CHAPTER II

Agricultural Science

Kṛṣirdhanyā kṛṣirmedhyā jantunāṃ jivanaṃ kṛṣiḥ ।
Parāśara

Section – I: Early Period

'Agriculture is a system of life where humans, plants and animals are intimately interwoven'. It entails selection of plants, their cultivation, harvesting, storage of crops, a fair conception of soil, irrigation including rainfall and many other such pertinent factors. It is certain that man started domestication and cultivation of plants out of necessity.

It has been established scientifically that the genesis of agriculture in India as a means of sustaining human life can be traced back to a period around 7000 B.C. and in an agricultural country like India which is endowed with a long agricultural tradition, it is expected that one should find a good number of old works bearing upon the development of agricultural science. But it is a fact that such works are not many in number. *Kṛṣi-Parāśara* is one of the three or four such treatises which are known to us. It is the only text in Sanskrit known till date, exclusively dealing with different agricultural operations. Various information on agricultural operations in ancient India are available from some other texts and archaeological sites. The ancient people of India had to go long way to acquire practical knowledge about cultivation of plants, their rearing as well as reproduction and their effects on the human system. There were of course several steps between the food gathering stage and that of regular cultivation. It is to be noted here that ancient science of agriculture and ancient plant science are so closely connected and interwoven with each other in Indian thought and practice in the period of its infancy, that they can not be well separated[1].

The earliest evidence of fulltime plant and animal domestication in the Indian sub-continent is found at Sambhar, Lunkaransar and Didwana in the vicinity of the saline lakes of northern Rajasthan[2]. The process of recognition of plant species which were useful to people commenced in the Indian sub-continent in the pre-historic times[3]. Domestication, cultivation and diffusion of plant species brought a gradual change and marked a transition from full-time hunting-foraging practice to a settled agricultural life.

The origin of plant domestication could be traced to the early attempts of the food gathering people at settling down in congenial environment and gradually utilizing the plant and animal resources which were found easily accessible to them. Undoubtedly wild plants, their roots, fruits, tubers and seeds were among the principal plant resources, used as food by early men. For many years man had to continue his struggle for existence with the help of stone weapons only in search of food and defence. But still, the fact remains that the Stone Age is a long chapter of stagnation because stone as a material for tools had its obvious limitations. 'The advent of metal was a real break-though in man's technological progress[4]. The mastery of the metal was a big boost to the development of human society. The Chalcolithic people equipped with copper tools very likely preferred a dry milieu as their habitat. In India, some tools in the copper hoard of the Harappans helped largely to clear off the jungles of the Indus area and ushered in an era of successful agriculture and that the entire civilization flowered forth as a result of surplus agricultural economy 'can not be doubted'[5].

The fertile alluvial soil along with heavy monsoon rainfall at that point of time and the water of the Indus were conducive to the growth of a number of domesticated plants, certainly useful to the inhabitants of the locality. J. Marshall has stated rightly that great cities with teeming populations like Mohenjodaro and Harppa could never have come into being save in a country which was capable of producing food on a big scale and which was endowed with transport, irrigation and trading facilities. Understandably the great river was the source of the prosperities of the Harappan culture.

In the early Chalcolithic phase (4700-4300 B.C.) wheat, hulled and naked barleys were cultivated. Fruits of jujube, prunus, cotton and dates were produced.

The next phase i.e. the period between 4300-3500 B.C. was marked by the manufacture of wheel made pottery which facilitated better preservation of harvested crop. Practice of cultivating high yielding hexaploid wheats (bread, club and dwarf) and barley (hulled and naked) continued[6].

By the mid-third millennium Harappan phase i.e. 3200-2500 B.C. several rabi crops were grown. Among them may be mentioned wheat, barley, lentil, chick pea, flax / linseed, etc.

Archaeobotanical investigations of several sites in some areas of Baluchistan revealed that some sites were Neolithic settlements when other sites had already entered the Chalcolithic period. Agriculture perhaps began independently at different sites. Diverse cropping patterns, using different crop species and development of agriculture at different sites in Baluchistan would suggest different routes of introduction of different crops as well as of stimulus to practice of agriculture.

In a number of Chalcolithic sites in India, both rice and wheat have been discovered. But the evidence of rice (*Oryza sativa*) in the core area of the Indus or Harappan civilization has not yet been found in the archaeological and palaeobotanical remains. With a view to investigate this aspect of Harappan plants economy, a joint team of palaeobotanists and archaeologists of Japan and Pakistan carried out studies at Harappa. They undertook the method of plant opal analysis. The results of analysis show that in the case of soil and ash samples, plant opals of rice, Ragi and some species of wild grasses were present at Harappa[7].

Weber identified generic names of plant remains of over 23 thousand seeds obtained from 66 soil samples excavated from Harappa[8].

The querns have been found in various excavated areas of the Indus culture. These querns have proved beyond doubt that grinding of the grains were carried out on a large scale. Agriculture in those days

mainly comprised cultivation of wheat, barley, sesamum, pea, cotton, date palm, pomegranate and banana[9]. Shapes and designs of several artifacts would suggest that the Indus valley people were quite familiar with several fruits. Mention may be made of two faience sealing shaped like date-palm, a pendent shaped like a lemon leaf, some earthenware vases shaped like a pomegranate and coconut and a few vestiges of seeds comparable to those of melon, from Mohenjodaro and Harappa.

The Harappans wore cotton garment and the history of cotton a commercially important product from plant can be traced back to the Indus valley civilization. From the sites of the Mohenjodaro cotton cloth and string have been recovered. Fibers of cotton were found adhering to a silver vase at Mohenjo-daro.[10] Several faiences and vessels unearthed from Mohenjodaro and Harappa bear the impressions of woven textile. We know from the careful microscopic examination of small vestiges of woven material found adhering to copper objects which had been wrapped in cloth, that this fabric was cotton of plain weave[11].

Earlier there were some controversies regarding the use of plough by the Indus people. Kosambi held that the Indus people did not have the plough but only a toothed harrow[12]. But the discovery of a furrowed field at Kalibangan proves the existence of a plough. In this context Chakraborty's opinion is worth mentioning that the terracotta model of a plough found at Banawali, sets at rest all the hypotheses about the use or no-use of plough in the Harappan civilization[13]. On the basis of these evidences the Allchins express the view that an agricultural practice was already in vogue during early Indus times[14]. It can hardly be denied that before reaching the 'Mature Indus style' the pre-Harappans introduced ploughs for cultivation in their formative state. The Indus people knew the technique of flood irrigation and could utilize the flood water of the Indus for a successful agriculture. Thus by irrigated farming and use of ploughs, they produced huge agricultural surplus without which the flowering of such an urban civilization could not have been possible. The transformation of the early Indus culture into the 'Mature Indus style' resulted in all probability from the tremendously productive agricultural potentialities of the alluvial soil of the Indus. The Allchins confirm the

observation of Lambrick on the way of their production[15]. The Indus people took the advantage of the yearly inundation by the river for sowing the cereals like wheat and barley i.e. the rabi crops just at the end of flood. Practically the inundated area acquired much fertility and the alluvium gave return on a large scale. Cotton and sesame were sown at the beginning of inundation and harvested in the autumn as Kharif crops.

Thus it can be concluded that the Indus people could gather knowledge for exploiting flood water for successful agricultural operation and the secret of their success in creating a vast agricultural surplus lies in their perfect understanding of the environment and the nature of the Indus flood.

The oldest evidences of the use of wood in the Indus region have been recorded from Harappa proper and from the sites of Harappan culture in Gujrat[16]. Harappans used the scented woods of Deodar (*Cedrus deodara*) and rose wood (*Dalbergia latifolia*) for making coffins. Jujube (*Zizyphus* sp.) wood was used for making wooden mortars. The selection of a particular type of wood for a specific purpose indicates that the Harappans were well aware of the different qualities of timber species. Chowdhury likes to interprete it as a strong evidence which indicates that Harappans culture was based on years of experience on the use of this botanical product. The charred timbers recovered from Lothal in Gujrat and studied by Rao and Lal were of *Acacia* sp., *Albizzia* sp., *Tectona grandis*, *Adina cordifolia* and *Soymida febrifuge*.[17] This is a clear indication that they knew well of the quality of the timbers mentioned above.

Mention should also be made in this connection of the two largest remains of wooden tools and implements which have been found at Burzhom in Kashmir and Chirand in Bihar. These remains indicate the various types of trees which were used by the Neolithic people of those area[18].

Thus on the basis of the inferences emerged out of the hard labour of the archaeologists and the palaeobotanists we can build some

idea about the knowledge level and experiences of the Indus people on different aspects of agriculture and plant life.

There are several representations of ships and boats in old Indian art. The earliest of these is the one found on a rectangular seal unearthed by archaeological excavation at Mohenjodaro, dated to at least 3000 B.C. The vessel portrayed on the seal is roughly cut and has a sharply upturned prow and stern. This is a feature which is usually found in the representations of boats known to ancient civilization. As the boat is shown as lashed together at both bow and stern, Mackay likes to suggest that the boat was probably made of reeds like the primitive boats of Egypt and the crafts that were used in the swamps of southern Babylonia. The hut in its centre also appears to be made of reeds[19]. On the basis of this evidence it is easy to conjecture that the Indus people developed considerable knowledge on the qualities and varieties of reeds also, side by side with the knowledge on the properties of woods.

The boat is without a mast, the absence of which suggests that it was used only for river works. But a boat with a mast, scratched on a pot-sherd was also found[20]. The presence of a mast at the centre in stead of the deck cabin as in the first boat gives an indication that the second type of vessel was for both riverine and sea-trade. The Indus valley in those days had intimate intercourse with Sumer and Elam both by sea and land, and the Indian merchants certainly used both sea and land routes[21]. Dr. Mookerji assumes that the sea-route was more frequently used though its total distance from a port like Karachi to a port like Basra at the other end exceeds 1400 miles[22]. It is very logical to believe that the existence of a large and navigable river like the Indus created a situation for brisk boat as well as ship building activities in the city. As a natural corollary of this situation, it may be argued that the Indus had amassed much knowledge about the characteristic features of different reeds and plants. They were certainly aware of the properties of different classes of vegetation like tree, weeds, reeds and creepers. It may be assessed that their long experience and knowledge helped them to build water vessels with such durable vegetal materials which could withstand prolonged wetting during voyages. The ships and the boats it seems, were

manufactured strong enough giving special attention to their durability so that sea faring of 1400 miles or even more was possible.

The discovery and utilization of burnt brick by the Indus people also point to a fact that sufficient timber was produced in the Indus valley. The earthen potteries and vessels were also to be burnt. The conjecture that the Indus valley could not have produced sufficient timber for such large scale burning has been set aside by the Allchins. They give emphasis on the opinion of Lambrick who due to his long experience as an administrator of Sind, held that timber grown along the riverine tracts was sufficient for all the burnt-bricks made in the province (at present) and naturally it may be held that in the Harappan period, the timber produced could not have been less abundant[23].

The picture of the animals of prehistoric India, built up from their actual remains and representations on potteries and figurines claims that the Indus people were well acquainted with the wild animals like tiger, elephant, rhinoceros and buffalo. The existence of such animals is possible only in thick forest covers which fact also strengthens the idea that the Indus people had their own timber resource in plenty. But at the sametime it is curious to note that trees are seen seldom on the seals of the Indus culture[24].

But even after making a thorough survey of the state of agricultural and botanical knowledge of the people of Harappan culture on the basis of archaeological remains only, the scholars are not in a position to comment on their perception on plant life and its utility for maintaining nature's balance. The absence of any written account as well as our inability still to decipher the scripts on the Indus seals stands on the way and deters us from making a conclusive estimate of the Harappans on this aspect. Besides, the scholars are yet to be unanimous regarding the functional aspects of the seals. As archaeology alone provides us with information no doubt of surest value, the Indus people, yet fail to bear any message to the posterity regarding their awareness of nature. In the pre-literate communities, the technological experience in which science is only implicit is transmitted as craft lore, in the form of

oral precepts and examples[25]. 'Craft-lore' to quote Chattopadhyaya, 'is circumscribing by severe conservatism'.

The invention of script and the possibity of committing to writing only can remove the conservation characteristic of craft-lore and a fetter for technology to develop into science. The profound importance of the invention of writing for recording the account of the development of science in historical outline can hardly be exaggerated. The Indus people had their script. They were equipped with the technique of writing no doubt, but the fact is that it still remains undeciphered. Invention of writing as Gordon Child observes 'was destined to revolutionize the transmission of human knowledge. By it means a man can immortalize his experience and transmit it directly to contemporaries living far off and to generations yet unborn. It is the first step to raising science above the limit of space and time.'[26] So decipherment of the Indus script can make a solution.

So with the breakdown of the highly developed socio-economic system of the Indus civilization their link with the posterity apparently seems to be missing largely. This happened perhaps because of non availability of written documents. May be the inhabitants used perishable materials for writing. Writing which is in the words of H.G. Wells 'a new means of continuity,'[27] cannot reach us from the Indus people bearing the message of their own.

The observation of M.R. Mughal can help us to have an idea of the extent of the civilization flourished at the dawn of Indian history — 'Starting from the borders of Afghanistan, northern Baluchistan (at Periano Ghundai), and the Iranian border on the Makran coast (at Sutkegan-Dor), it extended east and south-east and covered the entire Makran coast, the Greater Indus Valley and Gujrat. Beyond the vast plain of the Punjab, including that part which was formerly drained by the Ghaggar-Hakra River, remains of the Indus culture have also been found near Delhi in Ganges-Yamuna Doalb'. This observation was made in 1972. In 1983, the Allchins estimated the area covered by the Harappan culture to a little less than half a million square miles. Further

reference is not essential to stir the imagination of the people for making an idea of the vast extent of this material culture area. Understandably such an urbanization process could have been at work due to an accumulation of enormous amount of agricultural surplus. At the same time it may be kept in mind that such a vast stretch of human settlement with brick works required almost an astronomical number of bricks. Initial foundation and subsequent expansion of a great city civilization like that of the Indus can be thought of in those ancient days only when two resources are available, good soil for agriculture and plenty of timber for firing the bricks and potteries. Fertile soil must contain mineral, compost organic fertilizer and, soil water. All these essential components of good soil are contributed by a good forest cover in the nearby. Further, the retention of ground water also depends on forest tracts. Forest tracts maintain good humid climate favourable for adequate rainfall. Rainwater while flowing through the forest bed faces obstruction allowing time for seepage into the ground. This provides soil moisture for agriculture as well as ground water for domestic purpose. Being a member of the animal world, human life is intimately associated with vegetation. An area devoid of vegetation is subject to soil erosion causing repetitive flood as it is experienced in recent days in sub-Himalayan plains of North Bengal and Northern part of Bihar due to rampant deforestation in the upper forest tracts. A flood prone area can not be chosen for human settlement. The destruction of Indus civilization because of recurrent flood as has been emphasized by some historians (though along with some other factors) like the Allchins, M. R. Sahni, Raikes and Dales, Agrawal and others clearly points to a fact of deforestation either by human intervention or by calamitious natural disasters. According to Wheeler, widespread deforestation of the surrounding region was caused by the Harappan people to meet the demands of firewood for brick and pottery production, for domestic fuel and for smelting metal. There is hardly any doubt that the Indus people reached a considerable height of knowledge on agriculture and botany. They used to live in villages, cities and towns, wore cloths, cultivated different types of crops, fruits and cotton, utilized the river water,

worshipped trees, glazed their pottery with plant-juice and painted them with plant designs. So justification is there to think that they knew adequately about the characteristics of plants which grew in their surroundings. It appears that the ecology along Indus (in the shape of vast alluvial pliable plains and a gallery of forest) provided endless opportunities for their material prospect, but how far the people of the valley were prudent in the utilization of their living resource base still remains a historical problem.

Advent of the Aryans: Beginning of the Study of Indian Flora by the Aryans

The Aryans migrated to India from the west and poured into this country in batches. The Aryan conquerors, who in the words of Le onard Woolley were a 'simple, not to say a barbarous people, pastoral nomads for the most part'[28], opened a new vista in the history.

It has been more or less accepted by the scholars that the Aryan migration to this country occurred between 2300 and 1750 B.C. It seems relatively certain that the decline of the Harappan civilization began in about 1750 B.C. and this decline was in some way connected with coming of the Aryans to this country. That the Aryans were careful observer of the flora and fauna of the newly acquired country is proved from their literature. It is true that the Vedic people — before being merged into the vast mass of the Indian population among which the Aryan and non-Aryan elements are not very clearly distinguishable — left for the posterity nothing spectacular from the strict point of view of material culture. But they created something most amazing in world history — a vast literature of over a thousand songs and hymns which is compiled as the *Ṛgveda Saṃhita*. In any case it is certain that such a composition evokes appreciation primarily of the historian of literature. Nevertheless, it is true at the same time that even as literature; this contains certain concepts with exceedingly interesting science potential. Perhaps on this premise, D.P. Chattopadhyaya takes a firm stand

opposite to the remark of Woolley that for more than a millennium after their arrival the history of the Aryans is shrouded in utter darkness. He comments that this statement seems to be in need of some modification 'if not from the strictly archaeological view point at least from the standpoint of the history of science and technology in India'[29]. The history of science in India can not be designated as sufficiently scientific if the formal sciences embedded in the *Ṛgveda* like the metrics, linguistics etc. are ignored. Agreeing with the observation of Chattopadhyaya on the point of formal sciences like metrics and others, it may be argued that the verses in the *Ṛgveda* reflect a wider perspective of empirical sciences not to speak of experimental sciences at least the science of agriculture, knowledge of plants, rudimentary ideas about effects of sunlight, cloud etc.

The Vedic Aryans were mainly an agricultural people and agriculture was considered as an important vocation by them. The oldest composition of the people, the *Ṛgveda* reflects the actual esteem in which vocation of agriculture was held. It has several verses describing the profession of farming, farming operations and farmer's happy and enjoyable life. For example a verse may be cited from the *Ṛgveda* Book X, Chapter 34, and verse 13. It contains a divine message from the sun-god who directs the mankind to take to agriculture. The tenth mandala is regarded by the scholars as later interpolation, yet the verse may be cited as a proof of importance of agriculture as vocation. The exact verse runs thus:

'O' Gambler! Listen to me as you trust my word. Do not play with the dice. Instead take to farming. Enjoy your riches reaped therewith. Living by cultivation you shall possess cows; you shall regain the love of your wife. The Sun God, the composer of the sacred texts, who sets the world in motion, has stated this to me the very same thing in so may different ways'.

Griffith's translation: Play not with Dice: no, cultivate thy corn-land. Enjoy the gain, and deem that wealth sufficient.

There are thy cattle, there thy wife, O gambler. So this good Savitar himself hath told me. (*ṚV.*, X. 34, 13, p.555).

That the Vedic people attached great importance to agriculture is evinced from several hymns. A *Ṛgvedic* hymn says:

With the master of the field, our friend, we triumph, may he bestow upon us cattle, horses, nourishment, for by such (gifts) he makes us happy... May the herbs (of the field), be sweet for us; may the heavens, the waters, the firmament be kind to us; may the lord of the field be gracious to us ... May the oxen (Draw) happily; the men (labour) happily; the plough furrow happily ... Auspicious *Sītā* (furrow) be present, we glorify thee; that thou mayst be propitious to us, that thou mayst yield us abundant fruit.... May the ploughtshares break upon land happily, may the ploughman go happily with the oxen; may parjanya (water the earth) with sweet showers happily[30].

A number of verses have been quoted by Nene and Sadhale with a view to high lighting the general concerns of the Aryans for agriculture, environment, forestry, flora and fauna, animal husbandry and other related issues[31]. A few verses of their free translation along with Griffith's are quoted below:

'O sun! you are the purifier and protector of every thing. We praise the light by which you look after this world and feed all living beings.'

Griffith's translation: Swift and all beautiful art thou, O *Sūrya* maker of the light, illuming all the radiant realm. Thou goest to the hosts of Gods, thou comest hither to mankind. Hither all light to be beheld. With that same eye of thine wherewith thou lookest, brilliant *Varuna*, upon the busy race of men. Traversing sky and wide mid-air, thou mettest with thy beams our days, Sun, seeing all things that have birth (*ṚV.*, I. 50, 4-7, p.32).

'Ocean, sky and space are the three places where fire originates. Fire in the form of sun has divided seasons to produce all living beings on the earth in a sequence' (*ṚV.*,1.95.3).

'Through *yajña* the mother earth worships the father — the sun. Sun and earth produce the embryo which is irrigated with water inside the earth. Earth and sun have decided to produce all kinds of crops' (*ṚV.*,1.164.8).

'Water is the same, in summer it goes up and then comes down in the rainy season. Clouds make the earth happy and fire pleases the heaven' (1.164.51).

'The sun, who watches the whole universe and who destroys all invisible poisonous creatures rises from the east' (*ṚV.*,1.191.8).

Griffith's translation: Slayer of things unseen, the sun, beheld of all, mounts, eastward, up (*ṚV.*, I.191.8, p. 128). Consuming all that are not seen and evil spirits of the night.

'*Gṛṣma, varṣā* and *śisira* seasons are the heart of a *samvatsar* (full year) and *vasant, śarad* and *hemant* seasons are the breasts. A *samvatsar* is variable, characterized by heat, rain and cold, full of rain, and produce grains' (*ṚV.*,3.56.3).

'*Samvatsar* ensures production of flowers and fruits in medicinal plants. Water pleases *samvatsar* for tour months and leaves it for eight months' (*ṚV.*,3.56.4).

'O cows! Procreate calves, select fine quality grass for eating, and drink clean, safe water from the ponds' (*ṚV.*, 6.28.7).

Griffith's translation: (O cows) crop goodly pasturage and be prolific: drink pure sweet water at good drinking places.. (*ṚV.*, VI. 28. 7. p. 302).

The authors think that description of the sun as 'purifier' and 'protector' must have been based on a realization that human beings, animals, and plants enjoy good health when the sun regularly shines on the earth[32]. Similarly, observations must have revealed that harvested produce and food items are preserved better through solar drying. A statement that the light from the sun assists in feeding all living beings indicates a realization of a biological cycle and a food chain. The chapter is known as *saurasūkta*. G.P. Majumdar likes to think that there is

indication in the hymns of the *Ṛgveda* that the Vedic Indians had some knowledge of the manufacture of food, the action of light on the process and storage of energy in the body of the plants[33] — a great achievement for the people of ancient India.

The Vedic farmers were also aware of the method of rotation of crops which came into use for improving the fertility of the soil. From the *Taittirīya Saṃhitā,* we get the reference to cultivation of rice in the summer and pulses in winter as well, on the same field. Roxburgh who is called the father of India Botany thinks that the western world is to be indebted to India for this system of sowing[34].

The references to agriculture as found in the Vedic literature make it evident that the Vedic cultivators possessed knowledge of the fertility of soil, selection and treatment of seeds, seasons of sowing and harvesting, rotation and other cultural practices of crops along with watering and manuring for successful agricultural production. But rice was still a wild growth during the *Ṛgvedic* days. It began to be cultivated at a later time as it is known from the *Taittirīya* and other literature.

A few verses may be cited from the *Ṛgveda* to get a clean picture of the practice of collecting water from catchment areas.

'Arrange the buckets in their place: securely fasten on the straps.

We will pour forth the well that hath a copious stream, fair-flowing well that never fails'. (*Ṛ.V.,* X. 101. 5. p.614).

'I pour water from the well with pails prepared and goodly straps,

unfailing, full, with plenteous stream'. (*Ṛ.V.,* X101.6.p.614.).

'Refresh the horses, win the prize before you: equip a chariot fraught with happy fortune.

Pour forth the well with stone wheel, wooden buckets, the drink of heroes, with the trough for armour.' (*ṚV.*, X101, 7. pp.614-615).

Of the water lifting devices, the use of a stone wheel is very interesting.

The art of agriculture as it can be gleaned from the verses of the Atharva Veda is practically a reproduction of what we get in the *Ṛgveda.*

`In the hymn no 17 of the *Atharvaveda*, Book III, we get a picture of the art of cultivation. The hymn begins by asking to harness the ploughs' and 'to extend severally the yokes' and scatter the seed in prepared womb.

(*A V.* Book III., 17.2., Whitney, p. 115).

Another hymn is addressed to the god of plenty so that he might favours his worshippers with an abundance of grain (*A V.* Book II., p. 24).

Further a hymn in the *Atharvaveda* conveys a beautiful tribute to the rain which is a vitally necessary agency in the luxurious development of herbs and plants. The connection between rain and the growth of corn is acknowledged (*A. V.* IV.15). We also get the names of animal enemies of corn in another hymn. The locust, the rat, the devourers of corn are mentioned (*A V.*, VI. 50).

Desire for protection and health of cattle, the inescapable requisites for agriculture is beautifully expressed in a hymn. It is said.

'They shall not be lost; no thief shall harm (them); no hostile (person) shall dare attack their track. With whom he both sacrifices to the gods and gives, long verily with them does the Kine-lord go in company'.

'No dust - raising horseman reaches them; nor unto the slaughter-house do they go, etc.' (*A V.*, IV.21. 4. Whitney, p. 187).

'Rich in progency, shining in good pasture, drinking clean water at a good watering place — let not the thief master you, nor the evil plotter; let *Rudra*'s weapon avoid you'. (*A V.*, IV. 21.7. Whitney, p. 187).

From the *Ṛgvedic* literature it is clearly seen that field operation to raise crops were well- established. According to an observation of agricultural scientists of the recent period[35] it may be stated that: (1) the Aryans had knowledge on different kinds of soil and productive and non-productive fields were recognized. (2) Soil preparation was done through

repeated ploughing. (3) Classification of seasons into six different seasons was also done. (4) The technique of measurement of land with the help of stick was known to them. (5) Existence of wells for drinking water was obviously known. Artificial irrigation method was also followed. (6) The Aryans had fair idea about the horse, bulls and cattle for using them for different purposes in agricultural operation. (7) They were aware of the danger of insects, rats i.e. the devourers of corn. (8) Other farm operations like harvesting with sickle, threshing, winnowing, storing grain in storage bins and burning of trash / wastes were done by them. (9) There is an indication that barley was ratooned. Barley was probably roasted. (10) There is also reference to disease free (*roga-mukta*) food and continued productivity of soil.

POST VEDIC PERIOD

In the post Vedic period, the political unification which was brought about by the monarchs of Magadha contributed a great deal to the development of agriculture. With the birth of imperialism in Northern India, in or about B.C. 543, a change came to be noticed in the developmental process of different branches of knowledge. It must be emphasized that the state then had an established machinery for collecting taxes from its subjects who followed different vocations, the principal ones which provided the people with the means of livelihood being (*kṛṣi* (agriculture), *paśupālana* (animal-husbandry) and *vāṇijya* (trade). The ancient thinkers often advised the kings about the importance of *Vārtta*. Agriculture, animal husbandry and trade, these three together were recognized as *Vārttā*. (However according to both *Bṛhaspati sūtra* and *Prabodhacandrodaya*, *Vārttā* primarily means agriculture).

In the *Śāntiparva* of *Mahābhārata*, *Bhīsma* advises *Yudhiṣṭhira* by describing agriculture, animal husbandry and trade as very life of the people.

Agricultural development during the period contemporaneous to Buddha went on but this development depended largely on the *Śudra* cultivators[36].

The *Arthaśāstra* of *Kauṭilya* contains information of value to the understanding of importance of agriculture in those days. Some features of the state agricultural policy may be gathered from this invaluable book. Undoubtedly the state gave considerable encouragement to the settlement of people on unoccupied land with the aim of increasing the agricultural production. No doubt Magadha was gifted with rich soil for cultivation of crop, timber yielding forests in the neighbourhood, iron deposits and with elephant forests. But a well conceived agricultural policy of the state was at the root of prosperity of the Magadha Empire.

In the *Arthaśāstra*, we notice that there was a Department of Agriculture under the supervision of the Director of Agriculture[37]. Qualification, duties and responsibilities are all minutely defined by *Kauṭilya*. In the *Adhykṣapracāra Adhyāya*, *Kauṭilya* says.

1. 'The Director of Agriculture, himself should be conversant with the practice of agriculture, water-divining and the science of rearing plants, or assisted by experts in these, should collect, in the proper seasons, seeds of all kinds of grains, flowers, fruits, vegetables, bulbous roots, roots, creeper fruits, flax and cotton' (II.24.1. Kangle, p. 148).
2. 'He should cause them to be sown in land, suitable for each, which has been ploughed many times, through serfs, labourers and persons paying off their fines by personal labour' (II.24.2, Kangle, p. 149).
3. And he should cause no delay in (the work of) these on account of ploughing machines, implements and bullocks and on account of (the work of) artisans, such as smiths, carpenters, basket-makers, rope-makers, snake catchers and others (II.24.3, Kangle, p. 149).

The meteorological observations conducted in connection with and in the interest of agriculture over the whole of India seem to be simply marvellous for that age.

'The quantity of rain that falls in the country of *jāṅgala* (in the desert countries com) is 16 *droṇas*; half as much more in moist countries (*anūpānām*); as to the countries which are fit for agriculture (*deśavāpānām*) — 13.5 *droṇas* in the country of *Aśmakas* (the countries of *Mahārāṣṭra*-com); 23 *droṇas* in *Avantī*, and an immense quantity in western countries (*aparāntānām*) (the countries of *Koṅkaṇa*), the boarders of the Himalayas, and the other countries where water channels are made use of in agriculture (*Kulyāvāpānām*)' (II.24. Shamasastry, p.127). 'When one-third of the requisite quantity of rain falls both the commencement and closing months of the rainy season (the months of *Śrāvaṇa* and *Kārtika*-com.) and two-thirds in the middle i.e. in the intervening two months — then the rainfall is considered very even or excellent (*suṣamārūpam*).' (II.24. Shamassstry. p.128). 'A forecast of such rainfall can be made by observing the position, motion and pregnancy (*garbhādhāna*) of Jupiter, (*Bṛhaspati*), the rise and set and motion of Venus, and the natural or unnatural aspect of the sun.' (*I bid.*).

It is also stated:

'From the sun, the sprouting of the seeds can be inferred; from (the position of) Jupiter, the formation of grains (*stambakaṅitā*) can be inferred; and from the movements of Venus rainfall can be inferred. The superintendent of agriculture is expected to have clear concept regarding the nature of different types of clouds and variation in the quantity of rainfall. Hence i.e. according as the rainfall is more or less, the superintendent shall sow the seeds which required either more or less water' (*Ibid.*).

The Superintendent was also to see that seeds of crops are properly sown and reared in their proper seasons, in proper fields and under circumstances and conditions favourable to the growth. Thus it is instructed: 'The Superintendent shall grow wet crops (*Kedāra*) winter

crops (*Haimanta*), or summer crops (*graiṣmika*) according to the supply of workmen and water'. (II.24. SS. p.129).

Śāli (a kind of rice), *vrihi* (rice) kodrava (Paspalum scrobiculatum), *tila* (*Sesamum*), *priyaṅgu* (ponic seeds) (u) *dāraka* and *varaka* (*Phaseolus tribolus*) are to be sown at the commencement (*pūrvāvāpaḥ*) of the rainy season (*Ibid.*).

Mudga (*Phaseolus mungo*), *māṣa* (*Phaseelous radiatus*) and *śaimbya* are the middle sowings i.e. are to be sown in the middle of the season (*Ibid.*).

Kusumbha (safflower), *masura* (*Ervum hirsutum*), kuluttha (*Dolichos uniflorus*), *Yava* (barley), *godhūma* (wheat), *kalāya* (leguminous seeds), *atasī* (lin seed) and *sarṣapa* (mustard) are to be sown last. Or the sowing of seeds should be in conformity with the season (*Ibid.*).

Besides the principal crops like rice, wheat, barley or pulses there is specific mention of suitable soil for different kinds of vegetables and roots. A relevant passage may be cited here: 'Lands that are beaten by foam (banks of rivers etc.), are suitable for growing *vallīphala* (pumpkin, gourd and the like), lands that are frequently overflown by water for long, pepper, grapes and sugar-cane; the vicinity of wells for vegetables and roots; low grounds for green crops; and marginal furrows between any two rows of crops are suitable for the plantation of fragrant plants, medicinal herbs, khuskhus roots (*uśīra-grass*), *hrībera*, *piṇḍāluka* and others' (*Ibid.*, p. 129). The treatments of seeds are narrated in another verse. It says: 'The seeds of grains are to be exposed to mist and heat for seven nights; the seeds of *kośī* (such as mudga and *māṣa* etc. - com.) are treated similarly for three nights; the seeds of sugarcane and the like are plastered at the cut end with the mixture of honey, clarified butter, the fat of pig and cow-dung; the seeds of bulbous roots (*kanda*) with honey and clarified butter; cotton seeds with cowdung; and water pits at the root of trees are to be burnt and manured with the bones and dung of cows at occasions (*Ibid.*, pp. 129-130).

The sprouts of seeds, when grown, are to be manured with a fresh haul of minute fishes and irrigated with the milk of snuhi plant' (*Ibid.*, p. 130). Thus we find that *Arthaśāstra* gives concrete information regarding the state of agricultural knowledge of the ancient Indians in the 4th-3rd century B.C. Under the Mauryas, the political system acquired greater uniformity but available evidences, literary as well as archaeological also suggest that developments did not occur only in political and economic conditions; associated with this development was another important factor which also helped the Maurya rulers to adopt a definite agricultural policy of the state and that factor was the development of agricultural knowledge which in other words may be designated as agricultural science.

It is obvious from the chapter in the *Arthaśāstra* dealing with the qualifications and responsibilities of the Superintendent of agriculture, that the person assigned with the department of agriculture had to possess a wide range of knowledge in agriculture and *vṛkṣāyurveda* as well. The agrarian picture of the period shows that the Maurya administration was largely concerned with the efficient collection of taxes which depended mainly on the collection of land revenue taxes. The clearing and settlement of new areas were organized by the government. But at the same time, it does not escape the notice of the reader that the improved knowledge in agriculture and plant science also was responsible for successful management of the agrarian administration of the Mauryas. A study of the policy of *Janapadaniveśa* reveals that it was an economic programme launched by the government primarily to utilize the hither to untapped agricultural resources[38].

R. Chakravarti observes that the programme of *Janapadaniveśa* was economically so important to the royal authority that *Kauṭilya* did not allow a park, a recreation hall, actors, dancers, singers, musicians, professional story tellers or ministrels to be present in a newly colonized area so that no obstruction in the wealth producing activities arises. *Kauṭilya*'s stringent attitude against providing amusement in a newly acquired area was intended to bring optimum success in agriculture. The presence of entertainers could have diverted the attention of the people

engaged in agriculture and harmed the total process of operation. Rather temptation can not be resisted here to mention the model role of the Director or Superintendent of agriculture of the government as is expected by *Kauṭilya* for successful implementation of agrarian policy of the state. *Kauṭilya* never fails to assess the utilitarian value of agricultural knowledge accumulated through long practice and empirical observation of the people, '*Kṛṣitantragulma Vṛkṣāyurveda*' as is termed by *Kauṭilya*, seems to have had a strong data base and the state adopted a sincere role for successful implementation of its agricultural extension policy with the help of contemporary scientific ideas. In this context, an inscriptional reference may be drawn to show an all out effort of the Maurya government to avoid any calamitous circumstances in agricultural production. This is the reference of *Mahāsthangaḍ* and *Sohgaura* inscription[39]. The nature of both this inscriptions is similar and both are composed in *Aśokan Prākṛt*, inscribed in the *Brāhmī* script of the 3rd century B.C. and deals with relief measures to be adopted during a famine. These show that certain essential items like grains or something else were preserved in storehouses to combat untoward situation arisen out of natural calamities or sometimes emergency caused by fire, drought or flood. In case of the *Mahāsthāngaḍ* inscription, we get clear information that paddy, mustard seeds and sesame were preserved in the *koṣṭhāgāraḥ* of *Puṇḍranagara* to tackle the crisis at time of emergency due to flood or drought.

The inscription records the grant of paddy, and probably also of money to the people by way of loan in order to relieve the distressed caused apparently by famine. The information obtained from both the inscriptions throw some light on the concern of the state authority for sufferings of the subject people in an uncalled for situation and its attempt to relieve them by way of granting loan in cash and in kind. It may be defined as a sort of 'crisis management' in today's terminology[40]. The clear indication therein of the government store-house being provided with grains for the relief of the people during flood or famine finds its support from instruction laid down in the *Arthaśāstra*

to the effect that the government store keeper shall keep apart one-half of the stores of agricultural products for meeting such emergencies.

The King is advised to protect his kingdom from famine and other calamities. During famine, the King shall show favour to his people by providing them with seeds and food stuffs.

The Superintendent of store house was entrusted with the responsibility of supervising the accounts of agricultural produce which was practically the main source of state income. And further instruction for him was that 'of the store thus collected, half should be kept in reserve to ward off the calamities of the people and only the other half shall be used. The old collection was also to be replaced by new supply' (II.15.SS.p.101).

The references mentioned above are important not only for the reason that we get a picture of the role of the state authority in combating such calamitous situation but they bear deeper significance from the point of view of agricultural management. The authorities, we notice, did not remain satisfied only with the provision of offering food stuff to the famine-affected people; they also provided them with seeds. Certainly their consideration was that the food would save the people from starvation while the seeds would ensure the harvest for the next year.

It was a policy of prudence and at the same time may be viewed as supplementary measure for uninterrupted agricultural developmental programme of the state. The accounts left by the classical writers preserve information on fertility of soil and agricultural produces of the time. These are somewhat consistent with the growing condition of agriculture of the period as is evident from some other sources. Megasthenes indicates the fertility of India by saying that it produces fruit and grain twice a year. Eratosthenes also speaks of the winter and the summer sowing and also of rain[41].

The social division as understood by Megasthenes is also very interesting from the perspective of agricultural practices. Among the seven classes of people in India, the second one i.e. the cultivators who formed the bulk of the population were exempted from fighting and other

services. They devoted the whole of their time to tillage. In time of civil-war the soldiers were strictly prohibited from doing any harm to them.

Thus the overall picture clearly gives the reflection that from the very beginning the ancient Indian thinkers and the governing classes were conscious of the agricultural potentialities of the country and accordingly pursued a policy conducive for agricultural extension. It was done through administrative measures by way of utilizing knowledge acquired cumulatively through empirical observations of the people for centuries. Intensifying agriculture would have required some state interest in irrigation which is reflected in the erection of *Sudarśana* lake at Girnar[42]. Erection of dam or artificial irrigation system in fact falls within the scope of agricultural technology or agri-irrigation and ultimately within the wider scope of comprehensive agricultural science and management. The first and foremost need for an uninterrupted process of study in any branch of knowledge, be it in agriculture, plant study, medicine or others, is the creation of a congenial atmosphere and proper attention of the authority. There is hardly any controversy among the scholars on the question that the *Arthaśāstra* gives a clear indication that India made a long headway in this traditional branch of knowledge by the 3rd century B.C. as the text is generally accepted as a production of the same period.

Section – II: Later Period

The development of agriculture during the following years under review seems to have continued to the traditional line. Agriculture made a great headway as indicated by the wide variety of agricultural products grown in different parts of the country in the Gupta period. The *Bṛhatsaṃhitā* being the last major work of *Varāhamihira* is a product of mature age and accumulated experience of the author. It is a monument of encyclopaedic learning and a source-book of inestimable value. Inspite of the enormous industrial growth during the period under study, Indian economy was mainly agricultural and there are many information related to agriculture, rainfall, flora and fauna in the text. Besides, there

are many other chapters dealing with different branches of specialized knowledge.

Agricultural operations were quite elaborate[43]. Fields were demarcated by artificial boundary. Ploughing, sowing harvesting threshing, pounding and storing of the husked grain in granary – some are the steps of agricultural operations mentioned in the *Bṛhatsaṃhitā.* Numerous references to rivers, canals, tanks and wells are mentioned as source of artificial irrigation. *Varāhamihira* makes elaborate meteorological observations. Two crops were usually harvested annually and rotation of crops was known. As in the earlier period, two crops were sown. Thus, according to the variation in time, the earlier one was known as *pūrvaśasya* and the later came to be known as *aparaśasya. Purvaśasya* was sown early in rain and the *aparāśasya* in autumn respectively. They correspond to the present Kharif and Rabi[44] . Broadly speaking, the *purvaśasya* chiefly consisting of paddy would be ripened in autumn and consequently came to be known as autumnal crop (V. 21, 27, 78, 90). The *aparaśasya* which was termed as summer crop mainly consisted of wheat and barley. These would be ready in summer. *Varāhamihira* made botanical classification. Accordingly one type i.e. the awned or bearded grains were known as *Śukadhānya* (L.30) and the grains growing in pods were styled as *Kośa-dhānya* (VIII.8) or *Śamī-jāti* (VIII.10). *Śuka-dhanya* included numerous varieties of rice, millet, barley, wheat and such other cereals. *Śamī-jāti* on the other, comprised different varieties of pulses. The pulses growing on creepers were named *Vallīja* and constituted a separate group.

We get references to a number of varieties of rice in the *Bṛhatsaṃhitā.* The cultivation of different varieties of rice and to maintain their individual qualities and delicate differences may be taken as proof of experimental practice associated with agricultural science. Varieties of rice as mentioned in the text are as follows:

1. *Śāli,* a replanted variety; *Utpala,* the commentator on the *Bṛhatsaṃhitā* describes it as the most nourishing corn (*sāradhānya*).

2. *Kalamaśāli,* a variety of rice sown in May-June and ripened in December-January. *Uttamadhanya* (XV.5), *Śobhanā-dhānya* (XV.10) and *dhānya-vara* (XIX.6) are the qualifying terms used for this variety.
3. *Yavaka* (XXIX.3; L.30)
4. *Sūkaraka* (XXIX.2) or hog's rice. Regarding this variety A. Mitrashastri expresses that this term is completely new to him.
5. *Ṣaṣṭika,* (L.30;LXXV.8) a variety which takes sixty day to be mature.
6. *Raktaśāli* (XXIX.2) means red rice. It is regarded as the best variety of rice in *Caraka* and *Suśruta.* The mention of the variety by *Caraka* and *Suśruta* indicates its long cultivation from an early date.
7. *Pāṇḍūka* (XXIX.2) means yellowish rice. This variety also finds its mention in *Caraka* and *Suśruta.*
8. *Gauraśāli* (YY,VII.4) white rice seems to be a replanted variety of white coloured rice.
9. *Niṣpāva* (XVI.33, XL.5; LXXVIII.33). It is taken by *Utpala* as *śāli* in case of V.XL.5. In two other references some regard it *śāli* and some take it to be a leguminous corn.

As winnowing or cleaning of corn is meant by the term *niṣpāva*[45], it is possible that both rice and pulses may be indicated by the phrase.

Rice, wheat and barley constituted the principal food of the people. But the poor people used to eat *kodrava* and *priyaṅgu.* So these grains were cultivated for the poors. *Priyaṅgu* here is to be taken as chilli which could add taste to poor quality grains.

The cultivation of a number of varieties of pulses like *mudga, māṣa, masūra, kulattha, kalaya, oaṇaka* are known. Among the oil-seeds, mention may be made of *tila* (*Sesamum*), *sarṣapa* and *siddhartha* or *sita sarṣapa.* Among the fibrous plants mention may be made of cotton, hemp and linseed. Sugar-cane crop was produced on a large scale. The

reference to a term *ikṣu-van* (XV.6) bears an eloquent testimony to the huge production of sugar-cane.

We may get almost similar classification of plants based on dietic value in *Carakasaṃhitā* under the following *vargas*:

1. *Śukadhānya varga*
2. *Śāmīdhānya barga*
3. *Śāka varga*
4. *Phala varga*
5. *Harita varga*
6. *Āhārayogi varga*

Suśruta's classification according to Majumdar is more systematic and elaborate[46]. These are:

1. *Śālidhānya*
2. *Saṣṭhika* group.
3. *Vrīhi dhānya*
4. *Kudhānya varga*
5. *Vaidal (pulses)*
6. *Tila*
7. *Yava*
8. *Śimva*
9. *Phala varga*
10. *Śāka varga*
11. *Puṣpa varga*
12. *Udbhida varga*
13. *Kanda varga* (bulb group)
14. *Taila varga*
15. *Ikṣu varga.*

A further classification has been done by *Bhāvaprakāśa* in which he combines both the methods of *Caraka* and *Suśruta*. But the details are not needed to this context as it has been done by the above three authors keeping in view the dietic value and medicinal properties of the plants.

Varāhamihira in addition to agriculture, has shown concern for agriculture and other related issues like arbori-horticulture and treatment of plant diseases. But *Saṃhitās* of *Caraka* and *Suśruta* relate minutely the dietic value, tastes, potency of the crops and plants because the authors are more concerned with the promotion of health and hygiene of the people. It is unequivocally expressed in the *Sutrasthāna* (Chap 1. 51-53) of *Carakasaṃhitā* that it is only the man who is well-acquainted with the names, and external features of plants and is able to use them properly according to their properties is to be called an expert physician[47]. But a comparative discussion of the earlier medical treatises along with the encyclopaedic compositon of *Varāhamihira* reflects that agricultural science, plant science and ayurvedic science were interlinked. Hence these bear similar nomenclature, information and ideas to a great extent.

Kṛṣiparāśara, as already mentioned is the only treatise to deal exclusively with agriculture creates controversies regarding its date, authorship and the provenance of the work. The Sanskrit treatise *Kṛṣiparaśāra* was edited and translated by Dr. G.P. Majumdar (who was once the Secretary of Natural History [Biology] of The Asiatic Society), Calcutta) in collaboration with the great Sanskrit scholar S.C. Banerji[48]. The edition is based upon the collation of three manuscripts and an earlier Bengali version (*Vaṅgavāsī* edition) of the manuscript. There is also an English translation by S.P. Roy Choudhuri. But the Asiatic Society's publication is comparatively more accurate as the editors take as many manuscripts for collation as could be procured. It is to be noted that two of the manuscripts mentioned above bear typically Bengali character and further interesting point to note is that 'copy of a transcript of a manuscript in the Mandlik section in the Wadia Library, Fergusson college, Poona is itself a copy, made on 4th February, 1886, from a Bengali original in the Sanskrit *Pāṭhsālā,* Calcutta.' These remarks are recorded on the copy obtained from Bhandarkar Oriental Research Institute, Poona[49].

But frustrating news for the researchers in Bengal is that the original manuscript could not be traced in the Govt. Sanskrit College of Calcutta.

Some details of information on the manuscripts may appear essential to reach a conclusion whether the *Kṛṣiparāśara* was composed in Bengal or outside Bengal. There is a manuscript in the custody of Dacca University with the title *Kṛṣiparāśara.* The other two are: transcripts of India office manuscript and 1.0 manuscript, Tagore 24 which is written in Bengali but badly damaged.

Recently a new translation of the *Kṛṣiparāśara* has been done by N. Sadhale (in the Agri-History Bulletin, No 2, 1999[50]) along with commentaries based on scientific scrutiny. *Parāśara* gave an elaborate description of existing cultivation practices of various crops, soil preparations, land uses, tillage implements, weeding, water harvesting, diseases and agricultural meteorology.

It opens with an eulogy of the author and of agriculture. The relevant verse may be quoted here:

Prajāpati namaskṛtya kṛṣikarmavivecanam |

K*ṛṣakānāṃ hitārthāya brute ṛṣi Parāśa*raḥ ||

Trans: Having saluted *Prajāpati*, the sage *Parāśara* lays down reflections on agricultural operations for the welfare of cultivators.

Rice is eloquently extolled in the text. It is expressed, 'rice is vitality, rice is vigour too and rice (indeed) is the means of fulfilment of all the ends (of life). Gods, demons and human beings — all subsist on rice. (*Kṛ.Pa.*,6).

Next, we get reflection of high esteem in which vocation of agriculture was held. *Parāśara* says 'By means of agriculture alone, one, however ceases to be a beggar. One taking to agriculture can become a sovereign monarch in this world' (*Kṛ.Pa.*,3)

In an agricultural economy like that of India the importance of proper rainfall can hardly be exaggerated and it is quite reasonable to expect that ancient Indian authors should have made observations on meteorological condition of the country.

The emphasis on the importance of rainfall is already noticed in the Vedic literature.

A clear picture of variant quantity of rainfall may be obtained from the combined testimony of the *Arthaśastra, Bṛhatsaṃhitā* and *Kṛṣiparāśara* which will make us understand the level of consciousness of the meteorologists of the past for making a detailed data-base of rainfall and different types of cloud. It is indeed gratifying to note that valuable observation was really made and recorded with a view to advancing the understanding of the people in general and cultivators in particular for ensuring sustainable production in agriculture.

In the *Arthaśāstra*, we get the amount of ideal rainfall for good returns from agriculture in different region with soil of variant qualities. It is said: The quantity of rain that falls in the country of *jāñgala* is 16 *droṇas*; half as much more in moist countries (*anupānām*); as to the countries which are fit for agriculture (*deśvāpā*nam) —13 *droṇas* in the country of *Aśmakas*; 23 *droṇas* in *Avantī;* and an immense quantity in western countries (*aparātānām*), the borders of the Himalayas, and the countries where water channels are made use in agriculture (*Kulyavāpānām*). (II.24.SS.p.127).

The distribution of rainfall according to geographical location is summarized in the following table:

Jāñgala	Desert countries	16 *droṇas*
Anupānām	Moist countries	8 *droṇas*
Aśmakas	*Mahāraṣtra*	13.5 *droṇas*
Avantī	Ujjain or Malwa region	23 *droṇas*
Aparānta	Konkon i.e. coastal *Mahārāṣtra*	Profuse
Himālayas	Hilly tracts of north	Unlimited

Kauṭilya informs us that if one-third of the total annual rain came both during the commencement and closing months of the rainy season (*Śrāvana* and Kārttika) and two-thirds in the middle (*Bhādrapada* and *Āśvayuja*) then the rainfall is considered very even (*suṣamārupam*) and it argues for good and prosperous crops.

According to *Kauṭilya*, a forecast of rainfall could be made by observing the position, motion and pregnancy of Jupiter, the rise and setting and motion of Venus, and the natural or unnatural aspect of the sun.

'From the sun (is known) the successful sprouting of seeds, from Jupiter the formation of stalks in the crops, from Venus rain' (Kangle, II.24.8).

Among the extant texts, the most exhaustive treatment of the subject is to be found in the chapters XXI-XXVIII of the *Bṛhatsaṃhitā*. The importance of proper rainfall for production of food corn is explicitly expressed in the verse quoted below:

annaṃ jagataḥ prāṇāḥ prāvṛṭ-kālasya c-ānnam = āyattam

Yasmād=ataḥ parīkṣyaḥ prāvṛṭ-kālaḥ prayatnena (BS. XXI.I).

Trans: Food is the life of this universe. Food is controlled by the rainy season. So we must make efforts to study this season thoroughly. The *Bṛhatsaṃhitā* of *Varāhamihira* abounds in references to the views of *Garga, Parāśara, Vajra, Kāśyapa, Bādarayaṇa,* Asita-Devala, and others bearing on rainfall[51]. Extracts from earlier works are equally of great value.

According to *Kṛṣiparāśara* there are four types of cloud, *āvarta, saṃvarta, puṣkaro* and *droṇa* as under:

āvartaṣcaiva saṃvartaḥ puṣkaro droṇa eva ca ।

cattvāro jaladāḥ proktā avartādi yathā karamam ॥

(*Kṛ.Pa.*, 24).

The nature of these four types is also narrated as -

Ekadeśena cāvartaḥ samvartaḥ sarvata jalam ।

Puṣkare duṣkaram bāri droṇe bahujalā mahī ॥

(*Kṛ.Pa.*,25).

Trans: *Āvarta* is confined to a particular locality, under *saṃvarta* there is water everywhere; under *puṣkara* water is scarce and under *Droṇa* the earth has abundant water.

A different type of classification appears to have been prevalent in earlier times. According to *Kauṭilya*, there are three clouds that continuously rain for seven days, eighty are they that pour minute drops and sixty are they that appear with sunshine. But *Bṛhatsaṃhiā* does not make such classification of clouds. Besides, there are detailed information on pregnancy of clouds, rain forecast and measurement of rainfall in the ancient texts.

In a discourse on agricultural science of the past, meteorological information are urgently needed. *Parāśara* observes:

Bṛṣṭimūlā kṛṣiḥ sarvā bṛṣṭimūlam Ca jivanam |

Tasmādādau prayatnena bṛṣṭigñānaṃ samācaret ||

(*Kr.Pa.*,10).

Trans: All agriculture has rainfall at its root, life too has rainfall as its source. Therefore, at the outset, acquire knowledge of rainfall very carefully.

Kṛṣiparāśara as a specific text on agriculture deals with the then existing knowledge and practice relating to soil classification, land use, manuring, rotation of crops, irrigation, tillage implements, protection of crops from diseases an pests, care of draught animal other than agricultural meteorology.

On the question of manuring, cowdung has been highly extolled and even to the point of veneration. The processing of cowdung to turn it into a good manure making it free from bad chemical reaction is aptly described in the *Kṛṣiparāśara*, but in a simple and easily understandable language. The relevant verses containing the whole process are:

'Having worshipped the heap of cowdung in *Māgha*, one with reverence, should lift it with spades on an auspicious day and *Nakṣatra*. (*Kṛ.Pa.*, 109).

'Having powdered all that and dried it up in the sun, throw the manure into a pit in every field in *Phālguma*' (*Kṛ.Pa.*, 110).

'Then at the time of sowing, take out the manures; without manure, paddy plants grow up bereft of fruits.'

In the *Bṛhatsaṃhitā*, we notice the suggestion of preparing organic compost of superior quality for balanced nutrition of the plants. The *Bṛhatasaṃhitā* prescribes that seeds which have been properly treated are to be sown with the addition of pork or venision into soil (where previously sesame crop was raised, dug up and trodden) and sprinkled daily with wtar mixed with milk. It says further: 'To promote inflorescence and fructification, a mixture of one *āḍhaka* of sesame, 2 *āḍhakas* of excreta of goats or sheep, one *prastha* of barley power, one *tolā* of beef thrown into one *droṇa* of water and standing over seven nights should be poured round the roots of the plant. (BS.VIII.17-18). In order to ensure sprouting and growth of luxurious stem and foliage, the seeds should be soaked in a compound prepared of paddy powder, urad, sesame and barley which are mixed with putrefied flesh and the whole mass steamed with turmeric. (*BS.*, VV.16,17,19,21).

The use of fish water for irrigating certain trees was also in vogue.

Almost a similar instruction for preparing an organic compost to increase the production of flowers and fruits is given in the *Agnipurāṇa*[52]. It is said that in order to increase the production of flowers and fruits one should sprinkle ghee with cold milk, also a mixture of sesame, excreta of goats and sheep, barley powder, beef thrown into water and standing over for 7 nights should be poured round the roots of the plant.

The exact verses are:

'*Ghṛtasitapayaḥsekaḥ phalapuṣpāya*
sarvadā, ābikājasakrecūṛṇaṃ tilāni
ca gomāṃsamudakañcaiva
sapta rātrain nidhāpayet
utsekaḥ sarvavṛkṣānāṃ phalapuṣpādi
vṛddhidaḥ ॥ (Ag.Pu., 282.11-12).

Procurement of Healthy Seeds

Procuring good seeds for successful agricultural operation has been a major concern of the people associated with agricultural policies and practices. The traditional practice of preserving good and healthy seeds for successful propagation of plants has already been traced.

The advices extended both by *Kauṭilya* and *Varāhamihira* for treatment of seeds are linked with the treatment to be done prior to the task of sowing the seeds for good germination. Of course *Kauṭilya* advised for strong and damp free store house containing three floors for corns (II.2.5., Kangle, p. 72). But rules prescribed by *Parāśara* are related to long time preservation of seeds perhaps for using the seeds for the next year. *Parāśara* extends the following instructions:

'Collect all seeds either in the month of *Māgha* or in *Phālguna,* and dry them up thoroughly in the sun; do not keep them down' (*Kṛ.Pa.*, 157).

'Having made a small packet of seeds, purge the chaff; seed mixed with chaff is extremely damaging to crops' (*Kṛ.Pa.*,158).

'Seeds which are uniform yield a plentiful harvest; hence carefully make them of the same kind' (*Kṛ.Pa.*, 15a)

'Having made a very tight packet, cut off the grass that has come out. This being with grass uncut, crops become full of grass' (*Kṛ.Pa.*, 160).

'Do not keep seeds on an ant-hill, in the cow-shed, the place where a woman has been delivered of a child, nor also in a house having a barren woman in it'. (*Kṛ.Pa.*, 161.)

'Do not allow the seed to come in contact with remnant of food, a woman in her monthly impurity, a barren woman, a woman in the family way and a woman just delivered of a child.' (*Kṛ.Pa.*, 162).

'The cultivator should not, even by mistake, keep on seeds, ghee, oil, butter-milk, lamp and salt' (*Kṛ.Pa.*, 163).

All the provisions quoted above with the exception of no 161 and no 162 are related to proper preservation of seeds in a dried condition. Clean seeds purged off husks are to be kept in a safe position free from the possibility of damage by ants, fire and salt or damp caused by ghee, oil etc.

The rules regarding the prohibition of contact with barren women transcend the rational approach of science. Some sort of superstition in fact always crept in all spheres of human activities.

Kṛṣi-Gītā

The knowledge of the ancient Indians in agriculture is revealed by some ancient texts already considered. *Kṛṣi-Gītā*[53] in *Mālayālam* language further reflects the wisdom and experience of the traditional farming community of the land now known as Kerala in South India.

As in most other places in India, farming was the mainstay of people of ancient Kerala too. *Kṛṣi-Gītā* has been written as a discourse between the *Brāhmins* and the *Paraśurāma*, a great sage and one of the ten incarnations of the Lord *Viṣṇu*. Exact antiquity of the text can not be defined. The lyrics, without any doubt have been transmitted through oral traditions or through palm-leaf manuscripts. Neverthless, the book in its present form looks to be around 300 years old. The content of the book, no doubt bears testimony to long antiquity.

Kṛṣi-Gītā opens with the narration of one story of bewildered *brāhamaṇas* requesting Lord *Paraśurāma* to abate their sufferings by prescribing the best agricultural practices. The book deals with the issues like, paddy varieties, planting, draught animals, manuring, seasons, weed management, hydrological aspects, auspicious times, seeds and other issues related to cultural practices.

Success of agricultural operations obviously depends on good seeds.

Nene in his article has drawn a comparison between the earlier and the recent concept of seed health[54]. He comments:

'Modern seed testing involves procedures to check purity of seeds, ability to germinate, ability to emerge from soil with good vigor, and the presence / absence of pathogens and pests (mentioned above)[54a]. Criteria for healthy seeds in older days basically were the same as today but apparently no standard testing procedures existed then'.

Kāśyapiyakṛṣisūkti is a treatise on agriculture by *Kāśyapa*. A copy of the manuscript in Devnagari script is in the custody of Adyar Library, Chennai[55]. *Kāśyapa* has written 180 verses and deals with the subject of water management in great detail but surprisingly he is silent about rainfall. He focuses his attention entirely on alternative irrigation scheme. In a way the treatise is complementary to that of sage *Parāśara*. His perception of water management expressed in the form of counsel offered to the state. The following statements reveal how *Kāśyapa* advocates change in technologies with changes in time:

'As time changes the king should take into account a change in the manner and mode of agricultural technique for sowing of seeds, and also consider the application of agricultural (science) as different for cool and warm climates' (*Ka.kṛ.*,11.168-169).

'Cattle, rainfall, water reservoirs and many other factors also cause this change. Accordingly, the king should manage the farming activities depending primarily on the quality of the soil' (*Ka.kṛ.*,11.170-171).

M.S. Randhawa takes him to be resident of Kosala in U.P. but G. Wojtilla who translated the text in English suggests his South Indian origin as that *Kāśyapa* followed the *Vaiṣṇava* tradition of South India and wrote the text sometime during 700 to 800 A.D.

That the science of agriculture maintained its progress through applied methods and empirical observations in this country through the centuries is attested by a number of texts and that it continued and diffused through out the different regions of the country. This is evident from the discovery of manuscripts dealing with agriculture and other related issues even till the recent past.

Meghamuni of Punjab flourished in the 18th century. He composed *Meghamālā* on weather forecasting[56].

Thus we find that Indian agricultural science in the past was based on both speculation and practical experience. Most of the texts at the same time bear eloquent testimony to the fact that agriculture as a vocation was highly venerated by the people from the earlier period down to the very recent days. In the Vedic hymus we have glimpse of the deep longing of the people for abundance of crops. *Parāśara* says: 'Blessed is agriculture, holy is agriculture and agriculture is the life of the creatures'. Perhaps this avowed notion leads him to give the advice — 'Rice is produced from paddy, and paddy is not available without agriculture. Therefore, having given up all (else) take to agriculture carefully'.

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