliser, effective labor-saving tools, and correct pest and disease control approaches be used. These are some examples of water's many benefits [1], [2].

- (i) Water as a source of food
- (ii) Water as an agricultural tool;
- (iii) Water as a means of transportation;
- (iv) Water as an industrial commodity;
- (v) Water as a clean and pure resource;
- (vi) Water as a beautiful resource;
- (vii) Water as a destructive force that must be controlled;
- (viii) Water as a fuel for urban development
- (ix) Water as a place for recreation and wild life habitat.

Importance of Irrigation Management

Irrigation is the artificial application of water intended to make up for the insufficient soil moisture that does not fully fulfil the needs of growing crops. The main purpose of irrigation is to augment natural precipitation in order to increase crop output for both agricultural and horticultural purposes.

Effective irrigation is the regulated and consistent application of water to crops in the necessary quantity at the necessary time, resulting in the highest possible yields. The expense of irrigation must be maintained to a low, and irrigation must be done without wasting any water, which might have a negative impact on the soil by increasing salinity and creating water logging issues. Almost all-important crops are cultivated in irrigation systems. The most significant one is rice, which accounts for 67.5% of the total area irrigated in Tamil Nadu. The majority of the crops that get flow irrigation from rivers and tanks are rice and sugarcane, with minor amounts of banana and turmeric [3], [4].

Irrigation Management: Management is the control of activities based on different resources for their effective use and improved output, i.e., allocation of all resources for maximum profit and to meet the goals, without degrading the environment. The whole set of operations may be planned, carried out, monitored, evaluated, and reorganised in order to reach the goal. Water management relies on the soil and crop environment to increase output via effective water usage without harming the environment. Irrigation management studies the management of water, soil, plants, irrigation structures, irrigation reservoirs, the environment, social structure, and their interrelationships. The following topics must be understood in order to design effective irrigation management.

Physical and chemical characteristics of the soil, crop plant biology, water availability, timing and method of water application, climatic or meteorological influences on irrigation, and environmental changes brought on by irrigation are all factors. Irrigation agronomy is the science of controlling all the aforementioned components. Irrigation engineering is the management of irrigation conveyances, structures, and reservoirs; socioeconomic studies is the social structure, activities, lifestyle, irrigation regulations, farmer involvement, cost of irrigation, etc. The art and science of irrigation management include applying water from a source to an agricultural area. The source might be a lake, pond, canal, tank, river, well, or lake.

Maintaining irrigation lines free of leaks and weed growth, applying water to fields by installing local check structures such field inlets and borders for the irrigation area, etc., need some competence. These techniques represent the art of irrigation management. When and how much water should be used for irrigation (when and how much water should be applied?) The process of scientific irrigation management involves conveyance of water without seepage and percolation losses and water movement in soil, and is based on soil types, climatic parameters, crop, varieties, growth stages, season, quality of water, uptake pattern of water by plants, etc. Simply put, it is a systematic approach of art and science involved in soil, plant, and water by proper management of the resource [5], [6].

Relevance: Effective irrigation management is crucial

(i) To the nation's growth via wise water resource management for agricultural production and other uses like industrialisation, electricity generation, etc., which in turn creates job opportunities and improves people's living conditions.

(ii) To control and store water resources for future use or usage outside of the growing season.

(iii) To properly proportionately distribute the water depending on the area and crop being cultivated. Equity in distribution that is in balance.
(iv) To transport the water with little water loss due to seepage and percolation (Efficiency in usage).
(v) Applying a suitable amount to field crops (maximising usage).
(vi) To use the water while taking cost-benefit into account (economically sound management).
(vii) To equitably share the available water without causing any societal issues.
(viii) To meet future agricultural and other sectional requirements (Resource conservation).
(ix) To prevent excessive or improper use of water (environment-safe usage).

The effects of excessive and inadequate irrigation water on crops - Prevent giving the crops too much or too little water. Excessive irrigation causes a huge volume of water to be wasted, the loss of plant nutrients, the eradication of helpful bacteria, an increase in drainage costs, salt buildup that causes salinity and alkalinity, water logging that causes physiological stress, and yield loss or crop failure. Inadequate irrigation causes poor soil conditions, loss of agricultural production or crop failure, decreased grain quality, etc. Due to the many demands from industry, power production, agriculture, livestock, and rising urban and rural home consumption, water becomes a limited resource. The necessity for industrial complexes and urbanisation to provide basic requirements and to create job opportunities grows as the population grows. The need for water is therefore rising every day, making it crucial to research water potential and its role in agriculture, which will feed the expanding population.

Since the dawn of civilisation, irrigation has been a common practise. Although its origins are unknown, evidence suggests that the Sind and Nile River basins, where major civilizations first emerged, were the birthplaces of irrigation. When the irrigation system was unable to sustain agricultural production, this civilisation was destroyed. There are some indications that humans irrigated their crops with water from wells during the Vedic era (400 B.C.). During the Hindu, Muslim, and British eras, irrigation was steadily expanded. The Grand Anaicut (KALLANAI), which was built over the Cauvery River around the second century, is a magnificent example of the irrigation work carried out by the great Karikala Cholan, a Chola ruler. In Tamil Nadu, the Veeranarayanan Tank and the Gangai Konda Cholapuram Tank were built in the tenth century.

In Andhra Pradesh, Anantaraja Sagar was built in the thirteenth century. Samudragupta, an early Mauryan ruler, and Ashoka were both very interested in building wells and tanks. Later Moghul rulers of North India and Hindu monarchs of South India concentrated their efforts on building canals, dams, tanks, and other infrastructure. The current irrigation system underwent remodelling and refurbishment beginning in the 19th century by the British government. The important irrigation systems constructed by the British monarchs include the Upper Ganga Canal, the Krishna and Godaveri Delta System, and the Mettur and Periyar Dams. A number of multifunctional river valley projects, including Bhakra-nangal in Punjab, Tungabhadra in Andhra Pradesh, and Damodar Valley in Madhya Pradesh, were constructed after the country gained its independence.

Out of the 165 mha of total cultivable land, our nation has a maximum irrigation potential of 155 mha. The feat has been made possible by more than 215 big irrigation projects, 900 medium irrigation projects, and many small irrigation projects, which together cost the national budget between Rs. 25,000 and Rs. 35,000 crores annually. After the sixth five-year plan was finished, we could reach our irrigation capacity at a pace of 2.2 million acres per year. Irrigation potential is now increasing at a pace of 13 mha per year. Despite an increase in irrigation potential, there is a huge disparity between the amount of irrigation potential that is generated and used. As a result, closing the gap between the irrigation potential that has been produced and the irrigation that has been used is now crucial. If the resources which include surface and groundwater are used effectively, primarily via scientifically enhanced irrigation scheduling, more than 80% of the land area may be placed under irrigation. On the issue of irrigation scheduling, tremendous national and international scientific efforts have been undertaken, yet success has not yet been achieved. For our scientists, engineers, planners, policy-makers, and farm managers, this is a difficult assignment.

Important warnings: The soil quality within the lysimeter ought to be comparable to that of the surrounding area. The crop that is growing within the lysimeter must also be growing around it. The dependability of the data will be impacted by the presence of sidewalls, paths, or gravel around the lysimeter. To minimise the difference in soil temperature between the lysimeter wall and the fields, the rim or border of the lysimeter should be as narrow as feasible. The lysimeter comes in two varieties. The additional water and any water losses are weighed in this case using the weighing balance that is included within the lysimeter. To calculate the ET, the weight differential is taken into consideration. Non-weighing kind - In this case, the ET is calculated by employing a neutron probe to calculate changes in soil moisture over time. There are many lysimeter sizes available in both situations [7], [8].

DISUCSSION

Rain Gun

A raingun is a potent mega sprinkler that can produce fake rain by shooting massive amounts of water (up to 500 litres per minute) across a wide area (radius of 90 feet and beyond). It provides the farmer with a lot of advantages. When compared to flood irrigation, it uses 50% less water while producing the same yield. With the raingun irrigation system, there are significant water savings that occur. Both irrigation time (which is reduced by 60%) and electricity usage are reduced. Additionally, raingun irrigation requires less manpower than flood irrigation. As seen by sugarcane growers, it boosts crop production by 10%. The use of fertilisers may be decreased by applying fertilisers using the raingun irrigation method. Pests like aphids, white flies, and other insects are removed by irrigation with the raingun. The highly recommended practise of trash mulching in sugarcane, which involves turning waste into nutrients for the crop, is supported by raingun irrigation systems. To keep the cane safe from insects and illnesses as it develops, the debris is removed from the cane. The waste is also beneficial since it is rich in nutrients.

But instead of using this readily accessible fertiliser, farmers remove it or burn it to get rid of the massive amount of rubbish instead. Using rubbish as a soil cover to help retain moisture, stop the spread of weeds, and ultimately turn the waste itself into food is a practise known as mulching. With the help of the raingun irrigation system, farmers may effectively practise rubbish mulching. The raingun was designed with sugarcane in mind, but it may also be used successfully on a variety of other crops, including groundnut, tapioca, onion, potato, maize, and fodder crops, among others.

Raingun riser supports are permanently attached to a solidly installed pipeline network in a permanent method of installation. The area around the riser may also be supported with cement concrete blocks. In a semi-permanent system, the pipeline network may be both permanent and mobile, or it may simply be mobile while the raingun is being moved. By employing an HDPE Quick-ConnectTM male connection at the riser and a Quick-ConnectTM female connector at the pipe end, the raingun fiser stand may be made detachable. The pipe network may also be made of HDPE pipe that is available in coil or hose form and is the appropriate size and length, connected using a G.I. insert joint on one end and a Quick-ConnectTM female junction on the other.Alternately, a fast release key or quick coupling valve may be used to transfer a raingun by itself over risers that have been permanently installed.System that can be moved - A system that can be moved allows the whole pipeline network, as well as the raingun riser stand and raingun, to be moved from one place to another. This is accomplished by using Quick-ConnectTM pipes that are simply removable. Male connectors on Quick-ConnectTM pipes may be used to attach them to raingun riser stands. Shiftable systems may also employ flexible HDPE coil or hose. A raingun trolley may be used to transfer a raingun easily from one location to another**.**

Irrigation Management

The total amount of water needed for rice is 1100–1500 mm. Depending on the agroclimatic conditions, the daily water consumption for rice ranges from 6 to 10 mm, and the total water consumption is between 1100 and 1250 mm. The nursery uses 3%, or 40 mm, of the crop's total water need, 16%, or 200 mm, for ground preparation (puddling), and 81%, or 1000 mm, for main field irrigation. In terms of water management, the development of the rice plant may be split into four stages: seedling, vegetative, reproductive, and ripening. The sowing step uses less water than other stages. To encourage the growth of new roots, a shallow depth of 2 cm submergence is required at the time of transplantation. During the vegetative period, tiller production requires the same water level. Mid-season drainage is the process of draining the whole water in the field at the start of the maximum tillering stage and leaving it that way for one or two days.

This mid-season drainage may enhance the roots' respiratory processes, encourage strong root growth, and inhibit the establishment of ineffective tillers. Any stress experienced during the vegetative period may hinder root development and limit leaf area.5 cm of submersion should be maintained throughout the blossoming period since it is a crucial time for water requirements. All yield components will be damaged by stress at this period, severely reducing yield. In particular during the booting stage, more water than 5 cm is not essential and might cause a delay in heading. Less water is needed through out the ripening process than is required following yellow ripening. 15–21 days before crop harvest, the land may be progressively drained of water. When 5 cm submergence is advised, irrigation management may be carried out by irrigating to 5 cm submergence at saturation or one to two days after the ponded water has disappeared. Comparing this to continuous submersion, irrigation water use will be reduced by 30%.

Groundnut

A total of 500 to 550 mm of water is needed. During the first 35 days after planting and the last 35 days before harvest, evapotranspiration is minimal, reaching a peak need between the peg penetration and pod growth phases. The second irrigation following the sowing irrigation may be planned for 25 days after the sowing, or 4 or 6 days after the first hand hoeing, and an irrigation interval of 15 days is then maintained until peak blooming. Depending on the soil and environment, the gap during the key phases may be 7–10 days. The gap is 15 days when maturity is in effect.

Finger millet requires 350 mm of total water. A crop that can withstand drought is finger millet. Preplant watering is provided at 7 and 8 cm. For consistent establishment, watering with a modest amount of water on the third day after transplanting life is adequate. For healthy and strong development, water is then withheld for 10 to 15 days following seedling establishment. Three irrigations are then necessary during the primordial initiation, blooming, and grain filling phases.

Sugarcane

1800 to 2200 mm of water are needed overall. The important time for water consumption is the formative phase (120 days from planting-germination and tillering phases). Less water at more frequent intervals is preferred to achieve uniform emergence and the maximum number of tillers per unit area. When compared to the other two stages, the crop requires more water at this crucial time, hence the reaction to applied water is greater. During this time, there is a greater need for water, irrigation, etc. It is preferable to maintain the ideal amount of moisture throughout the primary growth stage since there is no subsequent thickening of stems or elongation of stems as sink for storing sugar. Water response is now minimal, and it will continue to be less as the fruit ripens. As harvest time draws near, the soil moisture level should be permitted to progressively drop throughout the ripening period to slow cane growth and boost sugar content.

Maize

The total amount of water needed is 500–600 mm. Although maize has a greater water need than other crops, it uses water quite well. Sowing, four-leaf stage, knee high, grand growth, tasselling, silking, and early dough phases are the maize crop's several growth stages. Water is a need for crops at every stage. Tasselling, silking, and the first phases of dough are crucial times in this.

Cotton

550–600 mm of total water are needed. Cotton is sensitive to the level of soil moisture Early in the season, plants need less water, and more water is lost by evaporation than transpiration. The plant needs more water as it develops, starting at 3 mm per day and peaking at 10 mm per day when it is covered with blooms and bolls. Only 10% of the total amount of water needed is utilised during plant emergence and the first stages of development. During the periods of blooming and boll formation, enough moisture is crucial. The crop needs less water in the beginning and towards the end. Until the boll growth stage, a high water need persists. Because it is an indeterminate plant, excessive watering during phases other than those that are important increases vegetative development, which might result in a reduction in boll setting. Until the first boll of the last flush opens, irrigation is maintained. After that, irrigation is terminated.

Sorghum

350–500 mm of water total are needed. The booting, blossoming, and dough phases are when you need water most. After seeding, the crop will immediately get irrigation. The following irrigation is applied 15 days after planting to promote the growth of a robust secondary root system. Crop production performance depends on irrigation ten days before heading and ten days after heading.

Water application efficiency (Ea)

Irrigation is used to restore moisture that has been lost by evapotranspiration in the root zone. According to Doorenbos and Pruitt (1977), the definition of crop water requirement is "The depth of water needed to meet the water loss through evapotranspiration of a disease-free crop, growing in large fields under non-restrictive soil conditions, including soil water and fertility, and achieving full production potential under the given growing environment." Effective irrigation is defined as using the least quantity of water necessary to raise the root zone moisture content to the field's capacity. On the other hand, if more water is applied than is really required for replenishment, the irrigator's application efficiency is drastically reduced. To use a field as an example, suppose the root zone requires 9 cm of water to fill the field at the time of irrigation.

CONCLUTION

Water management and irrigation are essential components of agricultural practises because they guarantee effective water utilisation and long-term crop growth. The relevance of irrigation and water management in agriculture has been examined in this research article, taking into account the difficulties caused by water shortage as well as the value of using water resources sustainably. The research emphasised several irrigation techniques and how well they suited diverse agricultural situations, including surface irrigation, drip irrigation, and spray irrigation. In order to maximise water distribution and water usage efficiency, it is crucial to understand the various irrigation strategies. The study also looked at how water management helps save water resources and satisfy agricultural water needs. Effective water management techniques support environmental sustainability and agricultural output.

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CHAPTER 15

IRRIGATION MANAGEMENT UNDER LIMITED WATER SUPPLY

Dr.Vibha Yadav, Assistant Professor
Department of Agriculture, IIMT University, Meerut, Uttar Pradesh, India.

ABSTRACT:

Agriculture has a significant difficulty when it comes to managing irrigation when there is a restricted water supply, particularly in areas where there is a water shortage and there is growing competition for water resources. With an emphasis on increasing water-use efficiency and crop yield, this research article intends to investigate the concepts and methods of irrigation management when water supply is constrained. The research explores the many methods and innovations for streamlining water distribution, including alternating wetting and drying, managed deficit irrigation, and deficit irrigation. It looks at how accurate weather predictions and soil moisture monitoring may help with irrigation planning. The study also looks at the role that water-saving irrigation techniques like drip irrigation and micro-sprinklers play in reducing the effects of water shortage. For sustainable water resource use, guaranteeing food security, and adjusting to water stress brought on by climate change, it is essential to comprehend irrigation management under restricted water supply. The paper also identifies possible uses for this information in planning water resources, increasing water usage efficiency, and precision irrigation, providing chances to increase environmental sustainability and agricultural resilience.

KEYWORDS:

Deficit Irrigation, Irrigation Management, Limited Water Supply, Water-Use Efficiency, Water-Saving Irrigation.

INTRODUCTION

To maximise food production per unit of water utilised to fulfil the demand from the current 1 billion people, integration of all water resources, including surface, ground, wastewater, snow, dew, etc., is crucial. Due to anomalous distribution patterns and uncertainty around the timing of rainfall, water supplies are now a problem. As a result, frequent droughts are now rather prevalent. In these conditions, it is necessary to implement a new water-saving plan for agricultural production and irrigation management. The chapter's discussion of water scarcity circumstances and strategies for dealing with them via drought relief measures may be found here.

The word "water scarcity" refers to inadequate storage of, or non-availability of, the necessary amount of water for agricultural production and other uses owing to monsoon failure. Due to the shortage, the cultivated fields will get insufficient water supplies, which will put the plant community under stress. The frequency of irrigation, the kind of crop, the type of soil, and other factors affect how stressed a plant is. Our main objective in this scenario is to obtain the most yield per unit of water. The approaches listed below may be used to manage stress.

Analyse the resource potential and employ approaches from linear programming to maximise water consumption. The relevant department should carry out this kind of activity, notably irrigation and agricultural. Farmers' attitudes - Farmers' or users' behaviours need to be significantly reoriented in order for them to understand that conserving water is their main duty and that it is an economic input. Changes to the conveyance system are needed since a lot is wasted during the transfer from source to field. The amount of water wasted through conveyance systems is thought to be between 30 and 40 percent. By performing routine maintenance, lining the channels, and other measures, such water losses may be reduced or entirely avoided. Pipe conveyance is often used for ground water resources. In command regions, such conveyance is possible even at low sluice levels [1], [2].

Conjunctive use of water refers to the integration of all water resources with water conservation techniques. Conjunctive usage's primary goal is to utilise water from many sources as efficiently as possible. Conjunctive use of water, for instance, refers to the best use of rainfall and well water in a canal irrigation system to preserve the crop without depleting either water supply. Rice is a semi-aquatic plant, thus for it to establish itself and produce more, water must be surrounded by it. The experimental data unmistakably showed that 5 cm of ponding depth is preferable to greater depths one day following the absence of previously supplied water. This was due to enhanced root activity and greater aeration [3], [4].

Water Relations of Soil

The mineral and organic components of soil are derived from a solid (albeit not rigid) matrix, whose interstices are made up of asymmetrical pores whose geometry is determined by the matrix's edges. In general, the liquid phase of soil water and soil air combine to fill the pore space to a certain extent. One of the most vital components of the soil is moisture. Additionally, it is one of its most dynamic features. Water has a significant impact on a variety of soil physical and chemical processes as well as plant development. The molecule's structure may be used to describe the characteristics of water. A mole is made up of three hydrogen atoms, one oxygen atom, and is mostly governed by the oxygen ion. The two hydrogen ions occupy hardly no space. Individual water molecules do not exist.

One molecule communicates with another via the hydrogen in the water. Water is stored in the soil like a reservoir. Only the water that a crop has stored in its root zone may be used by it for transpiration and the development of plant tissues. Plants can acquire the daily water needs for healthy growth and development when there is enough water in the root zone. The amount of water that is available decreases as the plants continue to utilise it, and if additional water isn't given, the plants will eventually cease growing and die. It is vital to water once more before the stage is reached when crop development is severely impacted. The qualities of the soil and the crop to be irrigated determine the volume of water to be applied to each irrigation and the frequency of irrigation [5], [6].

Movement of Water into Soils

The initial action or process of water intake after irrigation or rainfall is known as infiltration, followed by percolation and finally seepage. Infiltration refers to the passage of water from the soil's surface. One of the key factors affecting irrigation is the soil's capacity for infiltration. The infiltration rate of a soil determines the maximum rate at which water may enter the soil under various circumstances, especially when there is an abundance of water. It has velocities as its dimensions. The infiltration velocity is the actual rate of water infiltration into the soil at any given period. During irrigation, the rate of infiltration drops. Initial rates of reduction are quick, and the infiltration rate tends to stabilise. The fundamental infiltration rate is the virtually constant rate that emerges after some time has passed since the beginning of irrigation.

Factors impacting the pace of infiltration The initial moisture content, state of the soil surface, hydraulic conductivity of the soil profile, texture, porosity, and degree of swelling of soil colloids and organic matter, vegetative cover, duration of irrigation or rainfall, and viscosity of water are the main variables affecting infiltration of water into the soil. The initial pace and overall quantity of infiltration are significantly influenced by the antecedent soil moisture content, with both decreasing as the soil moisture content increases. Any restriction to the movement of water into and through the soil profile limits the infiltration rate of any soil. The infiltration rate is often determined by the soil layer with the lowest permeability, either at the surface or underneath it. The porosity of the soil, which is altered by cultivation or compaction, has an impact on infiltration rates as well. By enhancing the surface soil's porosity and removing surface sealing, cultivation affects the penetration rate. The impact of tillage on infiltration often only lasts until consecutive irrigations lead the soil to return to its original state of bulk density.

In general, infiltration rates are lower in heavy texture soils than in light texture soils. Numerous researchers have looked at how soil infiltration rate is affected by water depth. Increased depth in surface irrigation has been shown to marginally boost early infiltration, but the influence of the head during extended watering is minimal. The vegetation cover also affects infiltration rates. Grassland has a far greater infiltration rate than bare, uncultivated soil. Organic matter additions significantly speed up penetration. Because of the puddling of the surface brought on by the reorientation of surface particles and the washing of finger materials into the soil, the hydraulic conductivity of the soil profile often changes during infiltration. This is due to both the rising moisture content and the puddling of the surface. Water viscosity affects infiltration. Due to warm water's low viscosity, the tropics experience a greater rate of penetration under otherwise equivalent soil conditions [7], [8].

DISUCSSION

Water Vapour Movement

Under dry conditions, it occurs both within the soil and between the soil and atmosphere. Due to its limited range, vaporisation in the wet range is not taken into consideration in irrigation practises. The moisture tension at which maximum water vapour occurs is greater the finer the soil pores. When the soil dries out in the coarse-textured soil, the soil pores become empty of liquid water under low tension. There isn't much moisture left to pass as vapour. However, fine textured soil maintains a significant amount of moisture even at high pressures, allowing vapour movement to occur in soil before it reaches the PWP (Permanent Wilting Point). In this instance, the role of water vapour mobility to plant survival is taken into account. The figure below shows how water is distributed between sandy loam and clay loam types of soil. Water percolates down to 180 cm in coarse-textured sandy loam soil in about 24 hours, with a fairly limited distribution. The water expanded horizontally at the same time, reaching a maximum width of 30 cm. However, after 24 hours of irrigation, water percolates down to a depth of 90–120 cm in clay soil. During the same time frame, the water is distributed to a horizontal breadth of more than 60 cm. The graph makes it abundantly evident that, in comparison to soil with a coarser texture, water moves more slowly vertically and more widely horizontally in soil with a finer texture.

Saturation

After a major rainstorm, surface irrigation, or significant quantity of rainfall, the soil under the surface is totally submerged in water. All of the pores, both small and large, are now filled with water. The saturation point or maximum water-holding capacity of the soil is stated to exist at this location. When water reaches saturation point, it cannot be retained by any force or tension, or there is very little. This corresponds to the surface of free water. At this time, some water or a portion of water that is moving downhill owing to gravitational force tends to be pulled. This water is referred to as free water or gravitational water.

Field Capacity

This is the amount of moisture in the soil that remains when the water drainage caused by gravitational force has halted, ceased, or becomes very sluggish. As a result, it may also be described as the moisture content held against gravity. It may alternatively be described as moisture that is present in capillary or micropores but that gravity prevents from draining out. At this phase, the soil's moisture level is reasonably steady and a thick film of water fully envelops every soil particle. As a result, it is sometimes referred to as capillary water. In opposition to the gravitational pull, this soil moisture is retained with some force or tension. Moisture tension is a measure of the force needed to hold water. The typical range for coarse and fine grained soils is 1/10 atmosphere to 1/3 atmosphere. The maximum water point or field capacity is the amount of water that can be made accessible to plants. As a result, it is often referred to as Full point. The soil's texture or particle size, structure, and quantity of water applied all have an impact on its field capacity. Depending on the soil texture, the soil will attain saturation and its field capacity after two or three days of irrigation or rainfall. If soils are fine-textured and rich in organic matter, which slows the downward transport of water, it takes longer to attain field capacity state.

Water holding capacity - The Keen and Razowaski cup is used to assess water holding capacity. After placing a filter paper at the bottom, the soil is placed in this cup. Capillary action allows for soil saturation. Weight is obtained right away after wiping the cup's sides clean of water, and moisture is calculated on an oven-dry basis. Field capacity is calculated by ponding water in the area of the field that is completely surrounded by a bund. A 2 m2 test area is possible. Estimation may be used after intensive irrigation or a lot of rain. The extra water might drain from the soil. Evaporation is prevented by covering the surface. To do this, cover the ground with a thick layer of straw mulch or polythene sheeting. It is necessary to sample the soil after 24, 36, 48, and 72 hours. After drying in an oven at 105°C for 6 to 9 hours, concordant weights are collected, and the soil moisture content is measured using the gravimetric technique. In order to identify the comparatively constant values throughout time, moisture curves must be constructed. The sample period may be 48 hours after irrigation for all soil types, with the exception of hard clay soil. Depending on the rooting depth and information to be produced, the field capacity for a few layers (0–15, 16–30, 30-45, and 45–60 cm) in experimental fields may be predicted. By keeping a third of an atmosphere in a disturbed soil sample, the pressure plate device may also be used to assess field capacity.

Equivalent moisture - The disturbed and air-dried soil sample's equivalent moisture is determined. A 2.0 mm sieve is used to remove the dirt. Taken is a porcelain buchner funnel measuring 5 by 2 cm. Filter paper is moistened just enough to facilitate adhesion to the bottom. To achieve consistent packing, air-dry soil is supplied to the funnel while being gently tapped against a flat surface. The Buckner funnel is filled to the top with soil, then the top is scraped off using a spatula. A soil sample is placed within a funnel filled with water so that water may pass through the stem of the funnel due to capillary action. A 24-hour period is given for the soil in the funnel to reach an equilibrium with the water by capillary action. The funnel is taken out of the water column and attached to a filter flask after 24 hours.

The filter flask is attached to a vacuum pump that spins at 550 revolutions per minute for 15 minutes. The dirt is placed into an aluminium cup without filter paper during the suction process, and the moisture content is calculated using the oven dry technique. Wilting point - Wilting point estimation Sunflower is grown in a tin can as an indicator plant for moisture. The plant is allowed to grow through a gap in the lid as the tin can is covered with the lid. For three to four weeks, the plant is watered to grow until three to four leaves appear. The plant is watered last, and cotton is inserted into the gap under the cover near the plant's stem to reduce evaporation. It is permitted for the plant in the tin to gradually wilt. When the plant begins to lose turgor, the can containing the plant is moved to a humid, dark room with a high humidity level. A black polythene covering is placed over the damp cabinet to prevent transpiration. To keep moisture in the cabinet, the inside walls are coated with gunny. It is permitted for the plant to get moisture from the soil. If the plant is becoming turgid, it is placed in a humid cabinet after two hours of exposure to the environment. Until the plant in the humid cabinet does not recover, this practise is repeated. To determine the soil's wilting point, the moisture content of the soil in the can is currently approximated. Using a pressure plate device to calculate soil moisture constants - By using a pressure plate equipment or a pressure membrane device, soil moisture content measurements may be measured. The cups of the pressure membrane device are filled with the soil under test in this stratum. In order to achieve the necessary soil moisture constant (FC 1/3 atm), the desired pressure is applied, and the soil sample's moisture content is calculated.

Moisture Extraction Pattern of Crops

Plants use their root systems to absorb moisture from the soil. Depending on the crop and its rooting system, different amounts and methods of water absorption occur. The moisture extraction pattern reveals information about how and how much moisture is taken at various depths in the root zone. The relative quantity of moisture removed from various depths inside the crop root zone is shown by the moisture extraction pattern. Figure depicts the moisture absorption pattern of a plant growing in a uniform soil without a limiting layer and with sufficient soil moisture supply accessible throughout the zone. According to the following graph, the first quarter of the root zone extracts roughly 40% of the total moisture, followed by the second quarter, the third quarter, the fourth quarter, and the final quarter, which extracts 30% of the whole moisture. This suggests that for the majority of crops, the root zone will be accessible in the first quarter, yet it does not necessarily imply that the latter quarter will not need any irrigation. As a result, measurements of soil moisture in the root zone must be made at various depths.

(i) To calculate the amount of irrigation to be used;
(ii) To determine the soil moisture state**.**

varied agricultural plants have quite varied root systems. Rooting depth, root length, and the horizontal dispersion of roots are all subject to variation. These are further impacted by the genetic make-up and environmental circumstances. Cereals' roots seem to cover more soil surface than those of other crops. For instance, it has been shown that the roots of cereals reach a soil surface area of 200–400 cm, as opposed to 15–60 cm/m2 for the majority of graminaceous plants. The depth of the soil, its moisture properties, and the density of the roots all influence how much soil moisture is accessible to the plant. Greater potential are in modifying the rooting qualities of plants so that they go deeper, denser, and more proliferated to tap water from deeper layer of soil as well as from the broader surface area. The moisture characteristics of soil like FC and PWP cannot be changed as readily. Genetically, rooting characteristics differ among plants. Vegetable crops like onions, potatoes, carrots, etc., have relatively scant root systems and can't utilise all the water in the soil in the roots.

Rice, grasses, sorghum, maize, and sugarcane all have very thick, fibrous root systems that can draw large amounts of water from the soil. Millets, groundnuts, and grammes have a medium depth of rooting. Deep-rooted perennial plants like maize, sorghum, lucerne, cotton, and others can efficiently use both the moisture in the root zone and the deeper, untapped zones. Cotton, sorghum, and red gramme are examples of crops with deep, thick roots that can withstand significant reductions in soil moisture. Rice, potatoes, and tomatoes, which have shallow roots, may survive a little loss in soil water. Crops with somewhat deep roots, such as millets, groundnuts, and grains, may sustain a moderate loss in soil water.

Soil Moisture Stress

A number of interconnected and dependent processes make up the relationship between plants and water. As a result, a plant's internal water balance or level of turgidity relies on the relative rates of water absorption and loss and is influenced by a variety of atmospheric, soil, and plant conditions that change the rates of absorption and transpiration. Water responds to a potential gradient by moving. A base level of leaf turgor, or plant water potential, is attained when the roots of the plant are in equilibrium with the soil's water potential and the gradients of that water potential are close to zero. The values of water potential are often at or close to this level throughout the night and early morning (before to dawn) when there is less evaporative demand. The turgor pressure of the upper leaves decreases as transpiration rates rise along with evaporation rates during the day, and water potential gradients form within the plant from the evaporating surface of the leaves to the absorbing surface of the roots.

The rate of water loss is higher than the rate of water absorption, which leads to the development of an internal water deficit in the plant. The internal water deficit directly contributes to the development and yield of a crop under the current circumstances by influencing several physiological processes in the plant. Crop production is the culmination of a variety of physiological processes. Photosynthesis and respiration may be impacted by water stress. It may have an impact on both growth and reproduction. Under water stress, reductions in leaf area, cell size, and intercellular volume are frequent. Numerous physiological processes may slow down as a result of protoplasm dehydration. At some crucial plant development phases, water stress results in greater damage than at other stages. For higher wheat crop output, irrigation has been shown to be crucial during the crown root initiation stage.

Various strategies are used by plants to withstand times of water scarcity. Longer drought periods are avoided by short duration types, which may be more drought tolerant than other kinds. The development of acceptable drought resistant types may arise from studies on creating idiotype plants with leaf and stomatal features. Because they can tolerate tissue desiccation, plants can withstand drought conditions. Plants that can withstand drought often have smaller cells than those that prefer moisture. Small cells are dehydrated with a considerably less relative drop in volume than big cells are, hence they do not experience the same severe disruptions as the latter. Increased osmotic levels are often a sign of a plant's improved drought resistance. The capacity of cells to retain water is increased by greater osmotic values, but they may also have an extra impact by making the protoplasm more resistant to dehydration. A sorghum's deep and widespread root system is one of the most efficient defences against drought damage. plants like potatoes, onions, and other plants with shallow, sparsely branching roots. suffer more quickly than plants with deep roots, such as Lucerne and maize.

Nutrient Management

Growth is the process through which a plant, or a particular organ, develops. In addition to genetic characteristics, soil and climate-related environmental factors also have an impact on plant development. In this chapter, the delivery of mineral nutritional components to the plants is covered. Large numbers of elements are found after a thorough study of plants. But not all components are necessary. If a plant cannot complete its life cycle without it and only that element can treat the illness (deficiency) that arises in plants when it is absent, then that element is considered to be essential.

16 elements were formerly thought to be necessary for plant development. They are chlorine, iron, manganese, zinc, copper, molybdenum, boron, and the elements carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, and magnesium. The following list has recently been expanded to include sodium, cobalt, vanadium, silicon, selenium, gallium, aluminium, and iodine. A specific group or species of plants have been identified to need one or both of these newly added components. Plants absorb carbon, hydrogen, and oxygen in the forms of carbon dioxide, water, and molecular oxygen. Others are absorbed from the soil by plants. About 10% of the total dry weight of crops is made up of nutrients that are absorbed by plants; the remainder is made up of water.

CONCLUSION

Understanding the value of water-saving irrigation techniques like drip irrigation and micro-sprinklers provides potential for reducing the effects of water shortages and improving water usage effectiveness. Planning for precision irrigation, increasing water usage efficiency, and managing water resources might all benefit from the information obtained from researching irrigation management in situations when water supply is scarce. Applying these tactics may support environmental sustainability and agricultural resilience. In conclusion, further study in this area is necessary to advance our knowledge of irrigation control in water-scarce environments and the implications for sustainable agriculture. In the face of shifting environmental circumstances, putting a high priority on water-use efficiency and using water-saving technology may assist in addressing water shortage issues and ensuring food security. Including climate-smart irrigation techniques in water resource planning may also improve agricultural resilience and help save water. In order to achieve long-term sustainability and guarantee the availability of water resources for future generations, appropriate water management in agriculture must be encouraged.

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CHAPTER 16

ANALYSIS OF INTEGRATED NUTRIENT MANAGEMENT

Utsav Shroff, Director
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email id-utsav.shroff@atlasuniversity.edu.in

ABSTRACT:

A sustainable agriculture strategy known as integrated nutrient management (INM) comprises the prudent and balanced use of multiple fertiliser sources to maximise crop output while minimising environmental consequences. The purpose of this study article is to examine the Integrated Nutrient Management (INM) practises and concepts in agriculture. The significance of managing soil fertility as well as the function of vital nutrients in plant development are both covered in depth in the research. It looks at the idea of nutrient cycle and how to combine organic and inorganic fertilisers to increase the availability of nutrients in the soil. The study also looks at how INM might improve soil health, boost nutrient usage effectiveness, and encourage sustainable crop production. For increasing soil fertility, minimising nutrient losses, and guaranteeing food security in a changing environment, it is essential to comprehend the Integrated Nutrient Management concepts. The paper also identifies possible uses for this information in climate-smart farming, sustainable land use, and precision agriculture, providing chances to improve resource sustainability and agricultural resilience**.**

KEYWORDS:

Integrated Nutrient Management, Nutrient cycling, Organic fertilizers, Inorganic fertilizers, Soil fertility.

INTRODUCTION

The idea behind INM is to combine nutrient sources and application techniques for organic and inorganic nutrients to maintain soil fertility and productivity, i.e., to use chemical fertilisers, organic manures, and bio-fertilizers in conjunction to address issues with nutrient supply, soil productivity, and the environment. A thorough understanding of the effects of the previous crop, the contribution of legume in the cropping system, the residual effect of fertilisers, and the direct, residual, and cumulative effects of organic manures for supplementing and completing the use of chemical fertilisers is required to develop an INM system for a specific crop sequence to a specific location. Organic manures, such as green manures, crop residues, crop rotation and intercropping with legumes and cereals, bio-fertilizers like rhizobium, azotobacter, and azospirillum, and phosphorus-solubilizing microorganisms like mycorrhizal fungi, azolla, blue green algae, and cyanobacteria are the main elements of the N supply system. All of them may act as significant additional sources of nutrients in addition to artificial fertilisers. INM is thus technically sound, commercially feasible, and socially acceptable while also not degrading in the environment [1], [2].

Balanced nutrition for sustainable crop production

Agriculture's broad-based pace of crop production increase is much slower than the rate of overall country growth. If a nation wants to boost its economy via agriculture, it must develop its plans to make greater use of its natural resources while using chemical fertilisers and other inputs in moderation. Sustainability in agriculture and environmental safety are the top concerns for boosting food production to meet the demands of the nation's expanding population. It is necessary to create and practise a balanced use of chemical fertiliser in order to prevent the waste of valuable national resources and to reduce environmental harm. This will increase agricultural output in a sustainable manner while also reducing crop production costs. Higher levels of plant nutrients are required for increased food production. No single source can provide the necessary number of nutrients, tHus it is essential to employ all of them together to provide plants a balanced diet [3], [4].

balanced nutrition

The availability of nutrients already present in the soil, crop requirements, crop removal of nutrients, the economics of fertilisers and profitability, farmers' ability to invest, agro-techniques, soil moisture regime, weed control, plant protection, seed rate, sowing time, and soil temperature are all factors that must be taken into account when fertilising a crop in a balanced manner. It is a dynamic idea rather than a condition. The balanced use of fertilisers should primarily aim to increase crop yield, increase crop quality, increase farm income, correct innate soil nutrient deficiencies, maintain or improve lasting soil fertility, avoid environmental damage, and restore the fertility and productivity of the land that has been degraded by improper and exploitative activities in the past. Utilising plant nutrients in a balanced way corrects nutrient deficiencies, boosts soil fertility, improves water and nutrient use efficiency, boosts crop yields and farmer income, and promotes crop and environmental quality. It is crucial to have excellent seed, enough moisture, and improved agronomic practises with a higher focus on timeliness and accuracy in farm operations in order to profit from the balanced usage of plant nutrients.

One of the most crucial instruments for using balanced fertilisation is soil testing. Different areas, as well as different crops, need different amounts of balanced fertiliser. Farmers may determine the amount and kind of fertiliser to use for each crop via soil testing. The kind of crop and its variety, the availability and quality of water, the availability of organic manures, crop wastes, and biofertilizers, among other factors, may all be used to further optimise the fertilizer dosage. With the advent of high yielding wheat and rice types, India has achieved impressive strides in the utilization of fertilizer nutrients since the start of the green revolution in the late 1960s. Over time, crop production under increased agriculture has led to widespread nutrient loss from the soil, causing a negative balance and deteriorating soil fertility. Organic sources are unquestionably a significant source of nutrients, but their quantities, availability, and rate of release are tragically insufficient to satisfy the needs of intensive and high-yield crop cultivation. Chemical fertilizers are the current form in which 15 m.t. of nutrients are used in India.

It would take more than 1,000 m.t. to provide the equivalent from organic sources, which is an insurmountable effort. Such organic manures in such vast quantities are neither produced nor readily accessible. As a result, it is only possible to rely on organic sources of nutrients to partially satisfy the crop's nutritional requirements. For the stability and sustainability of food production, they should be used in addition to artificial fertilisers. Food grain output climbed from 50 million tonnes to 200 million tonnes in India over the same time, while fertiliser usage increased from less than 50,000 tonnes in 1950 to 15 million tonnes in 2000, demonstrating a strong correlation between the two. Without a massive rise in fertiliser usage, the green revolution or dramatic increase in productivity would not have been conceivable. The high yielding strains acted as a catalyst to transform chemical energy into biological productivity. These cultivars had not yet reached their full potential. Because nutrient intake does not correspond to the demands of the crop and soil, even the technology's maximum potential is mostly unfulfilled in most places.

In each location, the amount of fertiliser used per hectare of harvested land varies greatly. In the north, south, east, and west, respectively, the fertiliser usage ranges from 114, 103, 58, and 47 kg (NPK) per ha of cultivated land. While some states use less than 10 kg of nutrients per hectare, others, like Punjab, use more than 167 kg. Wheat and rice cultivation need between 70 and 80 percent fertiliser. Other than these, sugarcane, cotton, potato, plantation, and horticultural crops are the principal users of the remaining fertiliser. Rainfed farming, which accounts for almost 66% of the nation's total planted land, uses the least fertiliser. It scarcely needs to be emphasised that in these rain-fed regions, more people suffer from a lack of nutrients than from inadequate rainfall. However, the latter is valued more than the former. The intake ratio of the three key nutrients N:P2 O5:K2O varies significantly among locations, crops, and farming methods. Due to ad hoc adjustments in fertiliser price policy during the last several years, these discrepancies also increased and displayed anomalies. Together with this, India's NPK ratio changed from 5.9:2.4:1.0 in 1991–1992 to 9.7:2.9:1.0 in 1993–1994 in the period under review. Divergence in ratios across various areas is another issue. In contrast, the ratio in 1995–1996 was 3.8: 1.4: 1.0 in the south and 41.4: 8.5: 1.0 in the north. The disparities in land quality, natural soil fertility, cropping practises, and level of exploitative agriculture are also to blame for this variance in the new ratio [5], [6].

According to summaries of soil test results, 98 percent of Indian soils have low to medium levels of accessible P and 60 percent have medium levels of K, however N continues to be an issue for all soil types. Zn, copper, and manganese deficiencies affect 47%, 12%, and 4% of soils, respectively. The lack of B and Mo in certain areas and crops is also starting to hinder agricultural productivity. Sufficiency in S has increased dramatically in recent years, particularly in intensive cropping systems where high analysis fertilisers devoid of S are utilised. In crops like oil seeds, legumes, and heavily fertilised rice and wheat, the S deficit is particularly noticeable. In fact, the range of S deficit is growing so quickly that it will eventually become one of the main factors limiting production.

It is said that planners are more focused on the yield limitations of certain high producing cultivars than they are with the fast-developing problem of plant nutrient insufficiency and the critical function that fertilisers play in ensuring food security. Thus, in a scenario where NPK is not the only nutrient that is becoming a limiting factor, other nutrients like Zn, Fe, Mn, Cu, B, and S are as well. A sustainable food security without a balanced and integrated utilisation of nutrients from outside sources is unimaginable. Under regions with intensive agricultural systems, which are the major contributors to the National Food Stock of Food Corporation of India, the spectrum of nutritional shortage is becoming more obvious. Due to uneven fertiliser application, there are indications of production stagnation and poor responses to fertilisers and other inputs.

Without a question, nitrogen is the most limiting element for Indian agriculture, but nitrogen by itself is insufficient, and fertiliser does not only refer to nitrogen fertilisers. Most often, terrible outcomes have resulted from a lack of this comprehension. The main challenge to increasing the economy of N usage, particularly in rice-growing regions, is increasing N use efficiency. Legumes and other biological nitrogen fixation techniques like BGA, Azolla, etc. may help rice crops meet part of their N demands via green manuring, but their utilisation comes with a host of logistical, financial, and technical issues. Under proper care, they may be counted on for a supply of 30 to 60 kg at most. The effectiveness of using biofertilizers is more crop-, location-, and management-specific, so the anticipated contribution won't be made unless there is a dependable system of quality control and an effective system of storage, transportation, and management in the field. Undoubtedly, there is a rising knowledge of the benefits of fertiliser usage in moderation, but very high N:P:K ratios are a cause for serious worry. Amazingly, Haryana's NPK ratios in 1995–1996 were 186:42:1 compared to Punjab's 64:14:1 and Tamil Nadu's 1.9:0.6:1 compared to India as a whole's 8.9:2.8:1. To get the most out of fertilisers, this ratio has to be brought closer to the ideal ratio of 4:2:1 for cereals. In India, P and K's position is more concerning. Other problems of concern are the falling productivity of soil and the usage efficiency of fertilisers [7], [8].

In green revolution border states like Punjab, Haryana, Uttar Pradesh, and other heavily cultivated regions of the nation, this exhausting impact is particularly pronounced. According to estimates, we remove more nutrients from the soil each year in the form of biomass than we add back in the form of fertilizer and manures. About 10 M.Th. of NPK appears to be the approximate size of the yearly negative balance. If we try to double the output and productivity, it will multiply. Agriculture will be unable to maintain its current high production levels and sustainability if this nutrient outflow persists.

India's population is growing at a rate comparable to that of Australia and New Zealand, and by 2025, it is predicted to reach the landmark of 1.4 billion people. India would need roughly 300 million tonnes of food grains a year to feed its enormous population. It could need 35–45 m.t. of nutrients from fertilizer sources, both organic and inorganic. In addition to these, it will need thousands of tonnes of Zn, Fe, Mn, Cu, and B. The usage effectiveness and management system, which will define their economics or benefit/cost ratio, are just as vital as the enormous volumes of fertiliser nutrients. There is thus no substitute for a balanced and integrated supply and management system when it comes to ensuring future national food security and security. In order to increase the economics or profitability of fertiliser usage, which incentivizes farmers to use it effectively, balanced fertiliser use is also required.

Additionally, it raises the quality of the highly sought-after food for both the domestic and international markets. It scarcely needs to be emphasised that many false beliefs regarding fertiliser usage degrading soil quality are specifically connected to the improper and unbalanced application of nitrogenous fertilisers. No single source of plant nutrition, whether chemical fertiliser, organic manure, green manure, biofertilizer, or crop waste, is able to keep up with the rising need for nutrients from crops. Furthermore, it may not be possible to get all the nutrients that the agricultural crops need from a single source. For instance, many chemical fertilisers may provide the nutrients N, P, K, Zn, and S; green manuring usage can fulfil a portion of N demand, one t organic manure can provide around 12 kg NPK, and also certain chemical fertilisers can provide the nutrients [8].

Micronutrients: Using biofertilizers may provide nitrogen at a rate of 20–25 kg/ha and can mobilize soil phosphorus. Crop waste, such as rice straw, is an excellent source of potassium. This suggests that balanced fertilisation and increased nutrient availability are the two most evident reasons why integrated utilisation of plant nutrients is crucial. Additionally, the coordinated utilisation of various plant nutrition sources boosts crop yield and plant productivity. Farmers should be instructed on how to use fertilisers responsibly. Recently, certain fertiliser groups and corporations have stepped up their efforts to educate the villagers by publishing material in local languages about the balanced use of fertilisers for increased agricultural yields in a sustainable manner. The moment has really arrived; farmers, researchers, and other relevant groups should step forward and take appropriate action. To increase crop output and soil productivity in a sustainable manner, chemical fertilizers should be used sparingly and in conjunction with manures.

DISCUSSION

Dry Land Agriculture

Dry land agriculture is the practise of growing crops only under rainfed circumstances. Dry land farming may be divided into three categories: dry farming, dry land farming, and rainfed farming, depending on the quantity of rainfall received. Crops are grown using dry farming methods in areas with annual rainfall of less than 750 mm. Prolonged dry periods throughout the agricultural cycle are the primary cause of crop failure. These are dry areas having a growth season (amount of time when the soil is sufficiently wet) of under 75 days. Crop cultivation requires moisture conservation methods. The emphasis is on conserving soil and water, sustainable crop yields, and sparingly using fertilizer in accordance with the availability of soil moisture.

Crops are grown on dry soil in areas with annual rainfall of more than 750 mm. Crop failure is comparatively less common, even extended drought conditions. With a growth period of between 75 and 120 days, these semiarid areas. Crop cultivation requires moisture conservation techniques. However, vertisols in particular need appropriate drainage. The main focus is on soil and water conservation, sustainable crop yields, and moderate fertiliser usage in accordance with the availability of soil moisture.

Crop production in areas with annual rainfall of more than 1150 mm is known as rainfed farming. During the crop time, crops are not under stress from soil moisture. These are humid areas where there is increasing It is important to distinguish between the terms "arid" and "semiarid" when referring to dry farming. Only arid and semi-arid regions contain all of the dry agricultural zones. However, not all arid and semiarid environments are suitable for dry farming. Irrigated farming is widely used in arid and semiarid countries where irrigation facilities are available. The distinction between the terms "tropical" and "temperate" must also be made. Tropical or temperate refers to a region's thermal (temperature) regimes, while dry or semiarid relates to moisture regimes.

Semi-Arid Regions of the World

The latitudes of this area are between 10o and 30o N and S. It is dispersed among 48 nations on the continents of Africa, Asia, Australia, and Australia. Numerous regions of Africa, Asia, Northern Australia, South America, including Mexico, Paraguay, Bolivia, and Venezuela, as well as India, Pakistan, and North Eastern Burma are all included. SAT is estimated to be 18.9 million square kilometres in size overall. Semi-arid tropics are mostly found in West Africa (24%) and East Africa (18%), South Africa (20%), Latin America (17%), Australia (10%), and South Asia (11%). A semi-arid climate is basically a mixed climate in which a season that is somewhat damp or rainy alternates with a season that is entirely dry. As a result, the climate is characterized as alternately rainy and dry. Two to seven months of the year are rainy. It is referred to as dry SAT when there are 2.0–4.5 wet months, and wet SAT when there are 4.5–7.0 wet months. The fluctuation of annual rainfall is 20–30%, with a range of 400–750 mm. But the start, end, and length of the rainy season vary greatly from year to year.

Wide variations between years may also be seen in the seasonal distribution of rainfall. The majority of the rainfall is received in brief bursts of high intensity, which causes runoff. The average annual temperature exceeds 18 °C, and in the majority of months, PET is greater than precipitation. Lack of enough soil moisture is the main barrier to crop production. The semi-arid temperate zone includes parts of North Western China, the USA, Canada, and Russia. The amount of rainfall each year is low, but PET is also low for several months. The average yearly temperature is below 18°C. The summertime maximum temperature is 33°C, while the wintertime low may drop as low as 26°C. The most significant limiting factor for agricultural yield is temperature, not moisture.

Dry Farming in India

The livelihood of the 70% of rural residents who live in arid agricultural regions depends on the success or failure of the crops. A large portion of the recent rise in food production is thought to be mostly attributable to irrigated lands. The amount of irrigated land in the globe has grown from 94 million hectares to around 220 million hectares since 1950. However, since the 1980s, the pace of irrigation development has significantly decreased and is now less than 1% per year, while the global population is growing at a rate of 1.7% per year. Although just 18% of the world's farmed land is irrigated, it generates 33% of the world's food. The average cost to build new irrigation and drainage systems is above $5,000 per hectare, but it may cost up to $10,000. Therefore, it is certain that most of the extra food in the future would originate from dry places. The gross irrigated area is projected to rise to 75–106 ha at the present rate of irrigation development, while more than 55% of the gross cropped area will continue to be farmed under rainfed circumstances. A little under 43 ha of India's 143 ha cultivable land was irrigated, allowing the other 100 ha to be rainfed. Experts estimate that 55% of the net planted area will still be rainfed even if the maximum irrigation capacity is attained.

In India, rainfed agriculture contributes (produces) around 45% of all food grains, 75% of all oilseeds, 90% of all pulses, and over 70% of all cotton. If India were to feed 1090 million people adequately in the 21st century, dry areas must provide 60% of the total. To accomplish this goal, enormous efforts are needed on both the development and research fronts. Sorghum, groundnuts, and pulses are grown on more than 90% rainfed land. 82–85% of the land used for growing maize and chickpeas is rainfed. Even 78% of the cotton growing area is rainfed. Approximately 66 percent of the land is rainfed in the case of rapeseed and mustard. Interestingly, but not unexpectedly, rain-fed agriculture accounts for 62%, 44%, and 35% of the land under rice, barley, and wheat, respectively.

Although India has an average annual rainfall of around 1200 mm, which is significantly more than the world average of 990 mm, the destiny of dry land crops depends on the amount, timing, and geographical distribution of monsoon rains. 30% of the nation receives less than 750 millimeters of the average annual rainfall, while 40% receives between 750 and 1250 mm. Only 20% of the land receives yearly precipitation between 1250 and 2000 mm, leaving 10% of the land with precipitation exceeding that amount. A thorough analysis of the current availability of rainfall reveals.

Currently, 3 ha of a dry land crop yields the same amount of cereal grain as 1 ha of an irrigated crop. The average production of dry land crops has room to grow by two times. Dry land agricultural yield increases are virtually undetectable. The only remaining alternative, given the limited potential for expanding the area under plough, is to boost productivity using contemporary technology and inputs, since the per capita land availability, which was 0.28 ha in 1990, is predicted to decrease by 0.17 to 0.19 ha in 2010.In irrigated agriculture, grain yield has already reached a plateau as a result of issues with nutrient depletion, salt buildup, and rising water tables. The problems of the current millennium thus lie in producing more from fewer dry areas while guaranteeing resource conservation. Therefore, new approaches would need to be developed to increase the sustainability and productivity of the vulnerable dry land ecosystems. We must use the most recent technical advancements to turn dry, grey landscapes (dry lands) into green in order to realise the evergreen revolution. Dry terrain has excellent opportunities for the establishment of agroforestry, social forestry, horti-sylvi-pasture, and other similar systems that will not only provide food, fuel, and fodder for the villagers' livestock, but also provide an appropriate vegetative cover for ecological preservation.

Soil erosion and runoff

In arid agricultural locations, detachment and movement of soil and soil components due to water and wind are quite common. Both red and black soils are subject to erosion. The most important fundamental resources, soil and water, must be preserved as efficiently as possible. Soil erosion, which results in the loss of precipitation and fertile topsoil, is the most devastating phenomena. The only known method for preventing land degradation and boosting the yield of dry land crops is soil and water conservation. Rainfall is wasted due to runoff. Even up to 40% of rainfall may be lost as runoff in uncontrolled circumstances. High intensity rainfall may cause up to 10% to 20% of rainfall to be lost as runoff, even when moisture conservation techniques are used. Erosion increases the likelihood of increased runoff by removing topsoil and exposing dense, impermeable subsoil. Erosion has a negative impact on the physical characteristics of the soil, including the loss of structure, decreased infiltration, depth, and moisture-holding capacity. Plant nutrients are lost when topsoil is lost due to erosion, and soil fertility is decreased.

The process of soil particles being separated from the topsoil and being transported by wind and/or water is known as soil erosion. Wind, channel flow, and raindrops dropping to the ground are the detaching agents. Moving water, splashing rain, and wind are the transportation agents. 175 m.ha. (53.3%) of India's total 328 m.ha. are affected by soil erosion and other types of land degradation. 104.6 mph. of which are cultivable. According to recent estimates, roughly 5,333 mt. (16.35 t/ha) of soil are removed each year (29% are taken by rivers to the sea, and 10% are deposited in reservoirs, causing a loss of 1-2% storage capacity).

erosion types

Geological erosion is thought to be in balance with the process of soil formation (a). It takes occur totally undisturbed by biotic influences beneath natural vegetative cover. Through climatic anomalies, such as intense rainfall and biotic intervention, the current topography features, such as stream channels, valleys, etc., have emerged over a long period of time.

Accelerated erosion

This occurs when human and animal activities such as poor land management, logging, overgrazing, etc. upset the natural balance. More soil is lost to erosion than is created by the process of soil formation.

Water erosion

The two primary factors that cause soil erosion are water and wind. The main erosive agents in water erosion are hitting raindrops and runoff water moving over the soil surface. Water erosion is commonly defined as loss of soil from land surface by water, including runoff from melting snow and ice. The processes of soil particle separation, transit, and deposition are embodied in erosion and sedimentation. By using erosive chemicals, soil particles are detached from the soil bulk. Transport refers to the removal of separated sediment (soil particles) from their original place. Part of the silt may ultimately reach the ocean as it travels down the stream. Along the route, some silt is often deposited at the bottom of slopes, reservoirs, and flood plains.

The three main objectives are to

- (i) Shape the land surface manually or with tools to decrease runoff velocity,
- (ii) Give raindrops more time to rest on the soil surface, and
- (iii) Promote greater penetration of raindrops into soil layers.

Characteristics of the rainfall, soil type, crops, sowing techniques, and slope of the land all affect the choice of any specific approach in a given setting.

- (i) **Basin listing:** Using a tool called a basin lister, little depressions (basins) that are 10-15 cm deep and 10-15 cm wide are created at regular intervals. The little basins catch the rain and make it easier to store. Usually, it is finished before seeding. All soil types and crops may use it.
- (ii) **Bunding:** Depending on the slope of the field, bunds may be formed across the slope at proper intervals, either narrow or wide in base. The bunds restrict runoff water from flowing freely, store rainfall in the inter-bund area, boost infiltration, and enhance soil moisture retention. The inter-bund gap must be levelled to guarantee an even water distribution and prevent water stagnation in certain areas. Three categories may be used to classify it:

a. **Contour bunding:** Bunds are built following the contour with dimensions of 1 m for the base, 0.5 m for the top, and 0.5 m for the height. Slope affects how far apart two contour bunds are. Cropping is done on the interbund surface after it has been levelled. It works well on deep red soils with a slope of under 1%. In thick black soils with little infiltration, where bunds are prone to cracking when dried, it is not recommended. Contour bunds are long-lasting constructions that need a lot of technical support and money.

b. **Graded/field bunding:** Depending on the slope, bunds are built at reasonable intervals of 20–30 m with basal widths and heights of 30-45 cm and 15-20 cm, respectively. Levelling and cropping are done in the inter-bund region. It works well on medium-to-deep red soils with 1% slopes.

Due of its vulnerability to cracking and breaching, it is not appropriate for dark soils. Bunds may be kept up for two to three seasons with occasional reshaping. (c) Compartmental bunding: To divide the field into tiny basins or compartments of 40 sq. m. size (8 5 m), little bunds of 15 cm width and 15 cm height are built in both directions (along and across slope). It works well with soils that are red or black and have a slope between 0.5 and 1%. With a local wooden plough, the bunds may be created both before and after sowing. It is ideal for crops that are widely planted. For the Kovilpatti area of Tamil Nadu, CRIDA has identified this technique as the optimum in situ soil moisture conservation mechanism. Sorghum, sunflower, and maize all work well for this sort of bunding.

Ridges and furrows

Alternatively, you may plant by yourself. Tie ridging is a variant of the ridges and furrows technique described above in which the ridges are joined or tied by a small bund spaced 2-3 metres apart along the furrows. Another variant is random tie ridging, which uses 20–25 cm-long discontinuous furrows. When weeding, spaces of 15 cm in depth, 45–60 cm in breadth, and 45–60 cm in length are created between crop clusters or hills. The practise of sowing in lines on flat beds and creating furrows between crop rows at 25–30 DAS is yet another variant of the ridges and furrows approach. This makes it possible to plant via a seed drill or behind a plough.

Recycling of rainwater

Runoff is the fraction of precipitation that travels as surface flow towards a stream, channel, lake, or ocean. Runoff often solely refers to surface flow. Rainfall runoff cannot be totally stopped and is an unavoidable occurrence. In arid agricultural regions, rainfall is often intense, exceeding the rate of penetration and leading to runoff. Additionally, runoff must occur when the amount of rainfall is greater than the soils' ability to retain water. In other cases, the surface properties of the soils can contribute to runoff. Normally, roughly 40% of rainfall may be lost as runoff under uncontrolled circumstances. Even if moisture conservation techniques are used, runoff still accounts for around 10-15% of rainfall in black soils and about 20% of rainfall in red soils.

Such runoff fluctuates in volume according to factors including rainfall frequency, soil characteristics, plant cover, slope, and cultural practises. If runoff water is not controlled, it wastefully runs out and damages the land. To increase the amount of water available to crops grown using rainwater, it may be directed, collected, and recycled. The method of water harvesting involves gathering, storing, and reusing runoff water. There are two perspectives from which to view water harvesting. First, let's look at a situation where runoff was caused by regular, heavy rain on a couple wet days. This runoff may be directed and collected in farm ponds, which are storage facilities, and then utilised to provide additional irrigation to crops that are under moisture stress. Macro watershed approach or macro catchment water harvesting are the terms used to describe this. The second situation involves less overall rainfall and insufficient soil storage to enable crop development. Here, a portion of the land is left uncultivated and barren. This region is referred to as a donor area and is managed to enhance drainage following rainfall. To boost the next lower strip's ability to store soil moisture, the runoff from the donor strip is diverted there. Crops are raised on this stretch. Micro watershed technique or micro catchment water harvesting are the terms used to describe this.

Water harvesting through farm ponds

In India, the practise of collecting rainwater and storing it in large agricultural ponds is not new. Since the beginning, it has been popularised in the shape of tanks. Small storage facilities called farm ponds are built at the lowest point of a farm to catch and hold runoff water. Grass-lined canals correctly direct runoff from different catchment areas into the farm pond. When building agricultural ponds, the following factors need to be taken into account.

(i) Farm pond technology is better suited to deep heavy soils with limited permeability than to shallow light soils with high permeability. Ironically, however, light soils with little water storage capacity benefit from agricultural ponds the most.

(ii) To collect runoff water from the whole farm area, a farm pond must be built at the lowest point of the farm.

(iii) The amount of rainfall, soil type, catchment area (the size of the farm), and expected drainage all affect the size of the farm pond. It is necessary to make arrangements for a weir to stop dirt from entering the pond at the intake point and for the drainage of extra water once the pond is full.

(iv) Grassed streams must be used to direct runoff to the farm pond.

(v) Water loss from evaporation and seepage has to be monitored. The bottom and sides may be lined with soil, sand, cement, or soil, cow dung, and straw, and the top can be treated with sodium chloride or sodium carbonate to prevent seepage loss. By using floating objects to keep the water's surface from being exposed directly and by making the pond circular rather than rectangular, it is possible to lessen evaporation loss.

Advantages: Harvested water may be used to crops during vulnerable phases as protective irrigation. Erosion is reduced because runoff is correctly directed via grassed streams. Field bundling and levelling may be accomplished using earth removed from ponds. Water that has been stored may be utilised for fish farming, spraying activities, and drinking water for people and animals. With the use of protective irrigation, high-value tree crops may be grown next to agricultural ponds. The region's ground water may be replenished through a network of agricultural ponds.

CONCLUSION

A sustainable agriculture method called integrated nutrient management (INM) is essential for maximising crop yield and fostering soil health. This study work has investigated the ideas and methods of INM in farming, highlighting the significance of balanced Nutrient management for long-term crop growth. The research emphasised the importance of managing soil fertility and the function of critical nutrients in promoting plant development. Formulating efficient INM methods requires a thorough understanding of nutritional needs. In order to increase nutrient availability in the soil, the study also looked at the idea of nutrient cycling and the combination of organic and inorganic fertilisers. INM seeks to preserve nutrient balance and reduce nutrient losses, ensuring that crops use nutrients effectively. Understanding the advantages of INM provides chances to improve soil health, boost nutrient usage effectiveness, and encourage sustainable crop production.

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CHAPTER 17

ANALYSIS OF REDUCE EVAPORATION LOSS IN AGRONOMY

Utsav Shroff, Director
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email id-utsav.shroff@atlasuniversity.edu.in

ABSTRACT:

The loss of important water resources from reservoirs, lakes, and other water bodies is a key problem in the management of water resources. This study intends to investigate evaporation loss estimates, effects, and mitigation techniques. The research explores how variables including temperature, humidity, wind speed, and surface area affect evaporation and the amount of water available. It looks at how evaporation loss affects the viability of water resources, agricultural output, and ecosystem health. The efficiency of different evaporation reduction strategies, including as covers, films, and water-saving technology, is also investigated in this study. Optimising water usage efficiency, resolving water shortages, and promoting sustainable water resource management all depend on an understanding of the dynamics of evaporative loss. The report also discusses how this information may be used to improve water resource resilience and environmental sustainability via climate-smart water management, water conservation, and water policy.

KEYWORDS:

Evaporation Reduction, Sustainable Water Management, Water Conservation, Water Resource Sustainability, Water-Saving Technologies.

INTRODUCTION

Shallow surface tillage: Capillary pores are disrupted and water cannot ascend by capillary action when surface soil is agitated by tillage. After summer rains, shallow tillage is advantageous in this respect. Dust mulching is the term for this procedure. Similar results are seen by inter-tillage between crop rows during early dry periods. Mulching: Mulching is the practise of covering the soil's surface with any kind of substance, such as plastic, polythene sheets, organic waste, etc. Crop stubbles, straw, coir pith, groundnut shells, husks, and other organic wastes are utilised as mulch. These wastes are dispersed throughout the surface of the soil at a rate of 5–10 t ha1. The following advantages of mulching include: lowering the direct effect of raindrops on soil particles and reducing splash erosion. Infiltration is increased. Controls erosion and lowers runoff water velocity [1], [2].

(i) enhances soil moisture absorption from precipitation.
(ii) manages loss due to evaporation.
(iii) inhibits the development of weeds.

Reduces soil temperature, which affects the thermal regime of the soil, enhances microbial activity, regulates salinity development, and may subsequently be added as manures.A method called vertical mulching involves digging trenches that are 40 cm broad and 15 cm deep at 2-4 m intervals over a slope, and then filling them with organic waste or stubble until they reach a height of 10 cm above the soil's surface.Runoff is analysed, gathered in the little trenches, and then redistributed to surrounding soil strata. This technique might be seen as a forerunner to the wide bed furrow technique. In an intercropping system, covering the soil surface via the plant canopy is known as live mulching. For instance, sorghum combined with forage cowpea or sword bean. The term "dust mulching" describes the tillage-related changes to the soil. The surface soil is disrupted when land is ploughed or agitated, which disrupts the continuity of capillary pores from the subsurface to the top. As a consequence, soil moisture is preserved and evaporation is controlled. The tools used for dust mulching include the Guntaka (blade harrow), Danti, and hand hoe [3], [4].

Covering the soil's surface with cumbu/sorghum straw, sugarcane rubbish, or "straw mulch," lowers evaporation and improves soil moisture efficiency. Similar mulching techniques may be used with organic waste, agricultural wastes, and plastic materials. By stirring the soil with tools that leave a significant portion of plant matter, agricultural leftovers, or vegetative litter on the surface, erosion is prevented and moisture is conserved by promoting infiltration and lowering evaporation. This practise is referred to as "stubble mulch." In western nations, where agricultural byproducts like straw, stover, or haulms are not used as animal feed, Stubble mulch is used quite well. There are specialised farming tools that cause the least amount of disruption and leave a significant amount of surface unaffected. Additionally, it serves as conservation and little tillage [5], [6].

Pebble mulch is created by covering the soil's surface with tiny stones or pebbles. Fruit tree cultivation on dry terrain will benefit from this mulching. In addition to lowering evaporation, stones put atop tree basins also make it easier for precipitation to infiltrate the basin. Utilisation of anti-evaporating substances Anti-evaporants are substances like hexadecanol. Hexadecanol is said to minimise evaporation by 43% when sprayed on top of soil. The treated top layer quickly dries off and forms a diffusional barrier that prevents water vapour from rising. It is not susceptible to microbial growth or deterioration. It stays in the soil for almost a year. Additionally, it improved the stability of soil aggregates. Wax emulsions, rubber/plastic boats, or sawdust may all help to minimise evaporation from free water surfaces such as agricultural ponds, lakes, and lakes by as much as 80%.

Protection belt: The hot winds in arid and semiarid areas dry the topsoil, generate a vapour pressure gradient, and cause continual vapourization to occur. By increasing the shelterbelt, this ongoing vapourization may be stopped. To lessen the impact and speed of the wind, it is common practise to plant one or more rows of trees, shrubs or crop plants across the wind direction in the field or along field borders. By decreasing evaporation and increasing soil moisture content by 3-5%, shelterbelts may help crops cultivated nearby that are under terminal moisture stress. Due to the pleasant microclimate that shelterbelts have helped to produce, the percentage of soil moisture has increased. In arid terrain, cattle might utilise it as a resting spot.

A decrease in wind speed reduces pollen drift in orchard crops, which increases pollination percentage and enhances fruit setting. Numerous trees in the shelterbelt are crucial economically. Trees that have been maintained for a long time may be removed and used as raw materials for manufacturing. Fruit produced by trees planted in a shelterbelt has a greater monetary value. Although a windbreak is a kind of shelter belt, it only consists of one row of tall trees with a decent leaf canopy planted in a North-South orientation to reduce wind velocity and, therefore, soil erosion. For wind breaks, tall trees like eucalyptus, casuarinas, and wood apples are cultivated. After years of upkeep, these trees may be inexpensively removed [7], [8].

Preventative measures against transpiration loss Even while transpiration is a necessary and inevitable evil, it must be managed when it becomes excessive, particularly when soil moisture stress occurs during key periods of crop development. The potential for soil moisture, the need for water in the atmosphere, and characteristics of the plant canopy, such as leaf area, leaf orientation, stomatal resistance, etc., all influence the rate of transpiration. Antitranspirants and a few cultural practises may both help to minimise sweat loss.

DISCUSSION

Antiaspirants

In order to limit the rate of transpiration, plants are treated with substances or chemicals known as ntitranspirants.When using antitranspirants, it's important to keep two things in mind: (a) they should limit water loss from leaf surfaces without limiting carbon dioxide uptake for photosynthesis; and (b) antitranspirant application shouldn't completely halt transpiration, which would raise leaf temperature.Antitranspirants are divided into several categories based on how they work.They force the guard cells to shut, which causes the stomata to partially or completely close. However, total stomatal closure has a negative impact on gas exchange and photosynthesis. These substances are also very pricey and have the potential to be phytotoxic. For instance, alkanyl succinic acid (ASA) and phenyl mercuric acetate (PMA).

They produce a thin layer across the surface of the leaf to hide the stomata. These materials are non-toxic, non-biodegradable, and relatively simple to use, yet they have a negative impact on photosynthesis. For instance, folic acid 2%, wax and paraffin emulsions, and power oil 1%. Antitranspirants of the reflectant class make leaves more reflective of sunlight when they are sprayed on their surfaces. As a consequence, there is less demand for transpiration, lower internal leaf temperature, and less heating. For instance, a Kaolin and lime solution. Spraying kaolin at a concentration of 3-6% decreased transpiration by 22-28% and leaf temperature by 3–4 °C. Since there is no stomatal closure, they are less costly, non-phytotoxic, and do not affect photosynthesis. Growth retardant: When sprayed on foliage, chemicals like Cycocel (ccc-chloro choline chloride, chlor mequat) limit leaf area, which in turn reduces transpiration.

Intercropping

Growing two or more crops simultaneously on the same field is known as intercropping. Due of its various benefits, intercropping is commonly used in dry farming. Intercropping is a risk-reduction tactic that offers protection against total crop loss caused by anomalous rainfall. The time gap between the constituent crops allows for this. Compared to solitary cropping, it offers a higher return and revenue per unit of land and time. Production stability is attained. There are several goods accessible for both marketing and domestic use. Soil fertility is increased when legumes are included into intercropping. The canopy of intercrops inhibits weed development. Some intercrop systems, such as cotton and cluster beans, provide biological management of pests and diseases. Cluster bean intercrop lowers cotton jassid incidence. The efficient utilisation of light, water, and nutrients increases resource use effectiveness. The complementary benefits must be maximised while the rivalry between the component crops must be kept to a minimum for intercropping to succeed. The following methods may be used to achieve this:

(i) Selection of appropriate component crops with varying length, rooting pattern, canopy architecture, nutrient need, and occurrence of crucial phases.
(ii) Leguminous crops are preferred as intercrops;
(iii) Selected genotypes in each component crop;
(iv) Optimal population of component crops;
(v) Appropriate crop geometry to give appropriate area for intercrops;

Seed hardening:

It is done to increase the seedlings' resistance to drought. To make seeds more tolerant to drought, seeds are first soaked in a chemical solution and then dried. Germination and establishment are impacted by the immediate post-sowing soil moisture stress. Seed hardening makes it possible for seedlings to endure this first moisture stress. Before planting, seeds undergo partial hydration during seed hardening, followed by dehydration. In chemical solutions with a set concentration, seeds are soaked for a certain amount of time. After being soaked, seeds are dried in the shade to remove excess moisture. Water is ingested by the seeds while they are soaking, but the germination process is not yet complete. Thus, the hardened seeds are prepared for germination. Immediately after being planted in damp soil, seeds begin to grow. Such early germination aids in the emergence of seedlings before the topsoil dries up.

In comparison to untreated seeds, seed hardening provides earlier germination by 2-3 days and promotes greater root growth, which makes it possible to absorb more moisture. Before the topsoil dries up, germination and seedling emergence are finished. By strengthening early seedlings' resilience to protoplasmic dehydration while under moisture stress, it promotes drought tolerance. Within 30 days of treatment, hardened seeds may be planted immediately or later. The most crucial need for pre-monsoon planting is seed hardening, which is regarded as a low-cost technique. For seed hardening to be successful, consideration must be given to chemical choice, concentration, soaking period, volume of solution, and drying in shade to original moisture content.

For pulses (black gram/green gramme), 4 kg of wood ash is gathered, finely pulverised, 30% Acacia gum is added, and everything is well combined to create wood ash-gum paste. Spread over the Acacia-wood ash paste, 8 kg of black gramme or green gramme seeds are well mixed to cover all of the seeds with the paste. After being treated, the seeds must be shade dried for five hours before planting. Sowing when the soil moisture is ideal: For sowing, an effective rainfall of 20 to 25 mm is required, which may moisten the soil to a depth of 10 to 15 cm. The germination and establishment of seedlings are negatively impacted by moisture stress during or just after seeding. Sowing must be done as soon as feasible after receiving heavy rains in order to guarantee enough soil moisture at that time. Tools and techniques for sowing are essential in this respect.

Pre-monsoon dry seeding

Sowing after rainfall is difficult in certain areas where thick clay soils predominate because of the soil's extreme stickiness. Pre-monsoon planting takes place here on dry soil two to three weeks before to the start of the monsoon season. Only when seeds get the ideal amount of water will they stay in the soil and sprout. Early sowing, uniform germination, excellent establishment, using the first rains for germination rather than for land preparation in post-monsoon sowing, early maturity before monsoon closure, and avoiding stress at maturity are benefits of pre-monsoon dry seeding. Pre-monsoon dry seeding for sorghum on black soils is advised 1-2 weeks before the start of the monsoon, with a sowing depth of 5 cm and seed hardening with 2% potassium di-hydrogen phosphate or potassium chloride. Pre-monsoon dry seeding of cotton on black soils is advised at least 2-4 weeks before to the start of the monsoon, with a sowing depth of 5 cm and seed hardening with CCC (500 ppm), potassium chloride, or DAP at 2% level.

The following factors determine whether pre-monsoon dry sowing is successful:

It is only advised for crops with bold seeds, such as cotton and sorghum.

The following requirements must be met:

(i) Seeds must be hardened to ensure quick germination and drought tolerance;
(ii) Time of advance sowing must be determined based on rainfall analysis for date of monsoon onset and continuity of rainfall after sowing;
(iii) Seeding depth must be such that seeds will germinate only after receipt of rainfall to wet that depth is received. Less rain may fall as a result of surface seeding, but the ensuing soil drying may cause the seeds to die.
(iv) Off-season tillage is required to allow for planting on dry soil before to the monsoon. It is necessary to avoid soil insect damage to seeds.

Rainfall and soil moisture availability

Positive interactions between water and nutrients show a mutually enhancing impact. Higher nutrient absorption and reaction are made possible by sufficient and evenly distributed rainfall. This is made possible by enhanced root development, increased microbial activity, and increased nutrient transport in damp soil. Due to decreased nutrient mobility, constrained root development, a high salt content in the soil solution, nitrogen fixation, and decreased microbial activity during moisture stress, nutrient absorption is negatively impacted.

By promoting widespread root development, reducing soil evaporation, and increasing production, nutrient delivery increases water usage efficiency. For managing soil fertility, information on rainfall amount, distribution, and likelihood is particularly helpful. If a place is deemed to have a consistent monsoon onset and therefore sufficient soil moisture for crop development, basal fertiliser application would be safe. Top dressing would be advantageous if early growth stage rainfall was consistent and guaranteed. Given that arid soils often experience heavy rainfall, using nitrogen in two separate applications would be beneficial to avoid loss via leaching. The timing of fertiliser applications might be influenced by rainfall progress throughout the crop season and the soil profile's capability to store moisture.

(a) **Variety and crop:** The capacity of various crops and types to absorb applied fertilisers varies. Because hybrids and high yielding varieties (HYV) have higher production potential at the same level of resource availability, they perform better than local varieties. The way different crops react to certain nutrients differs depending on the species. Legumes react better to P2O5, oilseeds to N, P2O5, and K2O, whereas cereals and millets respond better to N.
(b) **Soil characteristics:** Soil physical characteristics primarily affect soil moisture availability, which has an impact on crop response. The condition of the soil's nutrients has a major impact on how crops respond. Most dry soils lack nitrogen, thus there is a global reaction to nitrogen. P2O5 response is based on soil fixation, while K response is based on leaching loss.
(c) **Management techniques:** Crop response to nutrients is also influenced by nutrient management techniques such as amount, timing, and manner of delivery of nutrients, inclusion of legumes in cropping systems, and soil moisture conservation techniques. Nutrient application in damp soil and loss prevention must be ensured by the application method. N may be applied broadly and integrated during the final ploughing. N fertiliser applied topically to crops may help them recover from stress. It is efficient to distribute P2O5 in the root zone through basal incorporation or at a distance of 5–10 cm from the seed rows in order to avoid fixation and provide easy availability. Application as enriched FYM is advised to prevent applied P from becoming fixed. For crops cultivated on moisture conserved after a wet season, deep placement is crucial. At the final ploughing, K is applied broadly and assimilated.

After seeding, micronutrients are applied but not assimilated. For the planting of fertilisers, using a seed cum fertiliser drill is particularly helpful.

The timing of the application should take into account the crop's needs and the availability of moisture. Since there is always enough moisture at the time of sowing, basal application works. Depending on the amount of rain, N may be top-dressed at 25–30 DAS. If rainfall is insufficient, this makes it possible to forego fertilizer and save money. For millets and cotton, complete P and K are applied as a base, and 12 N is used as a topdressing. Full NPK is administered basally to other crops. Whole P may be administered primarily as enhanced FYM to crops grown before to the monsoon, such as cotton and sorghum. Depending on the amount of rainfall during the relevant time, full N applications for sorghum may be made at 30-35 DAS and two equal splits for cotton can be made at 20-25 and 40-45 DAS.

CONCLUSION

The study of evaporation loss has the potential to inform water policy, water conservation, and climate-smart water management. By putting these techniques into practise, you may improve the sustainability of water resources. In conclusion, further study in this area is necessary to advance our understanding of evaporation loss and its consequences for managing water resources. Adopting evaporation reduction strategies and putting responsible water management first may support environmental sustainability and water conservation. Additionally, incorporating water-saving technology into water resource management procedures may assist sustainable water usage in the face of changing environmental circumstances and help optimise water resources. For present and future generations to have access to water resources and to promote a healthy and resilient ecosystem, prudent evaporation loss reduction must be encouraged.

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CHAPTER 18

ANALYSIS OF CLIMATOLOGY: WEATHER AND CLIMATE

Divya Vijaychandran, Assistant Professor,
Department of ISDI, ATLAS SkillTech University, Mumbai, Maharashtra, India,
Email id- divya.vijaychandran@atlasuniversity.edu.in

ABSTRACT:

The core field of atmospheric science known as climatology studies the variability and long-term patterns of weather and climate events. Understanding the connections between the atmosphere, seas, land, and biosphere that influence weather and climate patterns is the main goal of this study paper's exploration of the climatology's guiding concepts and methodology. The research explores the changes in temperature, humidity, air pressure, and wind across various geographical locations as well as other elements that affect weather. The study also explores the more general ideas of climate, such as classifications of climate, climate change, and climatic variability. For evaluating environmental threats, adjusting to changing climatic conditions, and boosting environmental resilience, an understanding of climatology is essential. In order to solve climate-related issues and advance sustainable development, the research also emphasises possible uses of this information in climate modelling, climate prediction, and climate policy.

KEYWORDS:

Climate Change, Climate Modeling, Climate Variability, Environmental Resilience, Weather Patterns.

INTRODCUTION

The study of the earth's gradient is called climatology. Its root is the Greek term Klima, which means "incline of the earth," and the word "logos," which means "study." It is associated with regular climatic fluctuations over an ambiguous time period. The phrases "climate" and "atmosphere" have there are many undertones. Climate is the state of the air at any given time that displays brief variations in the physical condition. For instance, pressure, wind speed, precipitation, darkness, and so on, whereas atmosphere is defined as the sum of the variations in climatic states of a certain location, district, or zone during a specified period of time, often a few years.

The climate and weather are governed by a number of elements. Latitude, elevation, precipitation, soil type, proximity to water bodies, terrain, vegetation, wind, air masses, etc. are some of them. The four classifications of altitude tropical, subtropical, temperate, and polar are based on latitude. The term "altitude" refers to the height above mean sea level, which affects the region's type of flora, soil, and agricultural output. The kind of vegetation in each location is determined by the quantity and quality of rainfall. Arid, semiarid, subhumid, and humid climates are divided based on the amount of precipitation they get. Another result of a shift in atmospheric activity is the kind of soil [1], [2].

Monsoon Rainfall Variability

The monsoon, a series of cyclones that form in the Indian Ocean, is the sole source of precipitation for the Indian subcontinent each year. The most significant cyclones, which produce summer storms or southwest rainstorms, happen between June and September. Another stormy season, from October to December, also exists. Out of four rainy periods, the southwest storm is the most important since it accounts for between 80 and 95 percent of the total precipitation. There are two different types of storm frameworks: the north-east monsoon and the south-west rainstorm.

a. In the middle of March, a south-west storm causes atmospheric pressure to increase in the interior of the Indian Peninsular, where the temperature rises swiftly. The area with the highest temperatures shifts to the north, the lower Punjab, and western Rajasthan in April and May. The south-west storm's western edge touches north Karnataka, south Maharashtra, and Gujarat. While the south-west rainfall is finishing up in western India, there is another portion of a related phenomena in the Bay of Bengal that causes downpours in Myanmar, the northern portions of India's east coast, Assam, and other places.
b. North-East Monsoon at the end of September, a storm from the southwest moves into northwest India.However, it stays in Bengal for the whole month. In northern India, there are increases in the barometric load. As a result, the atmospheric pressure shifts to the south-east and north-easterly winds start to impact the east coast. Summer precipitation is gotten from March to May as neighbourhood storms, which are typically gotten in the south-east of the peninsular area and Bengal.
c. Winter precipitation is more restricted to north India and is gotten as snow on slopes, with precipitation in the fields of Punjab, Rajasthan, and focal India.
d. The country's western regions do not experience precipitation [3], [4].

Cloud Formation and its Importance

The evident sum of water, ice, and bead particles that are visible at any one time and are typically above ground level are called clouds. Mists have been classified as high clouds, medium clouds, and low clouds depending on their size and appearance. Based on their heights and appearance, WMO (1957) divided clouds into ten types. Family A, B, C, and D clouds are divided into four groups based on height.

a. Cirrus (ci), Cirrocumulus (cc), and Cirrostratus (cs) are all members of Family A, often known as High clouds (height 5-13km and 20000ft above MSL). These are tall clouds. They are divided into three groups:

(i) Ice crystals in cirrus (Ci) have the appearance of being wispy, feathery, fragile, white fibrous, and silky. It is sunny and there is no precipitation.
(ii) Cirrocumulus (Cc), which resembles wavy sand and features white globular masses without any shading, contains ice crystals.
(iii) Cirrostratus (Cs) - It creates "Halo," contains ice crystals, and has the appearance of a milky white veil.

b. Altostratus (As) and Altocumulus (Ac), members of Family B, sometimes known as middle clouds (mean height 2-7 km and 6500-20000 ft above MSL), are two such clouds.

(i) Altocumulus (Ac) is a kind of cloud that resembles sheep wool and contains icy water.
(ii) Alto-stratus (As) - It forms coronas, contains water and ice, and casts a shadow.

c. Family C, often known as low clouds, contains the clouds Nimbostratus (Ns), Stratocumulus (Sc), and Stratus (St), which are all near to the earth's surface (mean 0-2 km).

(i) Stratocumulus (Sc), which is made of water, has bigger globular masses and a soft, grey appearance.

(ii) Water makes up stratus (St), which is mostly visible in the winter and sometimes drizzles.

(iii) Nimbostratus (Ns), which produces constant precipitation and is made up of water or ice particles. It has a consistent coating and a thick, greyish appearance.

d. Family D: Vertical growth is what causes the clouds to form. Cumulus (Cu) has a beautiful white look and is made of water. It transforms into flat-topped cumulo-nimbus clouds as it grows. Cumulonimbus (Cb) is a kind of cloud with ice in its top layer and water in its bottom. During the summer, these clouds create violet thunderstorms, hail, and lightning [5], [6].

DISCUSSION

Evaporation, Transpiration, and Evapotranspiration

The process from the soil is evaporation. It establishes how much water is needed for irrigation of a crop.It is influenced by a number of variables, including environmental conditions (such water temperature, wind, RH, and pressure) and water parameters (like water composition and evaporation area). Transpiration is the mechanism through which existing plants lose water. It could be cuticular, lenticular, or stomatal. It is influenced by a variety of environmental and plant-related elements, including as light, relative humidity, air temperature, wind, plant height, leaf features, and the availability of water. Water evaporates from the soil's surface and transpires from plant surfaces during evapotranspiration. The ET process is influenced by a number of variables, including the plant's energy source, light, temperature, relative humidity, and wind speed. The root shoot ratio, leaf features, cuticle thickness, etc. are examples of plant traits. Planning the crop's irrigation schedule and taking into account the relationship between crop output and irrigation water need a procedure known as soil moisture estimate.

Dryland Agriculture

The cropping system is made up of a number of parts that are important to agriculture, whether it is practised for self-sufficiency or for profit. Individual farmers, in contrast to commercial agriculture, adhere to a cropping strategy based on the crops' suitability to the environment and season, home necessity, and profitability. The primary element of the agricultural system, the cropping system, must be determined by both management practises and production technologies. It is about the editing style that is used at the homestead, its interactions with ranch resources, other ranch endeavours, and easily available innovation. It leads to the efficient use of available resources and a reduction in production costs. It describes the size of the area where yields are produced for a certain period of time in a given location. It might be a spatial game plan for the harvests in a particular region or the annual sequencing of crops. Crop rotation seeks to establish a schedule of harvests on a comparable plot of land, either annually or over a longer period of time, without compromising the soil's fertility. This will boost benefit with little expense and allow for the complete development of the planned progression of yields [7], [8].

The cropping pattern describes how much land is allocated for various harvests during a certain period of time in a particular location. The yearly grouping and altitudinal sequencing of harvests in a specific area may be used to objectively characterise the cropping pattern. The term "effective cropping zone" refers to the area where harvest productivity increases due to favourable environmental factors that promote crop growth and profitability. There are several different cropping zones, including those for rice, wheat, sorghum, maize, bajra, finger millet, pulses, and fodder crops.

The cropping system refers to the crops, their timing, and the management techniques used throughout time on a certain plot of land. Cropping systems come in a variety of forms, as seen below. These are what they are: Double cropping is another name for sequential cropping. This is the process of getting ready to plant a different crop soon after the previous one has been harvested. Thus, the same plot of land may produce two harvests in the same year. Intercropping is the simultaneous cultivation of two or more crops on the same plot of land. In the field, the two crops face up against one another. Row intercropping, when both crops are primary crops as well as intercrops, is a technique where weeding, harvesting, and other intercultural procedures are considerably simpler than with mixed cropping.

When one crop is planted on a field, the practise is known as monocropping or monoculture. Continuous monocropping is the practise of growing the same crop in the same land year after year. For instance, growing wheat on the same plot of ground every year. The ground loses fertility gradually, which makes it unproductive and may lead to pest, disease, and insect infestations. Relay cropping is the practise of planting different crops in the same land at different times. One method of planting a new crop before the current crop is harvested is the handoff cropping technique. This aids in preventing competition between the main crop and the intercrop where the field may be used for a longer period of time.Strip cropping occurs when at least two yields are planted in strips in the same field, which causes the plants' competition to occur inside the harvests rather than between the yields.Crop rotation is the practise of switching up the crops grown in a field every season [9], [10].

ndia is a tropical nation that lies between 68- and 96-degrees east longitude and 8 and 36 degrees north of the equator. The northern and southern regions of the nation experience different temperatures. In succeeding years, the rainfall is unpredictable. Western Rajasthan has some deserts with annual precipitation of less than 100 mm, whereas eastern India may get more than 10,000 mm. It may rain for one or two months in certain areas of the nation while it may rain for more than ten months in others each year. Rainfall varies in odd ways. Crops suffer when there is a rainfall shortfall, but when there is an excess, the soil's ability to store water is reduced. Rainfall that is distributed unevenly causes runoff, prolonged dry periods that interfere with agricultural development, and moisture stress. Early withdrawal or a lack of rain may sometimes stress a crop's maturation or lower its yield. For plants, rainfall is their main supply of water. Droughts are a result of unpredictable precipitation over an extended period of time.

India has two distinct monsoon seasons. The monsoon season accounts for over 80% of all yearly precipitation. The south-west monsoon, which originates in the south of India and flows towards the west of the nation, is the major rainy season and lasts from June to September. While it lasts for five months in Peninsular India, the distribution of rainfall lasts for around two to four months in northern and northwestern India's most agricultural regions. In the south, in places like Bangalore and Trivandrum, it lasts considerably longer. Rainfall climatology is the study of rainfall over a long period of time. It displays the typical pattern of local precipitation. Understanding the pattern of irrigation and the timing of irrigation is made easier with the use of rainfall analysis. Designing agricultural ponds and tanks for irrigation projects requires an understanding of the rainfall pattern. There are several kinds of precipitation and mist that builds up. Frost and dew are not regarded as precipitation. An increase in rainfall reduces yield. It might result in runoff, plant nutrients being lost to the root zone, and crops being negatively impacted by anaerobic conditions.

Indian Dry Farming Scenario

The amount of irrigated land in India and around the globe has increased from 94 million hectares to 20 million hectares since 1950. Out of the 143 million hectares of irrigated land in India, very nearly 43 million hectares are developed, while the remaining area is supplied by rainfall. Up to 85% of maize and chickpea crops are rainfed. The average annual precipitation is little over 1200 mm, which is somewhat more than the 990 mm world mean. Only 20% of the Indian zone receives precipitation between 1 and 500 and 2000 mm. And 10% of the zone receives more than 2000 mm of precipitation annually. Agroforestry, social forestry, silvi grazing, etc., are options for dry land farming that may provide the villagers' residents and their cattle with fuel instead of food while also providing an adequate vegetative cover for ecological preservation.

Things That Affect Dry Farming

The majority of the agriculture in the region occurs in semi-arid regions that get constant rainfall. A unstable agricultural output is caused by factors impacting dry farming, which was just low input subsistence farming before. There are many factors that limit dry farming, including: Variable precipitation also affects the coefficient of variety. Climate constraints include factors like atmospheric temperature, relative humidity, high atmospheric water demand (i.e., potential evapotranspiration), precipitation throughout most of the year, and whims of the monsoon. Uncertain rain or the majority of subsequent downpours call for an explanation, while less precipitation calls for another. Harvest effectiveness is impacted by the intensity and distribution of precipitation. In general, three to five stormy days or more than half of the entire precipitati6on occur within a week. This causes a major water loss due to surface water overflow, which causes soil erosion and, in turn, impairs dryland agriculture. Another factor is the late monsoon's arrival, which prevents the region's preferred crop kinds from blooming at that time. Delay in sowing might result in unprofitable crop output. Early monsoon departure is similarly hazardous since it causes crops to experience terminal stress and lower output.There is a crucial condition for soil moisture influencing production when the monsoon is interrupted for more than 15 days.

Irrigation Management Under Limited Water Supply

Integration of all water resources like surface, ground water, wastewater, snow, dew etc., is most important to achieve maximum food production per unit quantity of water used to meet the demand from 1 billion populations present. In this juncture, water resources itself become a constraint due to abnormality in distribution and uncertainty it in the occurrence of rainfall. Hence, at present frequent droughts are very common. Under these circumstances, a new water saving strategy has to be adopted in irrigation management and in crop production activities. This part of the chapter discusses about water scarce conditions and the ways to overcome it with some drought alleviating methods.

Water Scarcity Conditions

The word "water scarcity" refers to inadequate storage of, or non-availability of, the necessary amount of water for agricultural production and other uses owing to monsoon failure. Due to the shortage, the cultivated fields will get insufficient water supplies, which will put the plant community under stress. The frequency of irrigation, the kind of crop, the type of soil, and other factors affect how stressed a plant is. Our main objective in this scenario is to obtain the most yield per unit of water. The approaches listed below may be used to manage stress. Analyse the resource potential and employ approaches from linear programming to maximise water consumption. The relevant department should carry out this kind of activity, notably irrigation and agricultural.

Farmers' attitudes - Farmers' or users' behaviours need to be significantly reoriented in order for them to understand that conserving water is their main duty and that it is an economic input. Changes to the conveyance system are needed since a lot is wasted during the transfer from source to field. The amount of water wasted through conveyance systems is thought to be between 30 and 40 percent. By performing routine maintenance, lining the channels, and other measures, such water losses may be reduced or entirely avoided. Pipe conveyance is often used for ground water resources. In command regions, such conveyance is possible even at low sluice levels. Conjunctive use of water refers to the integration of all water resources with waterconservation techniques. Conjunctive usage's primary goal is to utilise water from many sources as efficiently as possible. Conjunctive use of water, for instance, refers to the best use of rainfall and well water in a canal irrigation system to preserve the crop without depleting either water supply. Rice is a semi-aquatic plant, thus for it to establish itself and produce more, water must be surrounded by it. The experimental data unmistakably showed that 5 cm of ponding depth is preferable to greater depths one day following the absence of previously supplied water. This was due to enhanced root activity and greater aeration.

Soil Fertility Management under Dry Farming

In the instance of dryland farming, the fertilisers used in the experiment and agricultural crises ranged from 5 to 50 kilos per hectare of nitrogen, phosphorus, and potash. There is a lot of uncertainty about the return from the speculation of fertiliser usage and scarce resources. To increase water absorption and stop erosion at the surface, several practises must be used in dryland areas. To avoid water logging, it is necessary to review the steps being taken to limit runoff. It may be accomplished by taking steps like, Cropland has to be as flat as possible to reduce field slope. To create a ridge that will allow water to flow downhill, tillage and planting must be done across the slope of the ground. It is necessary to reduce soil moisture loss and increase soil evapotranspiration. Bunding is essential, and it should be built every two feet of fall to a height of 18 to 24 inches. It will limit topsoil erosion and aid with water retention. Every developing plant draws water from the earth, and evaporation only occurs intermittently. Transpiration is the term for this action. If there is a way to lessen the impact of drought stress in these carrier crop types, which are known for dryland farming and have fewer leaves, less leaf surface, and fewer stomata that stay closed under stress. Some plants develop a waxy layer on their leaves that makes them resistant to the effects of dry stress. For an approaching drought, dry farming practises are a comprehensive set of methods that may aid to lessen the stress brought on by the dry environment. Mulching is a practise that may assist to lower the rate of transpiration.

Watershed Management

The majority of the marginal and poor farmers in our nation depend on degraded land and water resources since they are underprivileged. They are finding it difficult to understand the production, market risk, and meteorological conditions. In rainfed areas, where there are increased risks of soil erosion and runoff, the rate of crop degradation is particularly high. How to develop a good crop production is difficult in the vital region, where there is greater hardship for ecosystem services. A watershed is a small geographic area with a shared drainage system. By use of a drainage system that collects runoff from both land and water areas at one location. The most important aspects to take into account for sustainable water management are the properties of the water, such as inflow, water usage, outflow, and storage.

Precipitation, influx of surface water, and inflow of ground water are the three types of inflow of water. While evaporation, evapotranspiration, irrigation, and drinking water are ways in which water is used, surface water outflow and groundwater outflow are ways in which water is discharged. Surface, ground, and root zone storage are the several ways that water is kept on hand. Water harvesting, groundwater revival, support for the water balance to prevent water pollution, and monetary use of water are the important mediations if there should be an occurrence of water. Water collecting is a crucial part of the water reaping among all of them. Water harvesting constructions like permeation pits or tank revive channels, energise wells, ferro concrete tanks, ranch lakes, V discard, and seat terracing are all present in water the board.

CONCLUSION

Understanding climatology provides chances to improve environmental toughness and sustainable growth. Climate forecasts may be improved and evidence-based climate policy can be supported by incorporating climatological data into climate models and climate prediction systems. Climate modelling, climate prediction, and climate policy may all benefit from the information obtained by studying climatology. By putting these ideas into practise, you may assist sustainable development and improve environmental resilience. In conclusion, more climatology research is necessary to further our knowledge of weather and climate dynamics and how they affect environmental resilience. Addressing climate-related issues and safeguarding the welfare of present and future generations may be accomplished by prioritising climate research and advancing sustainable climate policy. Building resilience to climate effects and promoting a sustainable and resilient ecosystem need a focus on climate adaptation and mitigation measures.

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CHAPTER 19

ANALYSIS OF WATERSHED MANAGEMENT PROGRAM MEMES

Jayashree Balasubramanian,Assistant Professor
Department of ISME,ATLAS SkillTech University, Mumbai, Maharashtra, India
Email id- jayashree.balasubramanian@atlasuniversity.edu.in

ABSTRACT:

The management of watersheds is essential to maintaining and protecting the health of our ecosystems and water supplies. The Watershed Management Programme, which tries to address issues including soil erosion, water pollution, and diminishing water quality, is the subject of this study report. In the research, best management practises, community involvement, and adaptive management techniques are all covered along with the concepts and methods of efficient watershed management. It examines how watershed management affects soil health, biodiversity preservation, and water availability. The study also assesses the success of and difficulties encountered in putting Watershed Management Programmes into practise in various areas. Understanding the importance of these programmes is crucial for promoting environmental sustainability, preserving the resilience of water resources, and encouraging adaptation to climate change. The paper also emphasises how this information may be used to improve watershed health and ecosystem services via possibilities for integrated land and water management, water governance, and policy-making.

KEYWORDS:

Biodiversity Conservation, Environmental Sustainability, Soil Erosion, Water Governance, Water Resource Resilience, Watershed Management.

INTRODUCTION

The Indian government has started a plan to manage watersheds. The schemes include Control of Shifting Cultivation (CSC), Drought-Prone Area Programmeme (DPAP), Desert Development Programmeme (DDP), National Watershed Development Programmeme (NWDP) for rainfed agriculture, and World Bank-Assisted Integrated Watershed Development Project (WBIWDP). DPAP was started in 1970–1971 with the goal of restoring logical equilibrium and making the best use of both human and natural resources to lessen the consequences of drought. To lessen the consequences of droughts in desert regions and restore ecological balance, the DDP was started in 1977–1978. In order to save and use rainfall from both arable and non-arable land on a watershed basis, the NWDP for rainfed agriculture was launched in 1986–1987.CSC was started in 1986–1987 to improve the socioeconomic situation in hilly regions while maintaining natural balance.WBIWDP was established in 1990 to promote a sustainable growth in agricultural productivity while also comprehending and minimising environmental harm [1], [2].

Water Management Practices

There are techniques for managing water, such as vegetative techniques, agronomic techniques, and engineering techniques for structural techniques. The following are examples of vegetative or agronomic measures: (iii) Strip cropping, (iv) pasture cropping, (v) farming of grasslands, and (vi) forest. Terracing, contour bunding, earthen bank construction, check dam construction, ranch lake construction, redirection, structure foundation of perpetual field vegetation, provision of vegetative and stone obstructions and rock dam are examples of engineering measures or practises. Therefore, watershed management plans are used to safeguard watersheds or stop damage in order to reduce the impact of land use to a tolerable level. It is a multidisciplinary approach, and the planning's long-term goals include improving the community's quality of life as well as increasing farmland productivity in a sustainable way and preventing watershed deterioration. Watershed management is the study, fortification, repair, and preservation of a drainage basin for the best possible resource utilisation and water control and maintenance [3], [4].

Wasteland Management

Wasteland has a variety of meanings. It was classified as land by the Soil Science Society of America in 1956 as being incapable of generating goods or services of value for other types of land. Less than 20% of its potential is being produced, according to the Ford Foundation. There are several definitions of wasteland, including overgrazed and degraded forests, revenue wasteland, mountainous slopes, areas with eroding value or prone to drought, areas with excessive irrigation, usar or khar land, marshy terrain, etc. The National Wasteland Development Board classified wasteland as corrupted land under vegetative growth with sporadic efforts and that is degrading for lack of sufficient water and soil the board or as a result of common causes in 1987. According to the Society for Promotion of Waste site Development, this site should be considered as no man's land since it isn't producing green biomass that is in conflict with the state of the soil and water. The Society proposed that wasteland may be categorised according to ownership, much like forest land, which can comprise degraded agriculture and forest. Since there isn't a generally agreed-upon definition of wasteland, it is just territory that provides no economic benefit. Wasteland might be regarded as unsuitable for agriculture if it has water logging or other problems with the fertility of the soil.

In India, regions that rely on rainfall for agriculture are split into two general categories: dry lands that get less than 750 mm of precipitation yearly and rainfed areas that receive more than 750 mm of precipitation annually. For arid and semi-arid environments, the dry land extends from Rajasthan to the southernmost point and from Gujarat in the west to Madhya Pradesh in the east.

Basic Information about India's Rainfed Agriculture

It is necessary to practise rainfed agriculture due to population strain on horticultural land. Rain feeds around 60% of the net planted area. Due to water shortages and nutritional inadequacies, the climate of India's rainfed regions makes it difficult to cultivate the land, which has a negative impact on agricultural output. The rainfed region's climate is mostly semi-arid and dry sub-humid, with a brief rainy season and a protracted dry season. In the rainfed region, rainfall is erratic and of lower intensity.

Qualities of Agriculture that Is Rainfed

India has a variety of rainfed regions, from those with abundant resources to those with few resources. Some resource-rich places are very productive and have access to technology, but in resource-limited areas, there are arid conditions as well as technological limitations. In this situation, using the agricultural machinery to live is challenging. A broad range of soil types, agroclimatic conditions, and precipitation circumstances, from 400 mm to 1600 mm yearly, are used in rainfed agriculture. The harvests that have been established in the rainfed area that are prone to make due into the storm during the problems that may be caused by water pressure, because of the variability in rain delay in demonstrating diversity in crop management practises, or there is a variety of soil [5], [6].

Rainfed Agriculture: Crisis

Due to the different restrictions, there are a variety of problems in the rainfed region, including the water crisis, farmer suicides, the green revolution, ground water concerns, changes in cropping patterns, and groundwater level decline.

Suicides among Farmers in Rainfed Area

The inputs, crops, animals, etc. that are readily accessible locally are used in rainfed agricultural systems. Farmers may cultivate a variety of crops with the use of inputs, enabling them to thrive in arid environments. Nevertheless, despite having few alternatives for production and technology adoption at the moment, farmers still cultivate land that receives rain. Farmers in the rainfed area began growing high-value crops at the same period, or they began commercialising the cash crops that needed expensive inputs like chemical fertilisers, pesticides, hybrid seeds, irrigation, and electricity. It was challenging for individual marginal farmers to mobilise the resources on their own due to the high cost of production for the marketing of crops in the rainfed region. They were not well-versed in both the technical advancement and intercultural practises necessary for hybrid seeds. All of these reasons had an impact on their psyche, social circumstances for survival, and financial status, which caused them to commit suicide.

DISCUSSION

Problematic Ground Water in Rainfed Areas

In the rainfed regions, certain problems surfaced during the 1960s green revolution. The Green Revolution was conceived and created in a way that needed an incredibly high amount of water and other inputs to produce high yielding varieties of wheat and rice. Farmers in the north have understood that rainfed agriculture is declining and that they must switch to hybrid types since irrigation canals are there. Because the farmers in the dryland region were given seeds and fertiliser but could not get water, the scenario is different there. Farmers that want to use hybrid fertilisers and seeds therefore encountered obstacles.

After the introduction of electricity, farmers began to purchase groundwater pumps. Tube wells were created as a result, and they eventually became the basis of irrigation. In contrast to tube wells, which accounted for just 0.6% of nondownpour water for the water system, channels and tanks constituted 61% of it, according to the Planning Commission's Abstract of Groundwater Resources in India study from 1960–1961. The percentage of channels and tanks decreased to 33% in 2002–2003, while the percentage of tube wells increased to 39%.

Modification of Cropping Patterns

Some farmers altered their agricultural strategies in the dry regions to lessen their susceptibility to rain. They were cultivating pulses, jowar, and bajra. Low productivity was seen in coarse grains, but its impact was mitigated by farmers' food storage. They grew a variety of crops in the same area, including pulses, which can grow alongside wheat and are both crop and drought tolerant. Farmers in the area used a variety of agricultural techniques, and if they were close to a forested area, they would also keep livestock crops. They altered the cropping patterns as a result of the Green Revolution, the development of power, groundwater, and tube wells.

Resource Management

Crops need a variety of resources to flourish, including soil, water, and land. The environmental conditions of the soil and atmosphere also have a role water, irrigation, fertiliser applications, and tillage. Environmental studies may be divided into chemical, physical, and biological categories. Higher nutrient availability, which is essential for development, is caused by the favourable soil chemical environment. One of the key protoplasm is irrigation. Additionally, necessary for the movement of nutrients and heat dissipation. Water is lost by evapotranspiration as well as population growth in the soil outside the root zone.

water being applied to the soil to create plant growth. Rainfall is essential. The roots effectively eat some of the chemical components that are considered necessary to plants as inorganic particles. One important way to preserve soil quality, lower insect/pest infestation, and control weeds is resource management in the context of plant development.

Objectives

(i) To describe the soil ecosystem and conservation measures.
(ii) For an analysis of water management and
(iii) To describe the vitamins, fertilisers, and
(iv) To describe weed control and management strategies.
(v) To describe the plant protection strategies and the Integrated Pest Management Programme.

Soil physical problems

The potential physical issues include encrustation on the soil top, fluffy soils, poorly drained soils, soils with high infiltration rates, shallow depths, and soils with high infiltration rates. In clayey soils with high water retention, excessive irrigation leads to poor drainage, water logging, and crop loss. Red lateritic soils with high Fe and Al hydroxides and minimal organic matter experience hardening of the soil surface as a result of excessive irrigation and heavy rain. Soil crusts as a consequence of this. Poor germination, limited shoot and root growth, and a delayed absorption of water into the soil profile are the results of this.

Management - It is best to use shallow water more often on light soils. It is recommended to amend clay soil at a rate of 50 tonnes per hectare with coarse-textured soil or tank silt to boost the rate of infiltration. You may apply organic wastes once a year at a rate of 20 tonnes per hectare, such as crop residue, agricultural waste, coir pith, filter cake, etc. Clay soils with poor drainage may be made better by sporadically placing tile drains and trenches. to enrich the soil The cycle of removing soil particles from their parent material and moving the isolated soil molecules by air, water, or both is known as soil conservation. Falling raindrops, flow, and wind are the separating factors for soil particles. Rainfall, the kind of plant present, and the kind of soil all contribute to soil erosion. Erosion is brought on by prolonged, high-intensity rainfall. The vegetation covering the soil surface absorbs the force of raindrops, causing more soil aggregates to break down. This relies on the kind of vegetation, porosity, height, rainfall, and precipitation. The volume of runoff and the extent of erosion are also influenced by the soil's properties, as well as the slope's degree and length. The detachable ET as well as the movement of soil particles are influenced by the physical characteristics of soil, such as soil structure and texture. In contrast to soils with high salt and sodium contents, which are more vulnerable and result in soil dispersion, soils with higher exchange capacity, calcium and magnesium catio exchange have a positive impact on soil structure and are less prone to illusion [7], [8]. Utilising and managing the land's functional aspects, such as the use of best practises without endangering the environment, is known as soil preservation. Different techniques exist for protecting soil.

(i) Land use depends on its capability.
(ii) Protecting soil from deterioration and preserving it.
(iii) Correction of seepage, acridity, and alkalinity.

Preservation of the soil and water is essential for the supported efficiency of the land. The goals of soil and water protection are to:

a. Encourage proper land use; • Prevent soil disintegration;
b. Restore the effectiveness of disintegrated land;
c. Maintain the efficiency of soil;
d. Control spillover; and
e. Regulate water assets to the water system and seepage.

degrading the land

Any area that is helpful to humans has its potential and capacity reduced due to soil deterioration. There are several causes of land degradation, including improper land clearance techniques, soil compaction from mechanisation, acidification, crop intensification, improper fertiliser usage, salinization, organic matter, and desertification of the soil biota.

Soil Erosion

There are several factors, including wind and water, that contribute to soil degradation. Soil is broadly divided into two categories: accelerated disintegration and land or common or ordinary disintegration. Geological disintegration may often occur when soil transforms into residue. The cycle of soil development modifies the rate of soil breakdown. Water eroding soil - The three steps of soil erosion by water are detachment, conveyance, and deposition. Water erosion may take many different forms, including landslides, splash erosion, sheet erosion, gully erosion, and integral erosion. Climate, rainfall, soil properties, the existence of vegetation, the presence of crop forests, the management of vegetation, the topography of the land, human behaviour, and land exploitation are only a few of the variables that affect soil erosion by water. wind-induced soil erosion.

In this instance, soil material is detached from, transported by, and deposited by wind. Different forms of soil erosion exist. Extremely small amounts of dirt and debris that are often blown into the air with other particles by the wind itself may get suspended. Turbulence causes small, 2.5 mm-diameter particles to be lifted off the soil surface during the process of saltation. Saltation occurs when the wind moves the majority of the soil. All of the particles in this situation migrate throughout the saltation process, which may seriously harm both the flora and the soil's surface. Numerous elements, including soil moisture, height, wind turbulence, surface roughness, soil characteristics, vegetation, and length of the exposed area, have an impact on wind erosion.

Methods for Conserving Soil WaterDrought-related crop damage may be minimised using one of two ways. These techniques include conserving as much water in the soil as feasible, and A second strategy is irrigation. To prevent soil water erosion, there are certain agronomic practises. These include increasing evaporation from the water surface, decreasing soil surface pollution, making use of water storage efficiency, reducing seepage, losses from reservoirs, and decreasing percolation losses from farmland.The methods for reducing evaporation from water surfaces include stopping floating rafts, covering the water surface with barriers that impede vaporisation, and building dams out of sand and rock.Some of the strategies for reducing seepage from reservoir losses include touching the soil and chemically treating soil coverings like plastic sheet rubber.In humid regions where elevated agriculture is practised, percolation losses may be greater. These losses can be reduced by covering the soil surface with a lot of water light, water retardant mulches, as well as by installing wind brakes like trees and fences to slow down the wind. Using plastic sheets and a thick covering of composted manure can help to cut down on these losses.

The ability of an insoluble substance to undergo displacement of ions previously attached and loosely integrated into its structure by oppositely charged ions present in the surrounding solution is known as the ion exchange capacity of soil. The majority of chemical reactions take place in soil because charged surfaces clash most often. Because it contains more colloids than coarse-textured soil, fine-textured soil has a larger exchange capacity. Ion exchange capacity comes in two different varieties: a. Anion exchange capacity (AEC) refers to the positive charge that may be used to draw anions in a solution. The entire ability of a soil to store exchangeable cations is known as cation exchange capacity, or CEC. It is difficult to considerably change CEC since it is an innate soil property. It has an impact on the soil's capacity to retain crucial nutrients and acts as a buffer against soil acidification. CEC often exceeds AEC in soils.

A measure of soil acidity or alkalinity is soil pH. By modifying the surface charges of colloids, it impacts the cation exchange and anion exchange capabilities of the soil by measuring its hydrogen ion content. Therefore, the hydrogen ion concentration is low at high (alkaline) pH levels. The pH range of most soils is between 3.5 and 10. The natural pH of soils normally runs from 5 to 7 in regions with more rainfall, whereas it is 6.5 to 9 in drier regions.The majority of the arid and semi-arid regions, where evaporation exceeds precipitation and dissolved solids are left behind to accumulate in an area where there is an elevation and changes have caused the salt to reach down and accumulate in low-lying places, are salt-affected areas that can negatively affect the function and management of the soil. Saline, Sodic, and Saline Sodic soils are the three types of salt-affected soil. While sodium predominates in sodic soils, soluble salts including calcium, magnesium, and potassium are abundant in saline soils. Saline soil has a lot of sodium as well as salt.

The northern Great Plains are dominated by calcareous soil, which contains more calcium and magnesium carbonate. Whether they are physical, like soil-water relationships and soil crusting, or chemical, such the availability of plant nutrients, it impacts soil characteristics that are relevant to plant development. The cultivation of calcareous soils is difficult due to factors like poor structure, low organic matter and clay content, low CEC, loss of nutrients through leaching or deep percolation, surface crusting and cracking, high pH, and nitrogen fertiliser loss. Because of this, it's crucial to take carbonates into account when analysing the soil texture as calcareous soil, both in the field and in the lab.

A three-dimensional segment of the soil that comprises several Horizon layers is called the soil profile. The physical, chemical, and biological features of soil differ among all of these levels. The causes of many soil-forming processes, such as drainage, freezing, and management, as well as the outcomes, greatly influence how the soil looks. Each soil profile has at least one Soil Horizon, which may be classified as Topsoil, Subsoil, or Rock. Soil Horizons are the distinct layers inside the soil profile. Depending on how much the texture of the soil varies vertically down, there are three different kinds of soil profiles. If you're using stored water effectively, you should cut down on transpiration losses, employ windbreaks, sow the right number of seeds, and cultivate crops that use water wisely.

These techniques may help farmers increase organic matter and lessen soil deterioration. Numerous techniques, including crop rotation, decreased tillage, mulching, cover crops, cross-slope farming, etc., serve as models for soil conservation. Farmers may improve soil's organic matter content, soil structure, and rooting depth by using crop rotation. Growing secondary crops that improve soil health is how it is done by leaving a cover over the soil, which lowers soil displacement caused by the impact of rainfall striking soil particles, cover crops and mulching are useful in minimising soil erosion. Additionally, they lessen the amount and rate of runoff over the soil. Applying organic material to the exposed soil is known as mulching. Hay creates the ideal mulch, but it must be gathered before weeds get established. You may also use straws.

A field practise known as conservation tillage aims to protect soil aggregates, organic matter, and surface leftovers from previous crops. The practise of managing field activities perpendicular to the field slope is known as cross-slope farming. It is a practical way to manage heavy runoff that flows across a field. Cross-slope farming may be efficiently combined with other soil protection techniques. Buffer strips are vegetated regions that offer a barrier between field borders and waterways. With their enormous root systems, they successfully stabilise the banks of streams. By giving field runoff a somewhere to gather, they are also effective in preventing dirt and pollutants from entering watercourses.

Water Management and Irrigation System

A method called irrigation adds artificial water to the land in order to augment groundwater and rainfall for agricultural development. It is important to delegate to plants that contain 90% water since this water provides turgidity, which is crucial for transportation, protoplasm, and keeping the plant's ideal temperature. Crops absorb water from soil moisture that has been stored there. However, the plant's needs are artificially satisfied when the soil's water content is low. The field capacity serves as the top limit of the ideal soil moisture range, while slightly above the wilting point serves as the lower limit. Irrigation serves the aim of storing water in the soil in this range. Plants begin to wilt throughout the day and return to normal at night because they dry out during the day owing to water loss from evaporation and transpiration. A withering coefficient is used to describe this situation. The latter is defined as the amount of water in the soil as measured by its percentage when the plants growing there are first brought to a state of wilt from which they are unable to recover in an essentially saturated environment. There are many irrigation techniques, including surface, subsurface, and pressurised irrigation. There are several factors to consider when choosing irrigation techniques, including water upply sources, the topography of the plot, the amount of water to be used, the kind of crop, and the cultivation method. The three types of surface irrigation are furrow, check basin, and border irrigation [9], [10].

Types of Irrigation

There are many different kinds of irrigation techniques. Surface irrigation, sprinkler irrigation, and trickle irrigation are the three main techniques. The goal of offering different irrigation techniques is to apply a suitable quantity of water to the crop so that water may evenly apply throughout the crops, preventing needless wasting, and making sure that there are no long-term issues like salt or soil erosion. Understanding the crop-soil-water conditions, as well as the farming practises and methods, is crucial for choosing the appropriate irrigation strategy. Technical irrigation considerations might include labour costs, crop, climate, soil infiltration rate, soil water holding capacity, capital and operational costs, water supply amount and quality, as well as cost.

Basin irrigation, border irrigation, and furrow irrigation are all types of surface irrigation. Nearly 95% of irrigation worldwide is done using the popular irrigation technique known as surface irrigation. Since surface irrigation techniques are straightforward and accessible to farmers with little to no irrigation experience, they are often used. One of the simplest and most popular surface irrigation techniques is basin irrigation. In this situation, basins that are suited for the majority of soil types and agricultural techniques may be used. A variety of crops can be cultivated in a small basin. A basin may be built specifically for flooded rice, however it is presently being utilised more and more for diverse crops. Border irrigation is less common and carried out in areas with adequate big farms that are rectangular in form.

The most common irrigation technique for row crops is furrow irrigation. In dry climates, it is permitted when the slope of the land is up to 2%, but is prohibited in humid climates where there is a high danger of erosion from heavy rains. It makes mechanisation and may be effective in lowering the cost of drainage and irrigation. In around 5% of the irrigated land, sprinkler irrigation is employed. It is an irrigation water application technique that resembles rainfall. A system of pipes is used to deliver water, often via pumping. After being sprayed into the air, it is irrigated throughout the whole soil surface using spray heads, resulting in the formation of tiny water droplets that fall to the ground. Sprinkler irrigation is easy to use and requires minimal knowledge of water management.

CONCLUSION

A crucial and successful strategy to solve urgent environmental issues and advance sustainable water resource management is the Watershed Management Programme. The ideas, procedures, and effects of watershed management programmes on ecosystem health and the resilience of water resources have been emphasised in this study report. The research emphasised how important it is to use optimum management practises in order to reduce soil erosion and water contamination. These programmes contribute to the preservation of soil integrity and the reduction of sediment flow by putting into practise practises including afforestation, contour farming, and erosion control structures. The study also showed how watershed management improves the quantity and quality of available water. These programmes im prove the resilience of water resources and encourage sustainable water use by safeguarding water sources from pollution and reestablishing natural water flow patterns. Watershed Management Programmes encourage cooperative decision-making and responsiveness to changing environmental circumstances by understanding the significance of community participation and adaptive management measures. The information learned by researching water governance and watershed management programmes may be useful in formulating policy. Resource allocation and environmental protection may be improved by emphasising integrated land and water management. The long-term survival of our watersheds and the advancement of environmental sustainability depend on more research and continuing funding for watershed management programmes. These programmes may be very important in preserving our ecosystems and water supplies for future generations by encouraging stakeholder engagement, including traditional knowledge, and taking climate change issues into account.

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CHAPTER 20

ANALYSIS OF THE PROCESS IRRIGATION WATER MANAGEMENT

Sunny Kolekar, Assistant Professor
Department of ISDI, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email id- sunny.kolekar@atlasuniversity.edu.in

ABSTRACT:

A key component of sustainable agriculture is irrigation water management, which aims to effectively use water resources while maximising crop yield. In order to maximise water usage efficiency and reduce water waste, this research study examines the theories and methods of irrigation water management. In-depth examination of several irrigation techniques, including drip irrigation, sprinkler irrigation, and furrow irrigation, as well as their applicability to diverse crops and agro-climatic situations, is provided in this research. It examines how cutting-edge technology, such soil moisture monitors and weather forecasts, might help us make wise judgements about irrigation. The study also assesses the advantages of using water-saving techniques like deficit irrigation and controlled deficit irrigation in reducing the effects of water shortage. Understanding irrigation water management's significance is essential for using water resources sustainably, preparing for climate change, and guaranteeing food security. The research also shows the potential uses for this information in water resource planning, smart water management, and precision agriculture, providing chances to improve resource sustainability and agricultural resilience.

KEYWORDS:

Drip Irrigation, Smart Water Management, Sustainable Agriculture, Water-Saving Strategies, Weather Forecasting.

INTRODUCTION

The goal of irrigation water management is to avoid using too much water for irrigation. The goal is to avoid aggregation-induced freezing, cut labour costs, minimise pumping expenses, preserve or enhance the quality of groundwater and downstream surface waters, improve crop biomass, and produce higher-quality goods. Crop rotations and different tillage techniques may help irrigation implement appropriate irrigation water management. The latter involves scheduling and managing irrigation water application such that it meets the crop's water needs without wasting resources like water, energy, or plant nutrients or deteriorating the soil. This entails providing water at rates that are consistent with the crop's intake characteristics and in quantities that can be retained in the soil while still meeting the demands of the crop. A key goal is to help irrigators comprehend conservation principles by demonstrating to them how to assess the efficiency of their irrigation practises, choose wisely how to manage their water resources, and identify when new systems or adjustments to existing ones are required. The following benefits come from effective irrigation water management: Minimises water consumption; Prevents excessive soil erosion; Reduces labour; Maintains or enhances the quality of groundwater and downstream surface water; Increases crop biomass production and product quality [1], [2].

The correct management of irrigation water includes choices about when and how much to irrigate as part of irrigation scheduling. The information provided by scheduling tools helps irrigation decision-makers create irrigation plans for each farm. In both cases, information about the crop, soil, climate, irrigation system, water deliveries, and management objectives must be taken into consideration to tailor irrigation scheduling procedures to a specific irrigation decision-maker and field condition. These strategies may be based on long-term data that represent average conditions or may be developed as the season progresses, using real-time information and short-term predictions. In order to determine when and how much to water, an irrigation scheduling tool must be precise enough.

Transportation from the soil surface is what causes soil water to evaporate. Water is circulated deeply into the soil beyond the root zone before reaching the surface of the plant. The ocean contains 97% water, however that water cannot be used for cultivation. Only 2.6% of the entire amount of water is freshwater, while the majority (77.23%) is made up of glaciers and the polar ice cap. On Earth, only a very tiny portion of the water that is present in the ground, lakes, rivers, and atmosphere may be captured for use in irrigating crops. Regarding India's water resources, the average annual rainfall is 1194 mm, or 392 million hectares, across an area of 3.28 million hectares [3], [4].

Larger soil holes are filled with air in unsaturated flow, while smaller pores are used to store and convey water. The gravitational or hydraulic head components' contributions to total potential diminish with time. Vapour movement- When soil dries out, water from microspores is also gone. Instead, water is mostly present as vapour, which flows from one zone to another owing to a gradient in water vapour pressure from a higher to a lower pressure zone. With the aid of the diffusion process, which transfers water in the form of vapour to the atmosphere, evapotranspiration is a process where the evaporation occurs from the surface of the soil or free water. In vapour transpiration, there are two steps: first, water is transformed from a liquid to a vapour, and then the vapour is carried from the evaporating surface into the atmosphere. Water vapours leave the live plant body during the process of transpiration and are released into the atmosphere. There are two characteristics of soil water: the quantity of water present per unit mass or volume of soil and the significance of the energy state of soil water for plant-water interactions.

Irrigation Scheduling

Managers of irrigation systems utilise irrigation scheduling to decide on the proper frequency and length of watering. Water system booking is a dynamic cycle that occurs often each year and contains information on when to flood, how much water is required to address each standard impact, and the quantity and kind of the yield. It shows how much water is needed for the water system and how often it should be supplied. Additionally, undesirable is an abundance of water in the water system since it wastes water. Excessive watering below the root zone may result in the loss of fertiliser nutrients, which can lead to water stagnation and salinity and eventually harm the crop. For irrigation engineers, social scientists, and economics, irrigation scheduling is crucial because it enables them to use the water they have more efficiently or to completely irrigate a designated area within a canal or river system. Irrigation scheduling shouldn't be too delegated or undervalued in forest soil either, since both situations might upset the soil's chemical and physical balance. Scheduling is crucial for agronomic delegation in order to acquire the usage of per unit amount of water in a typical condition and to safeguard the crop in order to receive it as much as feasible [5], [6].

Integrated Nutrient Management

As a soil nutrient, this idea calls for a thoughtful balancing of inorganic, organic, and biofertilizers. The idea of INM encompasses the sources of nutrients, irrigation techniques, methods for applying organic and inorganic materials, and applications to preserve soil fertility and crop yield. To assure the provision of nutrients, complementary use of chemical fertilisers, organic fertilisers, organic chemicals, and biofertilizers is carried out. The impact of the preceding harvest must be well understood. Legumes have a dual role in the cropping system, acting as both a supplement to and implementr of the use of fertilisers and chemicals via residual and cumulative effects of organic manure.

In the case of integrated nutrient management, balanced fertilisation doesn't call for a specific ratio of nitrogen, phosphorus, and potassium, but it does take into consideration the availability of nutrients that are already present in the soil and are needed by crops. The loss of nutrients, the cost-effectiveness of fertilisers, the farmer's capacity to invest via soil moisturising methods, weed control, seed rate, sowing season, and many other variables must also be taken into account. So this is a dynamic idea where the balanced use of fertilisers should be having certain purposes like the correction of inherent soil nutrient deficiency, increased crops quality, increased farm income, maintenance of lasting soil fertility, avoiding damage to environment, and restoration of land productivity. One of the key instruments for providing balanced nourishment to the soil is soil testing. Farmers will be able to determine the amount and kind of fertilisers needed for each crop by using soil testing to compare the differences between crops and regions in the case of balanced fertiliser rates.

DISCUSSION

Classification of Organic Manures

They are separated into concentrated organic manure and bulky organic manure.Compost, sewage, sludge, and farmyard manure are examples of bulky organic manures.Oil cake and carcass waste are examples of concentrated organic manures.Leguminous and non-leguminous plants may be used as green manures, whereas green leaf manures are used to cover trees like neem, Gliricidia, etc.Farmyard manure is created on the property from the excretions of farm animals, including cow urine, bedding materials, and different types of domestic trash. Farmyard manure is not a standardised product, and the kind of animal diet and the volume of straw used in storage affect its value. Due to bacterial activity and an increase in manure temperature, there is a significant fluctuation. Compost is produced from the decomposed plant residue left over after fermentation of plant waste, and it generally fills a bigger hole while bringing plant nutrients in a more usable form.

Human excrement is flushed away in urban areas using a lot of water, or "sludge." It consists of two parts: a solid portion and a liquid portion known as sewage water. More nutrients are present in concentrated organic manures than in bulky organic manures. Oilcakes, blood and bone meal, fish manure, pressmud, and other significant concentrated organic manures are available. Additionally called organic nitrogen fertilisers, they are. Oil cakes, the gritty waste left behind after oilseeds are extracted of their oil, are a great source of protein and minerals for feeding chickens and other animals. They might be sold in pieces or processed into oil meal. Nitrogen content ranges from 3% to 9%. For the majority of the oil cakes, the CN ratio is typically 32:15. In order to fertilise the soil on an agricultural plot, green manure is spread as a cover crop. With its root system and a little amount of stable organic matter, it improves the soil's structure. While green leaf manures are the integration of green manure into the soil and are delivered from somewhere else, it functions as a benefit for roots and is best grown in situ and integrated into the soil. Nodulating stems The term "green manure" refers to plants that gener ate root nodules and fix atmospheric nitrogen, such as Sesbania rostrata, which also produces nodules on its stem. Nearly 22 tonnes of new biomass, which includes 3.3% nitrogen, may accumulate 150 kg of nitrogen per acre over 45 days. Green manure not only increases the soil's fertility but also contributes acid to the reclamation process. The daincha crop aids in reclaiming alkaline and salty soils. For the reclamation of alkali soil, adding sodium to the exchange complex with a more advantageous cation is beneficial. The result of improving alkali soil is the replacement of exchangeable sodium [7], [8].

Biofertilizers

By enhancing the delivery of vital nutrients to plants and trees, bacteria included in biofertilizers aid in stimulating their development. They are made up of living things like bacteria, blue-green algae, and mycorrhizal fungus. For the benefit of the plant, mycorrhizal fungi preferentially remove minerals from organic materials, while cyanobacteria are distinguished by their ability to fix nitrogen. The process of transforming the di-nitrogen molecules into nitrogen compounds is referred to as the later. For instance, several bacteria change the form of phosphorus in soil from insoluble to soluble. As a consequence, plants may get phosphorus. A genus of bacteria called Rhizobium is linked to the development of root nodules on plants. These microorganisms coexist with legumes. They absorb nitrogen from the air and transfer it to the plant, enabling it to flourish in nitrogen-deficient soil. Rhizobiums come in a variety of varieties, and they have specific host plant requirements; for instance, microorganisms that coexist peacefully with soybeans cannot coexist with lucerne. There are many types of Rhizobium leguminosarum associations, including Rhizobium meliloti, which can survive on lucerne, Rhizobium trifolii, which can live on clover, and Rhizobium leguminosarum, which can grow on peas.

Legumes and rhizobia, a kind of soil bacterium that fixes nitrogen, may coexist together. This symbiosis causes nodules to grow on the plant's roots, where the bacteria may transform atmospheric nitrogen into plant-useable ammonia. The Azolla freshwater fern is a rare species and one of the fastest-growing plants because of its symbiotic interaction with the Anabaena cyanobacterium (also known as "blue-green alga"). It is a pteridophyte that floats and is used in rice fields as a biofertilizer. It is either planted as a dual plantation with the rice plants or is put into the soil before the rice planting. Compared to legumes, azolla-anabaena can fix approximately three times as much atmospheric nitrogen. Legumes typically get 400 kg of nitrogen per acre per year. They are 1100 kg of nitrogen per acre per year for Azolla-Anabaena. Azolla Mexicana, Azolla microphylla, Azolla nilotica, and Azolla pinnata thrive in tropical environments because they are temperature-tolerant, but Azolla filiculoides and Azolla rubra are being grown in colder regions of India.

Azospirillum is renowned for its capacity to produce phytohormones and fix nitrogen. It is a well-researched rhizobacterium that supports plant development both in the lab and in the field. None of its species or strains are pathogens for people or plants. At the commercial level, it is regarded as the safest bacterium that may be utilised as a biofertilizer for a variety of crops, particularly cereals and grasses like wheat and rice. Its species have been known to have great salt tolerance and phosphate-solubilizing abilities. Azospirillum fixes 20–40 kg of nitrogen per acre and is advised for use with rice, millets, maize, wheat, sorghum, etc.

Azotobacter: These soil-dwelling, aerobic, free-living microorganisms play a significant role in the nitrogen cycle. Azotobacter uses the nitrogen in the air to create ammonium ions, which are then released into the soil. This is how the inaccessible form of atmospheric nitrogen gets fixed to nitrogen. Phytohormones, including auxins, which encouraged plant growth, are some physiologically active compounds that are produced by Azotobacter. In the bioremediation of soil from heavy metals including cadmium, mercury, and lead, Azotobacter plays a key role. The aromatic molecule 2,4,6-trichlorophenol, which contains chlorine, may be biodegraded by Azotobacter. Insecticide, herbicide, and fungicide 2, 4, 6-triclorophenol was also discovered to have some mutagenic and carcinogenic effects. Blue-green algae are prokaryotic, photoautotrophic algae. They are a class of free-living organisms known as cyanobacteria. In damp soils, they fix nitrogen from the atmosphere. BlueGreen Algae (BGA) thrive in the soggy conditions of rice fields and provide inexpensive nitrogen to plants, in addition to boosting crop output by enhancing soil vitality, fertility, and productivity. BGA biofertilizer for rice, sometimes referred to as "Algalization," aids in the development of an agro-ecosystem that is safe for the environment and assures the commercial viability of paddy agriculture while reducing the need for energy-intensive inputs [9], [10].

Another process that serves as a biofertilizer is mycorrhiza. Vesicular Arbiscular mcorrhiza is the name given to it. Arbuscular Mycorrhizal Fungi (AMF) are obligate root biotrophs that trade mutually beneficial effects with roughly 80% of plants. They are regarded as natural biofertilizers because they trade photosynthetic products for water, nutrients, and pathogen protection from the host.

Methods of Fertilizer Application

Given that various kinds of fertilisers need different types of application techniques, choosing the right method of fertilisation is crucial.Potash and nitrogen must be used for bund installation and broadcasting.In neutral and alkaline soil, water-soluble phosphorus fertiliser must be applied as a bund placement.In soil that is acidic, phosphorus fertiliser that is soluble in citrate is administered in a spread fashion.In broadcasting or band placement, sulphate fertiliser in the bisulfate form must be used.Sulphur must be applied while using the broadcasting technique.Some micronutrients may be sprayed onto leaves in modest amounts.

The use of fertigation is used to apply water-soluble fertilisers. The crop's physiology affects when fertilisers should be applied as well. Various crops require different methods of fertiliser application. For example, plain crops require two splits of fertiliser at the seeding stage and three to five weeks after the first dose, whereas flooded rice requires three splits at the transplanting stage, three and six weeks after the first dose. Given the antagonistic character of fertilisers, it is crucial to take into account how one nutrient interacts with the others. Crop yield and quality loss might result from fertiliser overuse in certain cases.

There are many crucial components needed for crop development that may be roughly divided into five groups. They are based on the proportional amount that is typically present in the plant, chemical make-up, overall function, and mobility. It is separated into three groups based on the proportionate amount that is typically present in plants: macronutrients, secondary nutrients, and micronutrients. The main or major nutrients are known as macronutrients and include elements like carbon, hydrogen, oxygen, nitrogen, phosphorus, and potassium. Micronutrients include iron, magnesium, zinc, copper, molybdenum, boron, sodium, and iodine, whereas secondary nutrients include calcium, magnesium, and sulphur. The categorization has been broken down into four groups: metals, non-metals, cations, and anions. It is based on their chemical makeup. Metals include K, Ca, Mg, Fe, Zn, Mn, Cu, Co, and V among others.

a. Anions include NH4+K+, Ca2+, Fe2+, Mg2+, Mn2+, Cu2+, and Zn2+.
b. Anions, including NO3, HPO42, H2PO4, SO42, BO33, MoO42, and C1.

The shape, quantity, and convenience of the farmers, as well as the effectiveness and safety of fertiliser application, all influence the technique and timing of application. There are many types of fertilisers, including liquid and solid. While other application techniques, including broadcasting, are more well-established for solid forms, fertigation is a popular technique for liquid forms. In the case of fertilisers in the solid form, broadcasting is one of the key techniques where manure and fertilisers are evenly dispersed in the field before planting the crop and it can be incorporated by tilling or cultivation practises. It may be carried out using a plough sole, a deep placement, or subsoil application. The fertiliser is sprayed or deposited into the plough sole, which is covered by the plough during the opening of the neighbouring furrow, in the plough sole placement technique. In the deep placement technique, fertiliser and manure are buried 10 to 12 cm into the topsoil, particularly in the puddle rice soil. Fertilisers are administered to the subsurface at a depth over 15 cm, particularly for three crops or in the case of orchard trees.

When fertilisers are applied locally or on-site, they are put close to the roots or in the root zones. Fertilisers may simply be absorbed from the roots. There are five ways to achieve it: by placing a drill contact, by placing a band, by placing a pocket, by treating the side, and by applying pellets. In the case of liquid fertiliser, treatment to the plant's foliage is done either from the nitrogen or the sulphur deficit for speedy recovery from the deficiency. Three techniques may be used to apply liquid fertiliser: Fertigation, or the dissolution of fertiliser in irrigation water either in an open or closed system and the sprinkling or trickling of the fertiliser.Another technique is starter solution, which involves soaking seedlings in fertiliser solutions that have been made at low concentrations.As liquid manure, urine, sewage water and cow shed washings are immediately injected into the field, liquid fertilisers may be delivered directly to the soil using specialised injecting equipment.

CONCLUSION

The study illustrated the value of cutting-edge tools for making educated irrigation choices, such as soil moisture monitors and weather predictions. Farmers may customize irrigation schedules to crops' water needs and reduce water loss by using real-time data. Understanding the advantages of water-saving techniques like deficit irrigation and managed deficit irrigation provides chances for reducing the effects of water shortage and preparing for water stress brought on by climate change. Planning for water resources, smart water management, and precision agriculture might all benefit from the information obtained through researching irrigation water management. These tactics can improve resource sustainability and agricultural output. For improving our comprehension of irrigation water management and its implications for sustainable agriculture, further study in this area is crucial. In order to support agricultural resilience, climate change adaptation, and food security, it is important to prioritise responsible water usage and employ effective irrigation techniques. Furthermore, incorporating intelligent water management techniques into agricultural systems may promote sustainable agriculture in the face of changing environmental circumstances by optimising water supplies. In order to achieve long-term sustainability and guarantee the availability of water resources for future generations, it is essential to promote appropriate irrigation water management.

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CHAPTER 21

ANALYSIS OF GROWTH ANALYSIS AND PLANT PROTECTION

Utsav Shroff, Director
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email id- utsav.shroff@atlasuniversity.edu.in

ABSTRACT:

In order to maximise crop yield and safeguard plants from a variety of biotic and abiotic challenges, growth analysis and plant protection are essential components of contemporary agriculture. Examining growth metrics, biomass accumulation, and physiological processes are the main topics of this research paper's investigation of the theories and methodology behind crop growth analysis. The research looks at how growth analysis may help us understand how plants react to their surroundings and to management techniques. The study also explores methods for protecting plants, including integrated pest management (IPM), disease control, and raising stress tolerance. It assesses how well crop losses are reduced and sustainable production is ensured by biological, chemical, and cultural plant protection techniques. Fostering agricultural resilience, food security, and environmental sustainability requires an understanding of growth analysis and plant protection. In order to increase agricultural production and resource efficiency, the research also emphasises possible uses of this information in precision agriculture, climate-smart farming, and sustainable land use.

KEYWORDS:

Crop Productivity, Growth Analysis, Integrated Pest Management, Plant Protection, Stress Tolerance Enhancement.

INTRODUCTION

This is a crucial element in raising the farm's output. A farmer must use good sustainable agricultural practises to reduce crop losses. He requires a suitable crop variety, effective production management, and protection management to increase agricultural yield. Crop protection is a strategy to boost crop productivity by defending it against harmful pests, diseases, weeds, and other organisms. Management of weeds, pests, insects, and plant diseases is a part of growth analysis and plant protection. The majority of crop pests are external, and they are accompanied by organisms that serve a variety of ecological roles, including parasites, pollinators, competitors, and decomposers.

Integrated Pest Management (IPM)

It is a method of pest and disease control used in agriculture to preserve a healthy environment and boost agricultural output and sustainability. Soil management, water stress, crop variety resistance, timing, and spatial arrangements are a few environmental aspects that are helpful in pest control. In order to make crops less vulnerable to pests like rice stem borers, soil management may use an ecosystem approach, such as mulching, increasing soil organic matter, and managing soil issues (such as saline water intrusion). Water stress has the potential to raise a crop's vulnerability to disease. The management of water throughout the manufacturing process may be used to prevent certain pests, such weeds in rice. Crop varietal resistance also aids in the management of plant pests and illnesses where susceptibility may develop if the host plant's genetic reservoir of defence is not expanding. IPM is a pest management method that takes into account the environment, population dynamics, and the use of suitable strategies to keep the pest population at a level below that which is causing economic harm. In addition to biological approaches, it also covers cultural methods, biopesticides, botanicals, and behavioural strategies [1], [2].

Cultural Methods

Agronomic changes are needed for a better return, while at the same time, controlling the harvest microclimate coordinates the avoidance, mass reproduction, and spread of vermin. This includes irrigation, sterilisation, culturing, development selection, planting season, plant population, and the use of excrements and manures. Anitation entails eradicating pests' wintering grounds and breeding habitats. Alternate host destruction reduces the spread of the pest population. The plough and intercultural activities provide ideal circumstances for the proliferation of weeds, illnesses, and pests. As a result, when in the pupae stage, it may be exposed to dehydration or prey on birds, which might cause mechanical injury or cause it to be buried deeply in the ground. Agroclimatic conditions may be used to enhance cultivars' resistance to pests and diseases, and choosing the right cultivars helps reduce agricultural yield losses.

The timing of sowing may have a significant impact on insect and disease attacks. If rice is sown in early June, for instance, borer attacks may be less severe. To avoid the pink bollworm, mature cotton cultivars have gained popularity in Punjab and Haryana.Plant density per unit area has a long-term impact on agricultural microclimate. For example, a thick crop canopy may result in high humidity, which makes it easier for insects, pests, and diseases to attack the crop. Application of manures and fertilisers may help stave against disease and insect infestations.An abundance of nitrogen makes crops more vulnerable to leaf-eating and sucking insect pests.

The effectiveness of irrigation and water management has an impact on insect attacks. Pests that live in the soil may be killed by irrigation by being suffocated or exposed to the soil surface, where they can be eaten by birds. Furrow irrigation may prevent diseases like anthracnose of the beans, early blight, and charcoal rot of the potato more effectively than spray watering. The likelihood of an infestation may also be impacted by habitat diversification since many pests prefer to feed on certain crops. Pest likelihood may be reduced by crop rotation, intercropping, trap crops, and strip cropping. If the cropping is in a small region, handpicking techniques are helpful. After pouring a little amount of kerosene into a polythene bag, you may collect the larvae at night. In addition to hand-picking insects, field bunds may be cleared of stray grasses and weeds to prevent them from having locations to lay eggs.

Bio-pesticides and Botanicals

Bio-pesticides: Microorganisms, including artificial medium culture and inoculum at the field, are employed to control pests. Numerous fungi and bacteria can manage this, but live insects may develop insect viruses. Similar to conventional pesticides, biocontrol agents are applied to the targeted insects and pests. They are also known as natural pesticides or bio-pesticides. One such is the bacterial pathogen Bacillus thuringensis, which infects a variety of insect pests. It is used to protect a variety of crops against caterpillar attacks. For bacteria like Dipel, Delfin, Halt, Spicturin, Biolep, and BioAsp, there is a commercial solution. Popillae japonica and Hototricha species are both white grubs that are susceptible to Bacillus popilleisis. Verticillium lecanii is a pathogenic fungus that can be used commercially to control aphids, thrips, and whiteflies in greenhouse environments [3], [4].

Botanicals: Some weeds, such lantana, tulsi, notch, and others, repel a variety of insect pests. Some trees, including Annona, Pungam, and Wood Apple, as well as their byproducts, contain insecticidal properties that may help manage infestations of aphids, whiteflies, leafhoppers, and the diamondback moth. Neem (Azadirachta indica), Pungamia (Pungamia glabra), and Mahua (Madhuca Indica) are often utilised plants. For insects including rice cutworm, diamondback moth, rice BPH, tobacco caterpillar, aphids, and mites, neem seed kernel extract (2–5%) is beneficial.

DISCUSSION

Field Crops, Farm Machinery and Seed Technology

In the Indian economy, agriculture is significant, and crops, particularly food crops, provide significant contributions to the nation's ability to provide for its own food needs. Nearly 70% of the population is economically and nutritionally dependent on agriculture. in especially the rural region. The unpredictable weather conditions and edaphic variables affect agricultural farming in India. The plants that are commercially grown and seeded are known as crops. Due to the nation's variety in terms of climatic and geographic elements, several cropping systems are used based on their appropriateness. Cropping pattern is a dynamic term that relates to the area that is covered by diverse crops in a certain location and changes by region. The variances are based on the region's geographic climate, sociocultural context, economy, history, and politics. A region's edaphic makeup, climate, and precipitation all have an impact on the cropping pattern there. With the aid of good soil management methods, the crop establishment system is a way to increase land productivity. Under crop establishment that will be appropriate for the region. The main food crop in field crops is grain, which supports the commercial agricultural industry. Soil is one of the edaphic variables that is crucial to the establishment and development of a crop. Numerous concerns with soil quality, including soil texture, structure, compaction, acidic soil, and alkaline soil, all of which call for soil management and conservation approaches. Improvements to the quality and output of farm machinery. The productivity of food items has improved effectively as a result of agricultural mechanisation. Other than these, seeds are the most crucial component of agriculture, and seed technology has made significant contributions to performance improvement [5], [6].

Objectives

To describe different field crops in India; To describe the country's varied cropping system; To analyse different crop establishment methods; To describe agricultural machinery, tools, equipment, and tillage operations; To describe seed techniques and certification In India's economy, where crops, particularly food crops, are abundant, agriculture is significant. Nearly 70% of the population is economically and nutritionally dependent on agriculture. In particular, the industry offers employment and means of subsistence to rural areas. The unpredictable weather conditions and edaphic variables affect agricultural farming in India. The plants that are grown and seeded in commercial fields are known as crops. Due to the nation's variety in terms of climatic and geographic elements, several cropping systems are used based on their appropriateness. Cropping pattern refers to the area covered by different crops at a certain location and time. The notion of cropping is dynamic and differs from place to region. The variances are based on the regional geocultural, economic, political, and historical circumstances. A region's edaphic makeup, climate, and precipitation all have an impact on the cropping pattern there. With the aid of good soil management methods, the crop establishment system is a way to increase land productivity. Crop rotations and cropping patterns may be altered during crop establishment in order to fit the local environment. The main food crop in field crops is grain, which supports the commercial agricultural industry.

Soil is one of the edaphic variables that is crucial to the establishment and development of a crop. Numerous concerns with soil quality, including soil texture, structure, compaction, acidic soil, and alkaline soil, all of which call for soil management and conservation approaches. Farm machinery and equipment have a significant role in improving production and quality. The productivity of food items has improved effectively as a result of agricultural mechanisation. Other than these, seeds are the most crucial component of agriculture, and seed technology has made significant contributions to performance improvement.

(i) To describe different field crops in India
(ii) To describe the nation's varied farming system
(iii) to investigate alternative post-cultivation and crop establishment methods
(iv) To describe the tillage operations and agricultural machines, tools, and equipment
(v) To describe seed production methods and seed certification
(vi) Detailed descriptions of significant crops
(vii) Cereals, oil seeds, pulses, and fibre crops are all types of crops.
(viii) planting new crops and following cultivation
(ix) Farm equipment and tillage activities

In India's economy, where crops, particularly food crops, are abundant, agriculture is significant. In the rural areas, in particular, around 70% of the population relies on the e-sector for employment and means of subsistence. The unpredictable weather conditions and edaphic variables affect agricultural farming in India. The plants that are grown and seeded in commercial fields are known as crops. Due to the nation's variety in terms of climatic and geographic elements, several cropping systems are used based on their appropriateness. Cropping pattern refers to a certain period and place. The notion of cropping is dynamic and differs from place to region. The regional geo-cultural, economic, historical, and political factors provide the foundation for the variances. A region's edaphic makeup, climate, and rainfall all have an impact on the cropping pattern there. Cropping patterns may be adjusted to be more appropriate for the local environment with the use of effective crop rotations and crop establishment systems, which are strategies to increase land productivity. The main food crop in field crops is grain, which supports the commercial agricultural industry. Soil and other edaphic elements were crucial for the establishment and development of the crop. Different soil conditions, such as soil texture, structure, compaction, acidic soil, and alkaline soil, demand different soil management techniques, and equipment plays a significant role in improving quality and production. The productivity of food items has improved effectively as a result of agricultural mechanisation. The seed is the most significant component besides these.

India has the greatest area under rice cultivation in the world and is the second-largest producer of rice globally. Due of the green revolution's primary concentration on wheat, its productivity is lower than that of wheat. The traditional rice field, also known as the paddy field, has to be saturated with water 10 to 12 cm deep in the first stages of the rice producing process. The second-most significant food crop in India is wheat, which is grown during the rabi season. India is the world's second-largest producer of wheat. When it comes to growing in different climate variations and growth circumstances, wheat is much more hospitable.

Millets/ Coarse Crops

Crops like coarse grains or millet may be cultivated for a short time, do well in warm climates, and serve as both food and fodder. Jowar, bajra, ragi, finger millet, and other varieties are the main millet crops. The millet crops may be produced primarily on dry ground, which is why they are referred to as dry land crops. They can also be grown in places with extremely low rainfall, such as those with 50–100 cm. The coarse cereal crops are less susceptible to soil inadequacies and may be cultivated in both loamy and poor alluvial soil. Maharashtra, Karnataka, and Rajasthan are the states that produce the most of the millet crops. These three states are also the leading producers of crops grown for coarse cereals.

Cash Crops

Pulses: The majority of pulses are leguminous crops, and they are the main source of protein for vegetarians. The most widely used pulses in India are Tur dal and gramme. Other popular pulse crops are black gramme, green gramme, horse gramme, black gramme, and peas. In India, there are many different types of cash crops, but the main ones include jute, cotton, tobacco, groundnuts, and sugarcane. One of the crucial cash crops is sugarcane, of which India is the world's second-largest producer. Sugarcane is a crop that needs a lengthy, wet season to grow up to seven or eight months. Traditionally, sugarcane was farmed in Northern India, but it is now being grown in Southern India. One of the causes of the winter shutdown of the sugar plants in Northern India was the poor sugar content of the subtropical kinds of sugarcane. While the high sugar content and high production of the sugarcane harvests in southern India are a result of the tropical variety and coastal regions.

Another profitable crop is cotton, a fibrous plant sometimes referred to as "white gold." The kharif crop for the tropics and subtropics is cotton. In terms of global cotton output, India comes in third. Although cotton is a crop that can be produced on dry ground, when the crop is mature, it needs a consistent source of water. Jute is a tropical crop that needs a warm, muggy atmosphere to grow. In terms of cultivation and as a source of natural fibre, jute is among the best fibrous crops. The Ganges Delta region produces over 85% of the world's jute. One of the significant oilseed crops is groundnut, which may be grown in both the Rabi and Kharif seasons, although around 90% to 95% of the acreage is grown during the Kharif season. In terms of environment, groundnut may grow best in tropical climates; it needs temperatures between 20 and 30 °C and rainfall between 50 and 75 mm. The crop that is most vulnerable to cold, constant rain, drought, and stagnant water is ground nut, although it requires dry weather while the crops are maturing. To produce groundnuts, soil must be well-dried, sandy loam, and red or black in colour. The majority of the oilseeds in India, approximately half of them, are groundnuts. India is the world's second-largest producer of groundnuts. Gujarat, Andhra Pradesh, and Tamil Nadu are the states that produce the most groundnuts.

Agriculture is significantly impacted by the weather. A crop requires just the right amount of moisture. It is clear that climatic information might influence our business decisions. It helps plan effectively, control costs, and broaden the field for mutual gain. There are basically four key cultivating areas that are generally impacted by the effect of the climate, and ranchers may make daily assumptions about the climatic conditions. They are (a) the growth and application of crops, (b) the timing and movement of manure, (c) irrigation and disease management, and (d) the functioning of the field. They are a result of the changing weather, which has an impact on the decisions made by farmers. Temperature, light, and moisture levels must be just right for crop development. To better comprehend and follow the growing state of the crop and aid in the decision-making process for the farmers, detailed and accurate historical real-time and predicting weather information is available. If farmers have access to the data, they may use it to make cost-effective decisions about when and how to irrigate a crop, as well as if and when it needs to be watered at all. Farmers make a variety of choices, including when to apply fertiliser and how much to apply. These selections are crucial. The whole field profit might be lost if the choice is not made properly. In order to guarantee that fertiliser is administered under the proper circumstances, weather forecasting is crucial. It is beneficial in the dry weather. There are particular meteorological conditions that are necessary for disease and pest management. The modelling of diseases and pests is used in weather forecasts and recommendations. The harvest analyzers aeroplane, which can be used to spray synthetic fungicidal and insecticidal mixtures on plants from above the ground when wind conditions are insufficient to cause this sprayer compound to miss its target, is another option that is heavily influenced by wind forecasting. The term "field usefulness" refers to the availability of days that are suitable for field work, which mostly depends on the soil temperature and humidity as determined by detailed field-level climatic data. It may help farmers evaluate the efficiency of their farms and increase the productivity of their daily operations. Farmers' ability to save money and their ability to cultivate their land are both dependent on climatic data. Even if evaluating isn't always straightforward, the bulk of the main producers and growers can successfully make their decisions based on this option. Farmers may make careful, little decisions about their harvests in various months, and these decisions would have a cumulative effect on the financial costs and benefits, which might have a big impact on the state of the economy [7], [8].

Importance of Weather Forecasting in Agriculture

The discipline of horticulture, where cultivating practises may emphasise accuracy and regulated usage with respect to development of yield, benefits greatly from meteorological data. This is one of the fundamental components of how to handle data innovation, which can enhance climate forecasting and other things like drones, variable rate manure applications, GPS guidance and sensors, and yield health indicators. The main purpose of farming is to increase individual seed and plant marking and development skill. When choosing which kind of fruits, vegetables, and pulses to cultivate, the farmer must consider the weather, climatic conditions, and temperature. He does his duties using forecasts when he lacks a thorough grasp of weather forecasting. On the basis of the weather defect identification, he can suffer losses. A farmer may now receive a more accurate weather report on his smartphone thanks to technological advancements and unique weather forecasting methods.

It is really easy for ranchers to know how, what, and when to do things thanks to climate gauging, which is a prediction that is based on the barometric conditions in each region during a given time period. The predictions for crops are affected by a number of indices, including temperature, sunshine, rain, and other factors. When deciding whether to water a crop or not, when to add fertiliser, or whether to begin or postpone harvesting entirely, the weather may be helpful in planning and agricultural activities. One way to artificially apply water to crops is via irrigation. The weather's unpredictable nature has an impact on the crop's need for irrigation. The time and volume of evapotranspiration are also important. These are two critical weather-related needs indicators. The timing of fertiliser application is important and has an effect on crop output. Their improper application may harm the crop in addition to limiting nutrient losses and avoiding environmental harm [9], [10].

Remote Sensing Application in Agriculture

In agriculture, if the process includes interaction between incidence response and the object of interest, remote sensing may be used. This kind of electromagnetic radiation, which comprises visible light, near-infrared, and short-wave, is helpful for distant sensing. Infrared. According to an FAO analysis, food output must grow by 60% by 2050 in order to fulfil the world's need for food. Numerous initiatives are being taken to boost total output in order to feed the people.

Agricultural applications such as crop discrimination, acreage estimate, crop evaluation, soil estimation, precision agriculture, soil survey, etc. may be investigated using remote sensing methods. Because suitable materials and soil are dynamic and naturally complex, remote sensing in agriculture may be used to intricate crops and soil. Comparing this technique to the conventional agricultural surveying approach reveals the following advantages:

Synaptic view's capacity

The capacity of recurrent coverage to spot changes in low-cost participation. Greater precision. There are several ways that remote sensing may be used in agriculture, including crop prediction, crop damage and yield progress evaluation, crop identifiable proof, crop modelling and assessment, crop infection, etc.

Western himalayan region

This comprises of the hills of Jammu & Kashmir, Himachal Pradesh, and Uttar Pradesh, which are three separate sub-zones. The area is made up of hilly brown soils, podsolic soils, mountain meadow soils, and skeletal soils of cold regions. The region's geography is undulating with steep hills. The majority of soils are silty loam with varying altitudes. They are vulnerable to erosion risks, and slides and slips happen often. The principal crops are rice, maize, millets, wheat, and barley. All crops are less productive than the national average in India. In this area, vegetables, flowers, and spices like ginger and saffron are farmed. The largest portion of this zone (45.3%) is covered by forests. A recommended approach for the development of the area is land use planting based on the idea that land with a slope of up to 30% is appropriate for agriculture on terraces, 30 to 50% for horticulture and silvi-pastoral projects, and above 50% for forestry. This area will be able to offer fruits and vegetables to the rest of the nation with the full support of storage and cold storage facilities for transport, marketing, and processing.

CONCLUSION

Understanding growth analysis and plant protection provide prospects for promoting environmental sustainability, food security, and agricultural resilience. Growth analysis and plant protection research has the potential to advance precision agriculture, climate-smart farming, and sustainable land use. The productivity and resource efficiency of agricultural systems may be improved by using these measures. To sum up, further study in this area is necessary to advance our comprehension of growth analysis, plant protection, and the implications for sustainable agriculture. Making plant protection measures a top priority may help to reduce crop losses and encourage environmental preservation. Growth analysis may also help resource-efficient farming techniques and improve agricultural resilience to changing environmental circumstances. For agricultural systems to be productive and sustainable over the long run, growth analysis and plant protection must be encouraged.

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CHAPTER 22

ANALYSIS AND DETERMINATION OF IRRIGATION SCHEDULING

Utsav Shroff, Director
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email id- utsav.shroff@atlasuniversity.edu.in

ABSTRACT:

A key element of effective water management in agriculture is irrigation scheduling, which aims to maximise crop yield while maximising water utilisation. This study article examines irrigation scheduling's concepts and practises, with a particular emphasis on choosing the right irrigation times and amounts based on crop water needs and environmental variables. The research examines a number of irrigations scheduling approaches, including crop coefficient approach, soil moisture approach, and weather approach. It looks at how cutting-edge technology, such sensor-based systems and remote sensing, might increase irrigation effectiveness and water resource conservation. The study also assesses the advantages of using deficit irrigation and precision irrigation techniques for reducing the effects of water shortage and fostering sustainable water usage. Understanding irrigation scheduling is essential for avoiding water waste, adjusting to changing climatic conditions, and guaranteeing food security. The report also discusses how this information may be used to improve agricultural resilience and resource sustainability via climate-smart agriculture, smart water management, and water resource planning.

KEYWORDS:

Deficit Irrigation, Precision Irrigation, Smart Water Management, Soil Moisture-Based Scheduling, Water-use efficiency.

INTRODUCTION

According to the demands of the crop and the characteristics of the soil, irrigation schedule refers to the frequency with which water should be administered. The number of irrigations and their frequency needed to fulfil the crop's water needs constitute irrigation scheduling. The goal of irrigation scheduling is to maximise crop production per unit of water applied over an area in a given amount of time by allocating irrigation water based on the individual crop water requirements (ETc) in a variety of soil and climatic conditions. The idea developed is that "if we provide irrigation facility, the agricultural production and productivity will go up automatically" based on the criteria given above. The choice of when to irrigate and how much water to apply is made many times a year throughout the irrigation scheduling process. Both factors have an impact on the crop's yield and quality. It specifies how much irrigation water must be utilised and how often that water must be provided.Excessive irrigation is damaging because it wastes water below the root zone, depletes nutrients from fertilisers, resulting in water stagnation and salinity, results in poor aeration, and eventually harms crops.But depending on the kind of operation, irrigation schedule has a unique significance [1], [2].

Irrigation Management

The total amount of water needed is 1100–1500 mm. Depending on the agroclimatic conditions, the daily water consumption for rice ranges from 6 to 10 mm, and the total water consumption is between 1100 and 1250 mm. The nursery uses 3%, or 40 mm, of the crop's total water need, 16%, or 200 mm, for ground preparation (puddling), and 81%, or 1000 mm, for main field irrigation. In terms of water management, the development of the rice plant may be split into four stages: seedling, vegetative, reproductive, and ripening. The sowing step uses less water than other stages. To encourage the growth of new roots, a shallow depth of 2 cm submergence is required at the time of transplantation. During the vegetative period, tiller production requires the same water level. Mid-season drainage is the process of draining the whole water in the field at the start of the maximum tillering stage and leaving it that way for one or two days. This mid-season drainage may enhance the roots' respiratory processes, encourage strong root growth, and inhibit the establishment of ineffective tillers. Any stress experienced during the vegetative period may hinder root development and limit leaf area.

5 cm of submersion should be maintained throughout the blossoming period since it is a crucial time for water requirements. All yield components will be damaged by stress at this period, severely reducing yield. In particular during the booting stage, more water than 5 cm is not essential and might cause a delay in heading. Less water is needed throughout the ripening process than is required following yellow ripening. 15–21 days before crop harvest, the land may be progressively drained of water. When 5 cm submergence is advised, irrigation management may be carried out by irrigating to 5 cm submergence at saturation or one to two days after the ponded water has disappeared. Comparing this to continuous submersion, irrigation water use will be reduced by 30%.

Groundnut: A total of 500 to 550 mm of water is needed. During the first 35 days after planting and the last 35 days before harvest, evapotranspiration is minimal, reaching a peak need between the peg penetration and pod growth phases. The second irrigation following the sowing irrigation may be planned for 25 days after the sowing, or 4 or 6 days after the first-hand hoeing, and an irrigation interval of 15 days is then maintained until peak blooming. Depending on the soil and environment, the gap during the key phases may be 7–10 days. The gap is 15 days when maturity is in effect.

Finger millet requires 350 mm of total water. A crop that can withstand drought is finger millet. Preplant watering is provided at 7 and 8 cm. For consistent establishment, watering with a modest amount of water on the third day after transplanting life is adequate. For healthy and strong development, water is then withheld for 10 to 15 days following seedling establishment. Three irrigations are then necessary during the primordial initiation, blooming, and grain filling phases.

Sugarcane: 1800 to 2200 mm of water are needed overall. The important time for water consumption is the formative phase (120 days from planting-germination and tillering phases). Less water at more frequent intervals is preferred to achieve uniform emergence and the maximum number of tillers per unit area. When compared to the other two stages, the crop requires more water at this crucial time, hence the reaction to applied water is greater. During this time, there is a greater need for water, irrigation, etc. It is preferable to maintain the ideal amount of moisture throughout the primary growth stage since there is no subsequent thickening of stems or elongation of stems as sink for storing sugar. Water response is now minimal, and it will continue to be less as the fruit ripens. As harvest time draws near, the soil moisture level should be permitted to progressively drop throughout the ripening period to slow cane growth and boost sugar content.

Maize: The total amount of water needed is 500–600 mm. Although maize has a greater water need than other crops, it uses water quite well. Sowing, four-leaf stage, knee high, grand growth, tasselling, silking, and early dough phases are the maize crop's several growth stages. Water is a need for crops at every stage. Tasselling, silking, and the first phases of dough are crucial times in this.

Cotton 550–600 mm of total water are needed. Cotton is sensitive to the level of soil moisture. Early in the season, plants need less water, and more water is lost by evaporation than transpiration. The plant needs more water as it develops, starting at 3 mm per day and peaking at 10 mm per day when it is covered with blooms and bolls. Only 10% of the total amount of water needed is utilised during plant emergence and the first stages of development. During the periods of blooming and boll formation, enough moisture is crucial. The crop needs less water in the beginning and towards the end. Until the boll growth stage, a high water need persists. Because it is an indeterminate plant, excessive watering during phases other than those that are important increases vegetative development, which might result in a reduction in boll setting. Until the first boll of the last flush opens, irrigation is maintained. After that, irrigation is terminated [3], [4].

Sorghum: 350–500 mm of water total are needed. The booting, blossoming, and dough phases are when you need water most. After seeding, the crop will immediately get irrigation. The following irrigation is applied 15 days after planting to promote the growth of a robust secondary root system. For crops to produce well, irrigation is required ten days before heading and again ten days after heading.

DISCUSSION

Irrigation Management Under Limited Water Supply

To maximise food production per unit of water utilised to fulfil the demand from the current 1 billion people, integration of all water resources, including surface, ground, wastewater, snow, dew, etc., is crucial. Due to anomalous distribution patterns and uncertainty around the timing of rainfall, water supplies are now a problem. As a result, frequent droughts are now rather prevalent. In these conditions, it is necessary to implement a new water-saving plan for agricultural production and irrigation management. The chapter's discussion of water scarcity circumstances and strategies for dealing with them via drought relief measures may be found here.

Water Scarcity Conditions

The word "water scarcity" refers to inadequate storage of, or non-availability of, the necessary amount of water for agricultural production and other uses owing to monsoon failure. Due to the shortage, the cultivated fields will get insufficient water supplies, which will put the plant community under stress. The frequency of irrigation, the kind of crop, the type of soil, and other factors affect how stressed a plant is. Our main objective in this scenario is to obtain the most yield per unit of water. The approaches listed below may be used to manage stress.

Analyse the resource potential and employ approaches from linear programming to maximise water consumption. The relevant department should carry out this kind of activity, notably irrigation and agricultural. Farmers' attitudes - Farmers' or users' behaviours need to be significantly reoriented in order for them to understand that conserving water is their main duty and that it is an economic input. Changes to the conveyance system are needed since a lot is wasted during the transfer from source to field. The amount of water wasted through conveyance systems is thought to be between 30 and 40 percent. By performing routine maintenance, lining the channels, and other measures, such water losses may be reduced or entirely avoided. Pipe conveyance is often used for ground water resources. In command regions, such conveyance is possible even at low sluice levels. Conjunctive use of water refers to the integration of all water resources with water conservation techniques. Conjunctive usage's primary goal is to utilise water from many sources as efficiently as possible. Conjunctive use of water, for instance, refers to the best use of rainfall and well water in a canal irrigation system to preserve the crop without depleting either water supply. Rice is a semi-aquatic plant, thus for it to establish itself and produce more, water must be surrounded by it. The experimental data unmistakably showed that 5 cm of ponding depth is preferable to greater depths one day following the absence of previously supplied water. This was due to enhanced root activity and greater aeration.

Fluffy soils, poorly drained soils, soils with a high infiltration rate, shallow-dwelling soils, and encrustation on the soil surface are examples of probable physical issues. In clayey soils with high water retention, excessive irrigation leads to poor drainage, water logging, and crop loss. Red lateritic soils with high Fe and Al hydroxides and minimal organic matter experience hardening of the soil surface as a result of excessive irrigation and heavy rain. Soil crusts as a consequence of this. Poor germination, limited shoot and root growth, and a delayed absorption of water into the soil profile are the results of this.

Management it is best to use shallow water more often on light soils. It is recommended to amend clay soil at a rate of 50 tonnes per hectare with coarse-textured soil or tank silt to boost the rate of infiltration. You may apply organic wastes once a year at a rate of 20 tonnes per hectare, such as crop residue, agricultural waste, coir pith, filter cake, etc. Clay soils with poor drainage may be made better by sporadically placing tile drains and trenches. It is recommended to add organic wastes or sandy soil at a rate of 20–50 tonnes per hectare in order to increase soil permeability and improve drainage. The incorporation of organic materials and the addition of silt-containing montmorilonite clay might help to solve the encrustation issue [5], [6].

Management of Poor-Quality Water for Irrigation

Any irrigation water, whether it comes from a river, canal, tank, open well, or tube well, always has some soluble salts dissolved in it. Ca, Mg, Na, and K as cations and chloride, sulphate, bicarbonate, and carbonate as anions are the principal soluble components of water. Yet other elements' ions are also present, including those of lithium, silicon, bromine, iodine, copper, cobalt, fluorine, boron, titanium, vanadium, barium, arsenic, antimony, beryllium, chromium, manganese, lead, selenium, phosphate, and organic matter. Calcium, sodium, sulphate, bicarbonate, and boron are among the soluble components that are crucial in evaluating the quality of irrigation water and its appropriateness for irrigation purposes. However, other elements like soil texture, permeability, drainage, crop kinds, etc., are equally crucial in evaluating if irrigation water is appropriate. The following are the most typical issues brought on by consuming water of poor quality. Salinity if the irrigation water has a lot of salts overall, the salts will build up in the crop's root zone and damage the crop's development and production. Due to the high concentration of soil solution, an excessive salt situation inhibits water absorption.

Permeability - Some particular salts slow down the pace at which water percolates into the soil profile. Toxicity: When some water elements are absorbed by plants, they accumulate in significant amounts, which causes toxicity and lowers yield. Other - Excessive nitrogen in irrigation water promotes excessive vegetative growth, which delays crop maturity and causes lodging. Sprinkler irrigation using water with a high bicarbonate content may result in white deposits on fruits or plants. Irrigation waters have been broadly categorised into good, saline, and alkali waters based on the distinguishing characteristics of the majority of ground waters used by farmers in various agro-ecological regions of the nation. Depending on the severity of the constraints.

The majority of naturally occurring ground waters have a pH between 7.2 and 8.5 and are either hyper saturated with regard to calcite and dolomite or in equilibrium with these minerals. Water with a pH lower than 7.2 seems to be calcite-unsaturated. SAR more than 10 is always present in water samples with pH greater than 8.4. Waters with a high carbonate: bicarbonate ratio and residual alkalinity are known to have high pH levels [7], [8].

Depending on pH, carbonate and bicarbonate ions are present in variable amounts in water with residual alkalinity. The ratio of CO3 ions in groundwaters typically ranges from 1:10 to 1:2, while waters that are just mildly salty have low SAR, with the typical range being up to 20. Only 10–15 percent of all ground waters have high salinity and high SAR (>20). The appropriateness of irrigation water is categorized into six groups based on various quality characteristics including EC, pH, content of Na, Cl, and SAR.

Irrigation Management in Command Areas

The process of storing, diverting, conveying, regulating, measuring, distributing, applying the ideal amount to crops, and removing extra water from the root zone as drainage is all included in irrigation management (also known as water management). The majority of irrigation projects in Tamil Nadu and other Indian states are designed to help with agriculture production and energy production. In nations like the USA, irrigation management planning also takes into account water for environmental stability and enjoyment in addition to electricity generation and agriculture production. The River Colorado runs through seven US states (Wyoming, Utah, Colorado, Arizona, New Mexico, Navada, and California) as well as Mexico, another country. Karnataka, Tamil Nadu, and Pondicherry states are irrigated by the River Cauvery, which has its source in the Karnataka state of Coorg.

All total, the Cauvery river system includes the states of Karnataka, Kerala, Tamil Nadu, and Pondicherry.The magnitude of numerous river systems is often larger (Ganges, Indus, Zambasi). Some river projects (such as the Zimbava and Zambia's Zambasi) are exclusively intended to produce electricity. The majority of projects in India are for irrigation and electricity generating. There is also navigation (Ganges) in large river projects. Due to the unique topographical, political, and socioeconomic circumstances of each project, river commands are complex and difficult. A component of the river commands between provinces and nations is hydro-politics (disputes). Due to a combination of historical, social, political, and economic factors, Tamil Nadu's Cauvery command is distinct. King Karikala Cholan constructed the Grand Anaicut in the first century B.C. (or, according to hypothesis, the second century A.D.) to redirect floodwater to Cauvery by erecting stone embankments at Coleron (Kollidam). At the time, this was regarded as the key achievement in water management. The Cauvery system originates in Kudagu and goes around 430 kilometres before reaching the Bay of Bengal. The Tanjavur district of Tamil Nadu's coramandal coast (Cholamandalam coast) has a highly well-developed delta. Here are the several states' contributions to the Cauvery's overall flow:

The government maintains 138 A-class channels and 36 river courses and branches, while farmers are responsible for the remainder. Cauvery system has changed from being a system of sufficiency to one of insufficiency. Rice, bananas, sugarcane, vegetables, coconuts, and sylviagronomy crops (tree crops in fields) are the principal crops farmed. Trans-basin systems are also present, such as the Periyar-Vaigai of Tamil Nadu. The Western Ghats' westward-flowing Periyar River has been tunnelled through to Tamil Nadu in the reverse direction. In 1896, the Royal Engineer Pennqiuik completed it. This is a distinctive initiative being undertaken for modernisation in Tamil Nadu, India. The need to update river commands - Earthen channels were coated with cement concrete on the bottom and sides in order to improve the effectiveness of the current system, decrease water losses, and add more land to irrigation. Field watercourses also used granite stone construction. The effectiveness of the water transportation has grown from 45 to 75 percent when the main canal and branch canals were modernised.

Irrigation Management Under Limited Water Supply

To get the best crop yield out of the limited water resources available, irrigation water also has to be managed, just like any precious resource does. Water management is carried out in two stages: management of water distribution and management of water use. The latter is the field-level management of crop watering. RWS is one of the methods used to control irrigation water distribution. By enforcing irrigation time schedules, it seeks to distribute irrigation water equally across the command area, regardless of where the property is located. A 10-ha block is split into three to four irrigation groups (sub units). Timetables are developed in accordance with irrigation water availability, stabilised field channels, and group-wise irrigation requirements. The block committees will closely follow the group-by-group time schedules for irrigation. The farmers in the group are expected to divide the time among themselves.

Water Relations of Soil

The mineral and organic components of soil are derived from a solid (albeit not rigid) matrix, whose interstices are made up of asymmetrical pores whose geometry is determined by the matrix's edges. In general, the liquid phase of soil water and soil air combine to fill the pore space to a certain extent. One of the most vital components of the soil is moisture. Additionally, it is one of its most dynamic features. Water has a significant impact on a variety of soil physical and chemical processes as well as plant development. The molecule's structure may be used to describe the characteristics of water. A mole is made up of three hydrogen atoms, one oxygen atom, and is mostly governed by the oxygen ion. The two hydrogen ions occupy hardly no space. Individual water molecules do not exist. One molecule communicates with another via the hydrogen in the water. Water is stored in the soil like a reservoir. Only the water that a crop has stored in its root zone may be used by it for transpiration and the development of plant tissues. Plants can acquire the daily water needs for healthy growth and development when there is enough water in the root zone. The amount of water that is available decreases as the plants continue to utilise it, and if additional water isn't given, the plants will eventually cease growing and die. It is vital to water once more before the stage is reached when crop development is severely impacted. The qualities of the soil and the crop to be irrigated determine the volume of water to be applied to each irrigation and the frequency of irrigation.

Movement of Water into Soils

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It is vital to water once more before the stage is reached when crop development is severely impacted. The qualities of the soil and the crop to be irrigated determine the volume of water to be applied to each irrigation and the frequency of irrigation. through and into the soil profile. The infiltration rate is often determined by the soil layer with the lowest permeability, either at the surface or underneath it. The porosity of the soil, which is altered by cultivation or compaction, has an impact on infiltration rates as well. By enhancing the surface soil's porosity and removing surface sealing, cultivation affects the penetration rate. The impact of tillage on infiltration often only lasts until consecutive irrigations lead the soil to return to its original state of bulk density.

In general, infiltration rates are lower in heavy texture soils than in light texture soils. Numerous researchers have looked at how soil infiltration rate is affected by water depth. Increased depth in surface irrigation has been shown to marginally boost early infiltration, but the influence of the head during extended watering is minimal. The vegetation cover also affects infiltration rates. Grassland has a far greater infiltration rate than bare, uncultivated soil. Organic matter additions significantly speed up penetration. Because of the puddling of the surface brought on by the reorientation of surface particles and the washing of finger materials into the soil, the hydraulic conductivity of the soil profile often changes during infiltration. This is due to both the rising moisture content and the puddling of the surface. Water viscosity affects infiltration. The low viscosity of warm water is the reason for the increased rate of infiltration in the tropics under otherwise equivalent soil conditions.

CONCLUSION

Scheduling irrigation is essential for sustainable agriculture since it maximises water usage efficiency and encourages resource conservation. The relevance of responsible water management for the sustainability of agriculture has been emphasised throughout this research paper's examination of the ideas and practises of irrigation scheduling. The research emphasised several irrigation scheduling techniques and how they might be used in varied agro-climatic settings. Adopting techniques like crop coefficient method and soil moisture-based scheduling may considerably increase crop water production and irrigation efficiency. The study also showed how important cutting-edge technology, such sensor-based systems and remote sensing, are for making wise irrigation choices. Farmers may customise irrigation schedules to crops' water needs and reduce water loss by using real-time data. Understanding the advantages of deficit irrigation and precision irrigation techniques provides chances to reduce the effects of water shortage and encourage sustainable water usage. Planning for water resources, climate-sensitive agriculture, and smart water management are three areas where irrigation scheduling information might be useful. These tactics can improve resource sustainability and agricultural resilience.

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