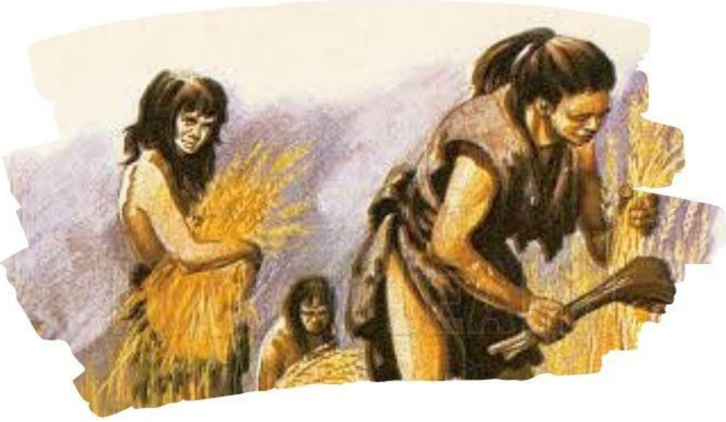
AGRICULTURAL HERITAGE



Agricultural Heritage

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Introduction of Indian Agricultural Heritage

Origin of Agriculture:

The beginning of 'agro' or 'agriculture' marks the beginning of 'civilized' or 'sedentary' society. Climate change and increase in population during the Holocene Era (10,000 BC onwards) led to the evolution of agriculture. During the Bronze Age (9000 BC onwards), domestication of plants and animals transformed the profession of the early Homo sapiens from hunting and gathering to selective hunting, herding and finally to settled agriculture. Eventually the agricultural practices enabled people to establish permanent settlements and expand urban based societies. Cultivation marks the transition from nomadic pre-historic societies to the settled Neolithic lifestyle sometime around 7000 BC. As per the modern definition of agriculture which would be" an aggregate of large scale intensive cultivation of land, mono-cropping, organized irrigation, and use of a specialized labour force", the title "inventors of agriculture" would go to the Sumerians, starting ca. 5,500 BC.

Agriculture in India

Agriculture in India, the preeminent sector of the economy, is the source of livelihood of almost two thirds of the workforce in the country. The contribution of agriculture and allied activities to India's economic growth in recent years has been no less significant than that of industry and services. The importance of agriculture to the country is best summed up by this statement: "If agriculture survives, India survives".

One of the many interesting aspects of the Rigvedic civilization was the role agriculture played in society. Indian society during this period was primarily agrarian, with a greater focus in the early part of the period on cattle, rather than on farming. Out of 10,462 hymns in the Rigveda, only 24 hymns mention agriculture.

Although agriculture apparently didn't flourish in Rigvedic society until the end of the period, it was clearly going on as a mainstay of society. In the first and tenth Mandals of Rigveda we find mention of many agricultural processes, such as forestry, ploughing of fields, sowing seeds, and harvesting corn. The mention of corn of quite interesting, given the general notion that corn was not common in India until much later on the timeline. The Rigveda mentions the process of separating the corn from the chaff, whereas in the Bible, there is the wellknown passage about separating the wheat from the chaff. In Rigveda, the only plant mentioned amongst the cereals and pulses is barley.

During this period of India's history, the owner of a plot of land was considered to be the individual who was cultivating it. Corn was one of several forms of payment to the tribal leaders who protected local residents, although the trading of cows is also mentioned.

Today, all aspects of ancient Vedic culture are a popular area of study, and Indologists are putting greater focus on the exceptional role India played in refining so many fields -- science, mathematics, medicine and agriculture, to name but a few. As India's population grows, agriculture is an increasingly important field of study, and this gives us hope that many Vedic concepts will come to attention that have been long forgotten, such as the role of Varnasrama in agriculture.

In a paper entitled, "Science in India with Special Reference to Agriculture", historians P.M. Tamboli and Y.L. Nene surveyed India's role in various sciences in the post-Harappan era. Making note of recent archeological evidence that challenges long-held beliefs about the Aryan colonization of India, they acknowledge that Vedic civilization flourished throughout Northwest India and Pakistan and elsewhere on the subcontinent more than 6,000 years ago, particularly along the banks of the Saraswati River. Following is their overview of various aspects of agricultural practice from ancient India:

"Archaeological findings have revealed that rice was a domesticated crop grown along the banks of the Ganges in the sixth millennium BC. Later, it extended to other areas. Several species of winter cereals (barley, oats, and wheat) and legumes (lentil and chickpea) domesticated in Southwest Asia were grown in Northwest India before the sixth millennium BC. Archaeological research also revealed cultivation of several other crops 3000 to 6000 years ago. These include oilseeds such as sesame, linseed, safflower, mustards, and castor; legumes such as mung bean, black gram, horse gram, pigeonpea, field pea, grass pea (*khesari*), and fenugreek; fiber crops such as cotton; and fruits such as jujube, grapes, dates, jackfruit, mango, mulberry, and black plum. Animals, including livestock, sheep, goats, asses, dogs, pigs, and horses were also domesticated.

Despite destruction of ancient libraries by invaders, some literature did survive and is available to us to this day. This literature includes the four Vedas, nine Brahmanas, Aranyakas, Sutra literature, Sushruta Samhita, Charaka Samhita, Upanishads, the epics Ramayana and Mahabharata, eighteen Puranas, Buddhist and Jain literature, and texts such as Krishi-Parashara, Kautilya'sArtha-sastra, Panini'sAshtadhyahi, Sangam literature of Tamils, Manusmriti, Varahamihira'sBrhat Samhita, Amarkosha, Kashyapiya-Krishisukti, and Surapala'sVrikshayurveda. This literature was most likely to have been composed between 6000 BC and 1000 AD. We find information related to biodiversity and agriculture (including animal husbandry) in these texts. Specifically, in the Puranas (300–750 AD) we find names of Shalihotra on horses and Palakapya on elephants, as experts in animal husbandry. For instance, Garudapurana is a text dealing with treatment of animal disorders while the classical work on the treatment of horses is Ashwashastra. One chapter in Agnipurana deals with the treatment of livestock and another on treatment of trees. The science of arbori-horticulture had developed well and has been documented in Surapala'sVrikshayurveda.

Forests were very important in ancient times. From the age of Vedas, protection of forests was emphasized for ecological balance. Kautilya in his Artha-sastra (321– 296 BC) mentions that the superintendent of forests had to collect forest produce through the forest guards. He provides a long list of trees, varieties of bamboos, creepers, fibrous plants, drugs and poisons, skins of various animals, etc. that came under the purview of this officer. According to Manu, the preservation of wild animals was encouraged and hunting as a sport was regarded as detrimental to proper development of the character and personality of the ruler.

There is more to learn from our ancient literature; for example, we learn about the biodiversity of flora. The four Vedas mention more than 75 species, SatapathaBhrahmana mentions over 25 species, and Charaka Samhita (c. 300 BC) – an Ayurvedic (Indian medicine) treatise – mentions more than 320 plants. Sushruta (c. 400 BC) records over 750 medicinal plant species. The oldest book, Rigveda (c. 3700 BC), mentions a large number of poisonous and non-poisonous, aquatic and terrestrial, and domestic and wild creatures and animals. Puranas mention about 500 species of plants.

Farm implements. Ancient literature of the subcontinent did not miss out on farm implements. Vedas describe a simple bullock-drawn wooden plow, both light and heavy, with an iron bar attached as a plowshare to open the soil. Krishi-Parashara (c. 400 BC) gives details of the design of the plow with Sanskrit names for different parts. This basic design has hardly undergone any change over centuries. Even today the resource-poor farmers use a similar bullock-drawn plow. A bamboo stick of a specific size was used to measure land. Vedic literature and Krishi-Parashara also mention disc plow, seed drill, blade harrow (*bakhar*), wooden spike tooth harrow, plankers, axe, hoe, sickle,*supa* for winnowing, and a vessel to measure grain (*udara*). Pairs of bullocks used for plowing in ancient days varied from one to eight.

Forecast of annual monsoon rains. Since crop production depended almost entirely on seasonal monsoon rains, it was imperative that methods of predicting rainfall were developed. Indian knowledge base in mathematics, astronomy, and astrology was strong. KrishiParashara (c. 400 BC) and Brhat Samhita give, what today one could describe as, simple astrological models for predicting rains in a particular season. Parashara's main technique of forecasting rain was based on the positions of the Moon and the Sun in the sky. Varahamihira (505–587 AD) in his Brhat-Samhita considered lunar mansions in predicting seasonal rainfall. It is noteworthy that even today a large number of farmers in India, carry out farm operations based on the local variations of these old models.

Kautilya in Artha-sastra indicates primitive models for optimum rainfall for most crops. It is significant that the great poet, Kalidasa (c. 500 AD) in his immortal poem, Meghdoot, described the course of monsoon clouds from the Bay of Bengal through central and northern Indian plains to the Himalayas. It is remarkable that this accurate knowledge was obtained without the aid of modern instruments.

Manures. Importance of manures in obtaining high crop yields was fully appreciated in ancient India. In Krishi-Parashara, it is stated that crops grown without manure will not give yield, and a method of preparing manure from cowdung is described. Kautilya mentioned use of cowdung, animal bones, fishes, and milk as manure. In the Kural (1st century AD), it is stated that manuring is more beneficial than plowing. Agnipurana recommends application of "excreta of sheep and goat and pulverized barley and sesame allowed to be soaked in meat and water for seven nights" to increase flowering and fruiting of trees. In Varahamihira'sBrhat Samhita, growing of sesame to flowering stage and then incorporating it as green manure is recommended. Surapala (c. 1000 AD) describes the "ancient" practice of preparing liquid manure (*kunapa*) prepared by boiling a mixture of animal excreta, bone marrow, flesh, and dead fish in an iron pot and then adding to it sesame oilcake, honey, soaked black gram, and a little ghee (or clarified butter). No fixed quantities of materials were required to prepare *kunapa*. This liquid manure was mainly used in raising trees and shrubs.

Irrigation. Archaeological investigations in Inamgaon in Maharashtra, India (1300 BC), revealed a large mud embankment on a stone foundation for diverting floodwater from the Ghod River through a channel. Rigveda mentions irrigation of crops by river water through channels as well as irrigation from wells. Buddhist literature (500–300 BC) provides evidence of building small tanks for irrigation. Artha-sastra of Kautilya refers to sluice gates of tanks and mentions that "persons letting out the water of tanks at any other place other than their sluice-gate shall pay a fine of six *panas*; and persons who obstruct the flow of water from the sluice-gate of tanks shall also pay the same fine." It is further stated that "the water of a lower tank, excavated later on, shall not irrigate the field already irrigated by a higher tank and the natural flow of water from a higher to a lower tank shall not be stopped, unless the lower tank has ceased to be useful for three consecutive years." Costs were levied on irrigation water, regardless of the source.

Extensive tank irrigation systems were developed in Sri Lanka and southern India during the first two centuries of the Christian era. Availability of irrigation made it possible to extend cultivation of rice to large areas, and thus improve food security. Sri Lankan knowledge of tank irrigation technology was most advanced. They could build large tanks and control release of water by 3rd century BC. For the maintenance of tanks in southern India, a committee of villagers called *eri-variyam* was appointed. The committee ensured repairs and desilting of tanks and distribution of water.

Irrigation from wells was practiced throughout India in ancient times. Bullocks pulled a leather bag with ropes to draw water from wells for irrigation. The so-called "Persian wheel" used for drawing water from wells was first developed in northern India prior to invasions by Turks.

Seed and sowing. Ancient scholars showed awareness of the importance of good seed; i.e., selection of the apparently healthy seed from a ripening crop, preserving it safely in storage, with or without treatments, and sowing the good seed, again with or without some treatment. About 2000 years ago, Parashara recommended (i) proper drying of seed, (ii) freedom from the seeds of weeds, (iii) visual seed uniformity, (iv) storing seeds in strong bags, and (v) storing seed where white ants would not have access and at a location where seed would not come in contact with substrates that would allow molds to grow such as cowshed wastes, damp spots, or leftover foods. Kautilya in Artha-sastra indicated that decision to sow seeds of specific crops should be taken on the basis of known rainfall patterns. He recommended that rice be sown first and mung bean and black gram later. He also suggested some seed treatments (e.g., cowdung, honey, and ghee) to ensure good germination. Manu mentioned that a professional farmer (the Vysya) must be able to determine the quality of seed. The most significant recommendation by Manu was severe punishment to a trader selling spurious seed. Varahamihira recommended pelleting of seed with flours of rice, black gram, and sesame and fumigating them with turmeric powder to ensure good germination. Surapala listed several botanicals such as seed treatment materials for shrubs and trees. Even today cowdung, suggested by Kautilya in the 4th century BC, is used for treating cotton and some other seeds by a large number of farmers.

The art of sowing rice seed in small areas, i.e., in nurseries, and transplanting of the seedlings is not a recent practice. It was first perfected in the deltas of Godavari and Krishna rivers in the 1st century AD (Randhawa, 1980).

Pests and their management. One of the earliest references to birds as pests is found in Rigveda. In the Kallavagga, Buddha pointed out when a disease called 'mildew' attacked a rice field, the latter would not produce grain. Likewise, sugarcane would be adversely affected if a disease called 'blight' affected it. Parashara listed white ants and a number of other pests such as the *gandhi* bug and stem borer of rice. Parashara used the word "disease" in Sanskrit (*vyadhi*) to differentiate from visible pests. He even listed goats, wild boars, pigs, deer, buffaloes, parrots, and sparrows as pests. However, no remedies except chanting of a mantra to ward off pests were indicated. Agnipurana states that if fruits were destroyed, a paste of horse gram, black gram, mung bean, barley, and sesame should be applied after sprinkling the affected areas with cold water.

In a later period, Varahamihira wrote a chapter on treatment of trees. He mentioned that trees are vulnerable to disease when exposed to cold weather, strong winds, and hot sun; consequently, their leaves become pale white, sprouts scanty and sickly, branches dry, and their sap oozes out. It seems Varahamihira laid the foundation of classifying tree diseases based on humors such as *vata*, *pitta*, and *kapha*, which were formalized in later centuries in Surapala'sVrikshayurveda. Varahamihira describes cleaning of "ulcers" on trees and treating those with application of paste of *vidanga (Embeliaribes*), ghee, and silt. Premature destruction of fruits of a tree was to be controlled by application of water and milk (boiled and subsequently cooled) with powder of seeds, as mentioned in Agnipurana.

Surapala'sVrikshayurveda, which deals with arbori-horticulture, gives considerable information on topics such as importance of trees, soil types, classification of plants, seed, sowing, planting, plant protection recipes, nourishment, types of gardens, locating groundwater, and bio-indicators for suitability or otherwise for raising crops and animals. Surapala gave description of disease symptoms associated with the three humors, *vata*, *pitta*, and *kapha*. In addition, he described disorders caused by excessive heat and wind, fire, lightning, drought stress, physical injury, ants (and other insects), excess water, bird damage, and possibly phanerogamic parasites. For treatment of disorders, he suggested use of a number of botanicals (many of which have antimicrobial properties) including mustard paste and milk. It is interesting to note that Surapala's reference is largely to those plant species, which originated in the Indian subcontinent, confirming thereby that plant introduction had occurred to a very limited extent. He described a method of dwarfing trees in situ to create the "bonsai" effect.

Horticulture and arboriculture. Excavations at Harappa have indicated that people were familiar with date palm, pomegranate, lemon, melon, and possibly coconut. Emperor Ashoka (274–237 BC) encouraged arbori-horticulture. Commonly grown fruit trees were plantain, mango, jackfruit, and grapes. The Sangam literature refers to jackfruit, coconut, date palm, areca nut, plantain, and tamarind. Agnipuranamentions many trees; it has a separate chapter on horticulture, which formed the base of treatises that followed.

Varahamihira wrote a chapter on "treatment of trees" in his Brhat Samhita. One of the highlights of Varahamihira's writing (Bhat, 1981) is specific reference on grafting to be done on trees such as jackfruit, plantain, *jambu* (black plum), *kapittaha* (wood apple), lemon, and pomegranate. A method of grafting described was what is known today as "wedge grafting" (Bhat, 1981).

Surapala'sVrikshayurveda provides excellent information on arbori-horticulture in the northern part of the Indian subcontinent. The text mentions 170 species of plants including trees, shrubs, and a few herbs and deals systematically with raising of orchards; procuring, preserving and treating seeds and planting materials; selection of land; preparation of pits for planting; methods of irrigation and ways to locate groundwater; nourishment and fertilizers; disorders of plants and their protection; laying out gardens and orchards; and growing unusual trees. Woodland gardening was a developed art. Layouts included designs such as *mandapa* (canopy), *nandyavarta* (quandrangle with an opening to the west), *swastika* (design of religious significance to Hindus), *chaturasra* (square), *sarvatobhadra*(a square enclosing a circle), *vithi* (line), *nikunja* (arbor), and *punjaka*(cluster). The text recommends layouts for the "pleasure gardens". Amarkosha mentions gardens such as *griharamah* (house garden), *vrikshavatika* (garden of ministers), aakrida (royal garden), and *pramadavanam* (garden for harem).

Current scenario of Indian agriculture

Indian farming is characterized by small and marginal land holdings. Majority of the farmers are having very little cultivable land. This land holding is progressively shrinking. According to the Agricultural Census, within one decade, the average size of landholding in India has declined from 1.33 ha in 2000–01 to 1.15 ha by the end of 2010–11. The average size of landholdings of small and marginal farmers is far smaller (0.63 ha) compared to the overall average size of operational landholdings in the country. In India, out of 138.35 million agricultural landholdings, approximately 117.6 million are small and marginal.

Indebtedness and noninstitutionalized credit: Farmers in India lack of access to institutional credit due to lengthy paperwork, beyond the understanding of farmers, absence of collateral, low financial risk-bearing ability and lack of alternative sources of income. There is a strong incidence of indebtedness. 16% farmers pay 6% rate of interest, 52% of farmers pay 6-10% rate of interest and 32% farmers are those who pay 18% and above rate of interest.

Indian farmers are unable to reap the benefits of the globalized market due to lack of access to credit, inability to bear investment risk and lack of ability to raise funds. Small farmers are lagging behind in adapting to the ever-changing market scenario – increasing consumer preferences for processed and value-added food products, reducing scope of direct marketing.

The others predominant characteristics are: illiteracy of farmers, excess spending on social ceremonies like marriage etc. 40.66% farmers are unable use modern machinery resulting in low productivity and low income.

Importance of agriculture and agricultural resources

- More than half of the Indian population is dependent on agriculture for its livelihood
- More than 13% of the GDP comes from agriculture sector

- Good crops increase purchasing power of the farmers, which leads to greater demand for manufactured products. Thus prosperity of farmers leads to prosperity of other industries. We note that rural markets are a large segment of market for durable products also.
- Failure of agriculture can derail the whole economic planning. This lesson was learnt during second and third five year plans and also in early 2000s.
- Most of the internal trade in the country is in agricultural products.
- Agricultural growth has direct impact on poverty eradication; it is important factor in containing inflation; raising farm wages and employment generation.
- Allied sectors such as horticulture, animal husbandry, dairy and fisheries have an important role in improving the overall economic conditions and health and nutrition of the masses.
- Agriculture sector provides raw inputs for the industrial production

Journey of Indian agriculture and its development from past to modern era

In India, while population grows, the land surface is fixed and of this only a certain proportion is available for cultivation. Further scope for bringing extra land under the plough is limited. If more production is to be got out the existing area, the problem has to be tackled on a wide front. This can be done by applying inputs in a more intensive way and by adopting modern methods of production through use of improved technology, besides making an adequate provision for institutional financing, better methods of marketing, etc. The combination of these factors is bound to result in modernization of agriculture and the outcome is increased production. The introduction of high yielding varieties in food crops as well as cash crops has created a transformation in the Indian agricultural sector. This transformation has been speeded up by the introduction of energised pump sets in well irrigation and improvements in farm machinery and transport facilities. This transformation observed in Indian agriculture may be termed

The first five-year plan (1951-56), emphasized the rapid agricultural development so as to achieve food self-sufficiency, control of inflation, and attempted a process of all-round balanced development which could ensure a rising national income and a steady improvement in the living standards of the people over a period of time. The total plan budget of the plan was about Rs 206.8 billion which was allocated to sectors such as irrigation and energy, agriculture and community development, transport and communications, industry, social services, and land rehabilitation.

The third five-year plan (1961-66) emphasized the need of a self-reliant and self-generating economy. To achieve this plan stressed the development and modernization of agriculture along with giving adequate emphasis on the development of basic industries necessary for the overall development of the Indian economy. The third five-year plan also saw the Green Revolution which advanced Indian agriculture.

The fifth five-year plan (1974-79) also focused on self-reliance in agricultural production.

One of the most disturbing features of the recent growth experience has been that of the deceleration in agriculture growth (Table 5). With about 60 per cent of the population still largely dependent on agriculture, this deceleration has clearly had a significant impact on slower reduction in poverty levels than otherwise would have been the case. Moreover, for aggregate annual GDP growth to exceed 8.5 per cent on a sustainable basis it will be difficult if agricultural growth itself does not exceed 4 per cent annual growth. Thus, the low growth rates registered in the agricultural sector clearly indicates that neither the five year plans nor the economic reforms have improved the growth of agricultural sector.

Classification of Crop Plants Need

and importance of crop classification

1. To get acquainted with crops.

2. To understand the requirement of soil & water different crops.

3. To know adaptability of crops.

4. To know the growing habit of crops.

5. To understand climatic requirement of different crops.

6. To know the economic produce of the crop plant & its use.

7. To know the growing season of the crop

8. Overall to know the actual condition required to the cultivation of plant.

Classification based on climate:

1. **Tropical:** Crops grow well in warm & hot climate. E.g. Rice, sugarcane, Jowar etc.
2. **Temperate:** Crops grow well in cool climate. E.g. Wheat, Oats, Gram, Potato etc.

Classification Based on growing season:

1. **Kharif/Rainy/Monsoon crops:** The crops grown in monsoon months from June to OctNov, Require warm, wet weather at major period of crop growth, also required short day length for flowering. E.g. Cotton, Rice, Jowar, bajara.

2. **Rabi/winter/cold seasons crops:** require winter season to grow well from Oct to March month. Crops grow well in cold and dry weather. Require longer day length for flowering. E.g. Wheat, gram, sunflower etc.

3. Summer/Zaid crops: crops grown in summer month from March to June. Require warm day weather for major growth period and longer ay length for flowering. E.g. Groundnuts, Watermelon, Pumpkins, Gourds.

Use/Agronomic classification:

1. Grain crops: may be cereals as millets cereals are the cultivated grasses grown for their edible starchy grains. The larger grain used as staple food is cereals. E.g. rice, Jowar, wheat, maize, barley, and millets are the small grained cereals which are of minor importance as food. E.g. Bajara.

2. Pulse/legume crops: seeds of leguminous crops plant used as food. On splitting they produced dal which is rich in protein. E.g. green gram, black gram, soybean, pea, cowpea etc.

3. Oil seeds crops: crop seeds are rich in fatty acids, are used to extract vegetable oil to meet various requirements. E.g. Groundnut, Mustard, Sunflower, Sesamum, linseed etc. **4. Forage Crop:** It refers to vegetative matter fresh as preserved utilized as food for animals. Crop cultivated & used for fickler, hay, silage. Ex- sorghum, elephant grass, guinea grass, berseem & other pulse bajara etc.

5. **Fiber crops:** crown for fiber yield. Fiber may be obtained from seed. E.g. Cotton, steam, jute, Mesta, sun hemp, flax.
6. **Roots crops:** Roots are the economic produce in root crop. E.g. sweet, potato, sugar beet, carrot, turnip etc.
7. **Tuber crop:** crop whose edible portion is not a root but a short thickened underground stem. E.g. Potato, elephant, yam.

8. **Sugar crops:** the two important crops are sugarcane and sugar beet cultivated for production for sugar.

9. **Starch crops:** grown for the production of starch. E.g. tapioca, potato, sweet potato.

10. **Dreg crop:** used for preparation for medicines. E.g. tobacco, mint, pyrethrum.

11. **Spices & condiments/spices crops:** crop plants as their products are used to flavor taste and sometime color the fresh preserved food. E.g. ginger, garlic, chili, cumin onion, coriander, cardamom, pepper, turmeric etc.

12. **Vegetables crops:** may be leafy as fruity vegetables. E.g. Palak, mentha, Brinjal, tomato.

13. **Green manure crop:** grown and incorporated into soil to increase fertility of soil. E.g. sun hemp.

14. **Medicinal & aromatic crops:** Medicinal plants includes cinchona, isabgoli, opium poppy, senna, belladonna, rauwolfra, iycorice and aromatic plants such as lemon grass, citronella grass, palmorsa, Japanese mint, peppermint, rose geranicem, jasmine, henna etc.

Classification based on life of crops/duration of crops:

1. **Seasonal crops:** A crop completes its life cycle in one season-Karin, Rabi. summer. E.g. rice, Jowar, wheat etc.

2. **Two seasonal crops:** crops complete its life in two seasons. E.g. Cotton, turmeric, ginger. **3. Annual crops:** Crops require one full year to complete its life in cycle. E.g. sugarcane. **4. Biennial crops:** which grows in one year and flowers, fructifies & perishes the next year? E.g. Banana, Papaya.

5. Perennial crops: crops live for several years. E.g. Fruit crops, mango, guava etc.

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Classification based on cultural method/water:

1. Rain fed: crops grow only on rain water. E.g. Jowar, Bajara, Mung etc.

2. Irrigated crops: Crops grows with the help of irrigation water. E.g. Chili, sugarcane, Banana, papaya etc.

Classification based on root system:

1. Tap root system: The main root goes deep into the soil. E.g. Tur, Grape, Cotton etc. **2. Adventitious/Fiber rooted:** The crops whose roots are fibrous shallow & spreading into the soil. E.g. Cereal crops, wheat, rice etc.

Classification based on economic importance:

1. Cash crop: Grown for earning money. E.g. Sugarcane, cotton.

2. Food crops: Grown for raising food grain for the population and & fodder for cattle. E.g.

Jowar, wheat, rice etc.

Classification based on No. of cotyledons:

1. **Monocots or monocotyledons:** Having one cotyledon in the seed. E.g. all cereals & Millets.
2. **Dicots or dicotyledonous:** Crops having two cotyledons in the seed. E.g. all legumes & pulses.

Classification based on photosynthesis' (Reduction of CO2/Dark reaction):

1. **C3 Plants:** Photo respiration is high in these plants C3 Plants have lower water use efficiency. The initial product of C assimilation in the three „C" compounds. The enzyme involved in the primary carboxylation is ribulose-1,-Biophospate carboxylose. E.g. Rice, soybeans, wheat, barley cottons, potato.

2. **C4 plants:** The primary product of C fixation is four carbon compounds which may be malice acid or acerbic acid. The enzymes responsible for carboxylation are phosphoenol Pyruvic acid carboxylose which has high affinity for CO2 and capable of assimilation CO2 event at lower concentration, photorespiration is negligible. Photosynthetic rates are higher in C4 than C3 plants for the same amount of stomatal opening. These are said to be drought resistant & they are able to grow better even under moisture stress. C4 plants translate photosynthates rapidly. E.g. Sorghum, Maize, napter grass, sesame etc.

3. **Cam plants:** (Cassulacean acid metabolism plants) the stomata open at night and large amount of CO2 is fixed as a malice acid which is stored in vacuoles. During day stomata are closed. There is no possibility of CO2 entry. CO2 which is stored as malice acid is broken

down & released as CO_2. In these plants there is negligible transpiration. C4 & cam plant have high water use efficiency. These are highly drought resistant. E.g. Pineapple, sisal & agave.

Classification based on length of photoperiod required for floral initiation:

Most plants are influenced by relative length of the day & night, especially for floral initiation, the effect on plant is known as photoperiodism depending on the length of photoperiod required for floral ignition, plants are classified as:

1. **Short-day plants:** Flower initiation takes plate when days are short less than ten hours. E.g. rice, Jowar, green gram, black gram etc.

2. **Long day's plants:** require long days are more than ten hours for floral ignition. E.g. Wheat, Barley,

3. **Day neutral plants:** Photoperiod does not have much influence for phase change for these plants. E.g. Cotton, sunflower. The rate of the flowering initiation depends on how short or long is photoperiod. Shorter the days, more rapid initiation of flowering in short days plants. Longer the days more rapid are the initiation of flowering in long days plants.

National agriculture setup in India

India has one of the largest agricultural research systems in the world with the largest number of scientific personnel of any developing country engaged in research and education relating to agriculture and allied areas. The research system includes approximately 30,000 scientists and more than 100,000 supporting staff actively engaged in research related to agriculture. Although the total number of scientists engaged in agricultural research in India looks very impressive, it compares less favourably with many developed nations in the world. The research system has evolved over years of innovation and experimentation, and it has withstood the test of time remarkably well. The present agricultural research system comprises essentially two main streams, viz. the ICAR at the national level and the Agricultural Universities at the state level. Besides, several other agencies such as the Conventional / General Universities, Scientific Organizations, and various Ministries / Departments at the Center, and also Private or Voluntary Organizations participate directly or indirectly in research activities related to agriculture.

1. The ICAR System

a) Mission: Sustainable growth of Indian agriculture by interfacing education, research and extension initiatives complimented with efficient and effective institutional, infrastructure and policy support that will create a proper fit between the humanity and its habitat. 5

b) Vision: "To harness science to ensure comprehensive and sustained physical, economic and ecological access to food and livelihood security to all Indians, through generation, assessment, refinement and adoption of appropriate technologies."

c) Mandate:

(i) To plan, undertake, aid, promote and coordinate education, research and its application in agriculture, agro-forestry, animal husbandry, fisheries, home science and allied sciences.

(ii) To act as a clearinghouse of research and general information relating to agriculture, animal husbandry, fisheries, home science and allied sciences through its publications and information system, and instituting and promoting transfer of technology programmes.

(iii) To provide, undertake and promote consultancy services in the fields of education, research, training and dissemination of information in agriculture, agro-forestry, animal husbandry, fisheries, home science and allied sciences.

(iv) To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology by developing cooperative programmes with other organizations such as the Indian Council of Social Science Research (ICSSR), Council of Scientific and Industrial Research (CSIR), Bhabha Atomic Research Center (BARC) and the Universities.

(v) To do other things considered necessary to attain the above objectives of the Society.

Organizational Structure:

As a Registered Scientific Society, ICAR now enjoys an autonomous status and it follows mutatis mutandis Government of India rules and regulations. It observes all procedures for the preparation of its plan, their scrutiny and approval by the Planning Commission, Finance Department, etc. The Minister for Agriculture in the Government of India is the President and the Minister of State for Agriculture is the Vice-President of ICAR. The Agricultural Scientists Recruitment Board (ASRB), charged with the responsibility of recruiting scientists as well as for looking after their career advancement in the ICAR system, is headed by a fulltime Chairman who is assisted by two eminent scientists as Members. The Chief Executive of ICAR is the Director General, who is an eminent senior agricultural scientist. He concurrently acts as the Ex-officio Secretary (DARE) to the Government of India. He advises the Government on all matters connected with agricultural and animal husbandry research and education in the country that are referred to him. In its functioning, ICAR is assisted by a number of bodies which provides direction and guidance on policy, technical, administrative, financial and other matters concerned with the national agricultural research and education efforts.

i) General Body: It is the supreme body, which transacts the business of ICAR. It is presided over the Minister for Agriculture in his capacity as the President of the Society and its membership is large. It is represented by many Ministers in the Center as well as the States, elected representatives of the people, representative of rural interests, farmers, Chairmen of Scientific Organizations, Director General (ICAR), Vice-Chancellors of Agricultural Universities, Directors of ICAR Institutes, technical representatives, and others. It meets at least once in a year and reviews the progress and performance of ICAR and gives such policy directions as it may deem fit to the Governing Body and other constituent units of the Society.

ii) Governing Body: It is the chief executive and decision-making authority, and is responsible for the governance of ICAR as a whole. It is pre-eminently a body of scientists and those with interest in or knowledge of agriculture, and is presided over by the Director General. It manages, administers, directs, and controls all the affairs and funds of ICAR, subject to the byelaws and orders of the Society. It prescribes polices, approves all research programmes and exercises control over the budget of ICAR. It meets once in three months and its decision will be final after approved by the President of ICAR.

iii) Standing Finance Committee: It is a subsidiary of the Governing Body with members drawn from it, and is presided over by the Director General of ICAR. It examines the annual budget of ICAR and the financial implications of all the proposals, including research projects, before submitting tot the Governing Body for approval. It also scrutinizes the Ad hoc Research Schemes and has the responsibility of operating the Agricultural Produce Cess Fund. Similar to the Governing Body, this Committee also meets once in a quarter and its decision will become final after approval by the President of the Society.

iv) Norms and Accreditation Committee: It determines the norms for financial assistance by ICAR to the Agricultural Universities and ensures maintenance of high standards of education in agricultural and animal sciences in the country. It essentially consists of five Vice-Chancellors of the Agricultural Universities and is presided over by the Director General of ICAR. Its functioning is supported by the ICAR Review Teams which visit the Universities and determine their programmes that need additional support and recommend financial assistance to them. The recommendations of this Committee are considered first by the Standing Finance Committee from the financial angles before sending for approval of the Governing Body. v) Scientific Panels: The Scientific Panels in different disciplines advise the ICAR on technical matters related to agricultural research, education and extension education. These Panels comprise 18-20 experts who are chosen form different scientific institutions, Universities and other agencies all over the country. There are 24 such Panels functioning in the ICAR and they scrutinize the technical soundness and feasibility of the project proposals submitted by various agencies. Besides considering schemes of research, these Panels may also advise the Governing Body on technical matters and draw its attention to gaps in the current research and education efforts. In addition to these Panels, the ICAR has also four Interdisciplinary or Joint Panels to consider schemes for collaboration in research with other agencies. The recommendations of these Panels are considered by the Standing Finance Committee from the financial angles before they are considered and finally approved by the Governing Body.

vi) Regional Committees: The Governing body of ICAR has constituted eight Regional Committees on the basis of eight agro-ecological regions identified in the country. The Director General, ICAR is the Chairman of these Committees. Other members of the Regional Committee comprise i) members of the ICAR Society residing in the region, ii) Chairmen of the Development Councils constituted by the Department of Agriculture of the

Government of India located in the region, iii) Directors of ICAR Institutes in the region, iv) Scientists / Technical representatives of the Agricultural Universities, State Development Departments related to agriculture, animal husbandry, fisheries, etc., Central Institutes, and Department of Agriculture of the Union Ministry of Agriculture, and v) farmers nominated by the President of the Society. One of the Directors of the ICAR Institutes in the Region acts as the Member-Secretary. There is an Assistant Director General at the ICAR Headquarters to coordinate the work of all the Regional Committees. These Committees meet once a year. The primary functions of these Committees include i) to review the status of agricultural research and education in the region, and ii) to analyse, discuss and make recommendations on the location-specific problems of agriculture, animal husbandry, fisheries and forestry peculiar to the region. The proceedings and recommendations of these Committees are put up to the Governing Body for information

On the technical side, the Director General is assisted by eight Subject Matter Divisions, one each in the fields of i) Crops, ii) Natural Resources Management iii) Education, iv) Animal Science, v) Extension, vi) Horticulture, vii) Fisheries, and viii) Agricultural Engineering. A Deputy Director General (DDG) heads each Division, and they are entrusted with the overall responsibility for the preparation, scrutiny, review, and technical supervision and guidance of the research schemes and projects within their respective disciplines. They are, in turn, assisted by 23 Assistant Directors General (ADGs) and other senior scientists dealing with sub-disciplines within these eight major areas. These Technical Divisions guide and service all the ICAR institutes. There is a Plan Implementation and Monitoring (PI&M) Unit and a Project Implementation Unit (PIU) headed by ADGs. There is yet another Director (NATP), who looks after the World Bank-aided National Agricultural Technology Project. On the Administrative side, the Director General is assisted by the Secretary, ICAR and a number of administrative units like International Cooperation Division, Finance Division, Personnel

Division, and Publications and Information Division. Each of these Divisions is headed by a Director who assists the Director General in the respective area. There are also a number of Under Secretaries and other supporting staff. The Joint Secretary in the Ministry at the Center is the Financial Adviser of ICAR. The Director General and the Secretary of ICAR are assisted by an Internal Financial Adviser in the preparation and control of the budget.

Research Infrastructure Although agriculture is a State subject, ICAR has established many Central Research Institutions over the years to meet the agricultural research needs of the country. These are essentially meant for: (i) implementing research mandates extending beyond the administrative boundaries of the States; (ii) pursuing basic research not undertaken by most Agricultural Universities; (iii) evaluating research results through multi - location testing; and (iv) developing manpower for Agricultural Universities and other agricultural institutions. The ICAR directly administers 47 Research Institutes in the areas of crop, animal and fishery sciences. They are:

A. National Institutes: The institutes engaged in research, teaching and training for manpower development include:

- Indian Agricultural Research Institute (IARI), New Delhi.
- Indian Veterinary Research Institute (IVRI), Izatnagar.
- National Dairy Research Institute (NDRI), Karnal.
- Central Institute of Fisheries Education (CFIE), Mumbai.
- National Academy of Agricultural Research Management (NAARM), Hyderabad.

B. National Bureaux: In order to collect, conserve and initiate such measures as would lead to long-term productivity of basic resources like plants, animals, fish, microorganisms, soil and water, the ICAR has established five national bureaux. They are:

- National Bureau of Plant Genetic Resources (NBPGR), New Delhi.
- National Bureau of Animal Genetic Resources NBAGR), Karnal.
- National Bureau of Fish Genetic Resources (NBFGR), Lucknow.
- National Bureau of Soil Survey & Land Use Planning (NBSS & LUP), Nagpur.
- National Bureau of Agriculturally Important Microorganisms (NBAIM), New Delhi.

Central Research Institutes: There are forty-two institutes carrying out basic and applied research on specific crops and transferring the results thereof. They are:

a) Crop Science Institutes:

- Central Rice Research Institute (CRRI), Cuttack.
- Central Research Institute for Jute and Allied Fibers (CRIJAF), Barrackpore.
- Central Tobacco Research Institute (CTRI), Rajahmundry.
- Indian Grassland and Fodder Research Institute (IGFRI), Jhansi.
- Sugarcane Breeding Institute (SBI), Coimbatore.
- Indian Institute of Sugarcane Research (IISR), Lucknow.
- Central Institute of Cotton Research (CICR), Nagpur.
- Vivekananda Parvatiya Krishi Anusandhan Shala (VPKAS), Almora.
- Indian Institute of Pulses Research (IIPR), Kanpur.

b) Horticulture and Plantation Crops Institutes:

- Indian Institute of Horticultural Research (IIHR), Bangalore.
- Central Institute for Subtropical Horticulture (CISH), Lucknow.
- Central Institute of Temperate Horticulture (CITH), Srinagar.
- Central Tuber Crops Research Institute (CTCRI), Trivandrum.
- Central Plantation Crops Research Institute (CPCRI), Kasargod.

- Central Institute for Arid Horticulture (CIRH), Bikkaner.
- Central Potato Research Institute (CPRI), Shimla.
- Indian Institute of Spices Research (IISR), Calicut.
- Indian Institute of Vegetable Research (IIVR), Varanasi.

c) Resource Management Institutes:

- Central Soil and Water Conservation Research and Training Institute (CSWCR&TI), Dehradun
- Central Soil Salinity Research Institute (CSSRI), Karnal
- Central Arid Zone Research Institute (CAZRI), Jodhpur
- Central Research Institute for Dry land Agriculture (CRIDA), Hyderabad
- ICAR Research Complex for North-Eastern Hill Region (ICAR-NEH), Barapani
- ICAR Research Complex for Goa (ICAR-GOA), Ela
- ICAR Research Complex for Eastern Region (ICAR-ER), Patna
- Central Agricultural Research Institute (CARI) for Andaman and Nicobar Islands, Port Blair
- Indian Institute of Soil Science (IISS), Bhopal

d) Technological Institutes:

- Central Institute of Agricultural Engineering (CIAE), Bhopal
- Central Institute for Research on Cotton Technology (CIRCT), Bombay
- National Institute of Research on Jute and Allied Fiber Technology (NIRJAFT), Calcutta
- Indian Lac Research Institute (ILRI), Ranchi 10
- Central Institute of Post-harvest Engineering and Technology (CIPET), Ludhiana

e) Animal Science Institutes:

- Central Sheep and Wool Research Institute (CSWRI), Avikanagar
- Central Institute for Research on Goats (CIRG), Makhdoom
- Central Avian Research Institute (CARI), Izatnagar
- Central Institute for Research on Buffaloes (CIRB), Hisar
- National Institute of Animal Nutrition and Physiology (NIANP), Bangalore f) Fisheries Institutes:
- Central Inland Fisheries Research Institute (CIFRI), Barrackpore
- Central Marine Fisheries Research Institute (CMFRI), Cochin
- Central Institute of Fisheries Technology, (CIFT), Cochin
- Central Institute of Brackish-water Aquaculture (CIBA), Chennai
- Central Institute of Freshwater Aquaculture (CIFA), Bhubaneshwar g) Social Science Institutes:
- Indian Agricultural Statistics Research Institute (IASRI), New Delhi
- National Center for Agricultural Economics and Policy Research (NCAP), New Delhi

D. Project Directorates

Because of the importance and magnitude of the work involved in a single commodity like rice, wheat and poultry, or a group of commodities like oilseeds, pulses and vegetables, ICAR has upgraded some of its research infrastructure/projects with added responsibilities, and designated them as Project Directorates. Except for the size and magnitude of work involved, these are basically the same as the Coordinated Research Projects. Additionally, they do undertake some research besides playing such national service roles like maintenance and supply of germplasm, organizing off-season nursery to promote and speed up research interests, monitoring pests and diseases, forecasting and issuing clearly warning about the pests and diseases outbreak, and performing such duties as a lead center in relation to their respective subject matter, and so on. There are now eleven of them under operation. They are: **a) Crop Sciences:**

- Directorate of Rice Research (DRR), Hyderabad.
- Directorate of Wheat Research (DWR), Karnal.
- Directorate of Oilseeds Research (DOR), Hyderabad.
- Directorate of Cropping Systems Research (DCSR), Modipuram.
- Project Directorate of Maize (PDM), New Delhi.
- Project Directorate on Soybean (PDS), Bhopal.
- Project Directorate of Biological Control (PDBC), Bangalore.

b) Animal Sciences:

- Project Directorate on Cattle (PDC), Meerut.
- Project Directorate on Poultry (PDP), Hyderabad.
- Project Directorate on Animal Disease Monitoring and Surveillance (PDADMS), Bangalore.
- Project Directorate on Foot and Mouth Diseases (PDFMD), Mukteshwar.

E. National Research Centres

The National Commission on Agriculture recommended setting up of `Centers of Fundamental Research' headed by eminent scientists in particular areas. Consequently, the ICAR conceived the idea of setting up a number of National Research Centers (NRCs). The concept of NRCs revolves around the need for concentrated attention with a mission approach by a team of scientists from different disciplines. They work under a senior leader on selected topics, which have direct or indirect relevance to resolving national problems in a particular crop or commodity or a problem area of research. These centres are designed to concentrate on those crops and commodities not well served by the research institutes. Unlike the institutes, these centers do not have divisional set-up for individual disciplines nor have regional stations. They feed the national network of research with new materials, technology and information for subsequent adoption in the different production-oriented research programmes. The NRC for Groundnut was the first to be established in 1979. There are now 31 such Centres, covering a wide range of areas like crops, horticulture, animal species, fisheries, resource management, etc. Some of the NRCs may grow into full-fledged institutes once their standard of work is established and if the subjects assume greater national importance.

a) Crop Sciences:

- National Research Center for Agro-Forestry (NRCAF), Jhansi.
- National Research Center for Banana (NRCB), Thiruchirapalli.
- National Research Center for Cashew (NRCC), Puttur.
- National Research Center for Citrus (NRCC), Nagpur.
- National Research Center for Grapes (INRCG), Pune.
- National Research Center for Groundnut (NRCG), Junagudh.
- National Research Center for Integrated Pest Management (NRCIPM), New Delhi.
- National Research Center for Litchi (NRCL), Muzaffarpur.
- National Research Center for Makhana (NRCM), Patna.
- National Research Center for Medicinal and Aromatic Plants (NRCMAP), Anand.
- National Research Center for Mushroom Research & Training (NRCMRT), Sholan.
- National Research Center for Oil Palm (NRCOP), Peddavagi
- National Research Center for Onion and Garlic (NRCOG), Pune.
- National Research Center for Orchids (NRCO), Pakyang.
- National Research Center on Plant Bio-technology (NRCPB), New Delhi.

- National Research Center for Rapeseed and Mustard (NRCRM), Bharatpur.
- National Research Center for Seed Spices (NRCSS), Ajmeer.
- National Research Center for Sorghum, NRCS), Hyderabad
- National Research Center on Soybean (NRCS), Indore.
- National Research Center of Water Technology for Easter Region (NRCWTER), Bhuvaneswar.
- National Research Center for Weed Science (NRCWS), Jabalpur National Research Center on DNA Finger printing (NRCDFP), New Delhi.

b) **Animal & Fishery Sciences:**

- National Research Center on Camel (NRCC), Bikaner.
- National Research Center for Equines (NRCE), Hisar. 12
- National Research Center on Meat and Meat Products (NRCMMP), Hyderabad
- National Research Center on Mithun (NRCM), Jharnapani.
- National Research Center for Pigs (INRCP), Ghuhati.
- National Research Center on Yak (NRCY), Dirang.
- National Research Center for Coldwater Fisheries (NRCCF), Nainital.
- High Security Animal Disease Laboratory (HSADL), Bhopal.

c) **Others**

- National Research Center for Women in Agriculture (NRCWA), Bhuvaneswar.
- National Center for Values and Ethics (NCVE), New Delhi.