CHAPTER – III

Origin and Development of Plant Science

Utpattiṃ prakṛtibhedamākṛtiṃ bhumibhedataḥ ।
Vṛkṣāṇañca cikitsitaṃ yathāha Caturānana ॥
Vṛkṣāvallayastathā gulmā bibidha tṛṇajātayaḥ ।
Ṛtupuṣpaphalāntā bai ouṣadhyo jagñire tviha ॥

Parāśara.

Section – I: Early Phase

Vegetation came under the influence of man during the post glacial climatic optimum when the Neolittic man commenced agriculture. The successive shifts in the plant populations in response to climatic changes gradually resulted in the present pattern of plant life[1]. The vegetation of a country depends on, and to a large extent is determined by, its geographical and climatic features and India stands in very favourable position with respect to both of these conditions[2].

'It is a region, indeed full of contrasts in physical features and climate'[3].

Some archaeologists believe that wood was simultaneously used along with stone by the people for hunting purpose during the Old Stone Age, but actual evidence of the use of wood is known only from the late Palaeolithic Age[4]. At this time men of the Clactonian culture in England used yew wood for spear. About the same time an entire spear of yew-wood, as Hawkes and Wooley have discussed was found in Germany inside the skeleton of an elephant[5].

But India can not claim the use of wood to such an early date. The oldest record of use of wood in India is from the sites of the Indus Valley Civilization. In the description of the dwelling houses in the Indus

Valley, the scholars suggest that the doors were possibly made of wood. The roofs are also described as flat and made of wood. The earliest specific record of use of wood comes from Harappa proper and from the sites of Gujrat. In the former, two types of woods were found to have been used for a coffin, namely of deodar and rose wood, and other wood remains found were used for a wooden mortar. The examination of these woods by Chowdhury and Ghosh makes it clear that choice of these woods for specific purposes shows not only knowledge of where the trees grew but also of the characteristic qualities of the woods used[6]. So we have strong evidence to believe that 'Harappan culture was based on years of experience on the use of this botanical product'. Other plant remains from Hastinapur have also been examined by Chowdhury. These were used as firewoods[7]. The potteries and the bricks were burnt on a large scale. The bricks were exceptionally well baked. Mackay's observation on this is very clear. He says that well burnt bricks of Mphenjodaro are of excellent quality and practically indestructible and can be used over and over again. So the huge amount of woods which were to be fired can easily be imagined.

The representation of ships portrayed on the seals unearthed at Mohenjodaro has already been taken into account to make it clear that the vessels intended for riverine as well as for sea-trade were made of reeds or such other vegetal materials[8]. These remains indicate that the Harappans were certainly well aware of qualities of different timbers and reeds.

The growing acquaintance of plant life is reflected in the Vedic literature of the Aryan people (Table I). This is not certain when the Aryans first entered into India, but their occupation of the country must have taken place at least as early as 1400 B.C. and a spirit of enquiry spontaneously grew among them as to the effect of natural vegetation growing near their dwelling places from the very beginning of their settlement in this new country. To the community of the Aryans, the study of plants and plant life of this country became a self imposed task as they were stranger in this *terra incognita.* Agricultural pursuits made a long advance in the Vedic period. The use of heavier ploughs, production

Table I: Plant species as referred in *Ṛgveda* (c.1500 B.C.) (Common names and botanical names as could be identified)

Herbs, shrubs and trees	Food grain	Grasses
Pippala or aśvattha (*Ficus religiosa*) Parṇa / pālaśa / kiṃśuka (*Butea frondosa*) Khadira (*Accacia catechu*) Śiṅśapā (*Dalbergia sissoo*) Śālmali (*Bombax malabaricum*) Śimbalam Urvaruka (*Cucumis melo*) Aśvavati (an unidentified plant) Somavati (a medicinal plant) Urjayanti (a medicinal plant) Udojasa (a medicinal plant) Vyaikasā (a water plant) Viṣanakā (*Gymnema sylvestre*) Vibhītaka (*Terminalia belerica*) Svadhiti (a big tree with hard wood) Puṣkara (*Nymphaea stallata*), a blue lotus Puṇḍarika (Nelumbo nucifera), lotus Pramaṇda, a sweet scented plant Nayagrodha (*Ficus bengalensis*) Soma (*Asolepias acida*) Madhuga, honey plant Karkandhu (*Zizyphus nummularia*), jujube tree Kākambīra Bhaṅga (*Cannabis sativa*), used as an epithet to soma	Yava (ka) (*Hordeum vulgare*)	Śara / Saira (*Saccharum* sp.) *Kuśāra (Saccharum officinarum)* Darbha (*Desmostachys bipinnata*) Muñja (*Saccharum munja*) Vīrana (*Vetiveria zizanoides*) Dūrvā grass (*Cynodon dactylon*) Ulapa (*Imperata arundinacea*), a spreading soft grass Sipalā / Śaivāla (*Blyxa ceylanica*) Śāda, agrass Pākadūrvā, an edible millet Kiyambu, a tender grass Kāśa (*Saccharum spontareum*), addressed as medicinal plant Balbaja (*Elensine indica/E. coracana*), used for making basket and other wicker receptacle.

of different types of agricultural crops, meteorological observation, knowledge of plant diseases, all indicate a considerable development in this branch of knowledge. An *Ṛgvedic* hymn[10] says:

'Sweet be the plants for us, the heavens, the waters, and full of sweets for us be air's mid region. May the Field's Lord for us be full of sweetness, and may we follow after him uninjured'(*Ṛ.V.*, IV. 57.3). Still, the plant science in true sense was in a rudimentary stage and took time to emerge as a distinctive branch of knowledge. A hymn in the *Ṛgveda*

expresses the long association of tree and wood with this universe from the day of its creation by the supreme power[11].

'What was the tree, what wood in sooth produced it, from which they fashioned out the earth and heaven?' (*Ṛ.V.*, XXXXI.4).

A glimpse of development of a kind of observation of the plant world is visible in the bulk of Vedic literature but the main difficulty lies in the scattered nature of the materials bearing on plants as on several other matters of scientific interest in these texts. Plant Science as a systematized branch of study was yet to flourish but a fair idea may be made of the morphology and internal structure of plants from the materials contained in Vedic literature. Sooth to say, a spirit of enquiry is traceable in the verses of the *Atharvaveda* but most of these verses are composed in laudable words for the medicinal properties of the plants and herbs. The different herbs and plants are named, classified and praised only for there medicinal values. In *Ṛgveda* we get the hymn which in the worlds of G.P. Majumdar is 'the first medical utterance of man'[12]. A few verses of the *Auṣadhi Sūkta* of the 10th *maṇḍala*[13] may be quoted below to get at the nature of observation of the *Ṛgvedic* people on different plants and herbs deemed beneficial to the man and animal world.

'Ye, mothers, have a hundred homes, yea, and a thousand are your growths. Do ye who have a thousand powers free this may patient from disease' (*Ṛ.V.*, X.97.2. p. 610).

'Be glad and joyful in the plants, both blossoming and bearing fruit, plants that will lead us to success like mares who conquer in the race.' (*Ṛ.V.*, X.97.3. p.610).

'The healing virtues of the plants stream forth like cattle from the stall, plants that shall win me store of wealth, and save thy vital breath. O man' (*Ṛ.V.*,X.97.8.p. 611).

'Let fruitful plants, and fruitless, those that blossom, and the blossomless, urged onward by *Bṛhaspati,* release us from our pain and grief,' *Ṛ.V.*, X.97.15.p.611).

That, plants and herbs were used for medical treatment equally for man and animal is clearly reflected in one of these verses — 'Unharmed be he who digs you up, unharmed the man for whom I dig:

'And let no malady attack biped or quadruped of ours'

(*Ṛ.V.*, X.97.20.p. 611)

The plants are of different types: Some are of the spreading variety, some bushy, some jointed, some rich in shoots; all types of trees with spreading branches or bushy or the one-spathed, the herbs are regarded as source of life to man[14].

'The spreading, the bushy, the one — spathed, the extending herbs do I address; those rich in shoots, jointed (*kāṇḍin*), that have spreading branches; I call for thee the plants that belong to all the gods, formidable, giving life to men. (*A V.*, VIII. 7.4. p. 499).

The scholars are yet to agree to decide on the point of time when exactly, scientific attitude and rational thinking developed and led to the emergence of plant science as a distinct branch of study, yet by arranging scattered materials in a systematic method, we can get a fair idea of the *Vedic* Indians' knowledge regarding the morphology and internal structure of plants and their physiology. Different sections of a plant have got a beautiful literary expression in the following verse:

'Rich in sweets the roots, rich in sweets the tip of them, rich in sweets was middle of the plants, rich in sweets the leaf, rich in sweets the flower of them; partaking of sweet, a drink of nectar (*amṛta*) let them milk out ghee, food, with milk (go) as chief (purogava) (*A V.*, VIII. 7.12. p. 500). It will be a futile endeavour to search for any detailed knowledge of the internal structure of plants but some gross anatomy of the plant body is indicated in the *Ṛgveda* as well as in the *Atharvaveda.*

A faint glimpse of scientific idea of fight between the herbal antidote and the germ within the body of diseased may be grasped in a verse of the *Atharvaveda.* This hymn, sooth to say, may help us to understand that the poets of the *Atharvaveda* are not often carried away by extra doses of idealistic imagination[15].

Yakṣma being trembled at the sight of the medicinal herb is nicely described in the following hymn:

'As at the roaring of a lion do they quake; as at fire do they treamble at [the herbs when] brought; let the *Yakṣma* of kine, of men, go driven by the plants beyond navigable streams'. (*A V.,* VIII.7.15. p. 500). Thus a deeper insight into the hymns of the *Vedas* sometimes suggest a formative stage of empirical science or a knowledge system widely based on observations of the tribal or common people of the vedic period. Dr. Majumdar has designated it as 'truism,'[16]

In the hymn of the *Ṛgveda*, we have already noticed, the poet speaks of 107 applications of plants to make people free from diseases but there is hardly any reference to the use of knowledge of herbs and plants for the development of agricultural production. Reference to application of knowledge of plant science to agriculture is equally absent in the *Atharvaveda.* In the *Atharvaveda* different herbs and plants are highly praised for their usefulness in treatment of disease. Here in this context, a few hymns may be quoted to make it evident that the *Vedic* people were inquisitive enough and many of their inferences were the outcome of their systematic observation and study of nature and its relation to animal world including the human community.

The laudable hymns expressed the high efficacy of the plants and herbs in combating against various physical diseases like leprosy, urinary problem, fever, eye disease, physical injury and other common problems of health. But it is to be noted here that the selection of herbs or plants was based on some sort of empirical study. The relevant verses are quoted below. These verses are related to the medicinal application for curing a man who is suffering from *Yakṣmā* (*A V.,*VIII.7.2. p.498):

'The boar knows the plant; the mongoose knows the remedial (herb) what ones the serpents, the *Gandharvas* know, those I call to aid for him' (*A V.,*VIII.7.23.p.501). 'What (herbs) of the *Aṅgirases* the eagles (Know), what heavenly ones the *Raghaṭs* know and what all the winged ones, what herbs the wild beasts know — those I call to aid for him' (*A V.,* VIII.7.24.p.501).

'The next verse is related to the observation on the food habit of cattle'.

'Of how many herbs the inviolable kine partake, of how many the goats and sheep, let so many herbs, being brought, extend protection to thee' (*A V.*,VIII.7.25.p.501).

'In how many (herbs) human physicians (***bhiṣaj***) know a remedy, so many all-remedial, do I bring unto thee' (*A V.*, VIII. 7. 26. p. 501).

The hymns if analyzed sequentially, it appears that the edibility of herbs and plants were ascertained initially by the partaking of the same by the animal world. The people as keen observer of nature and of animal behaviour, could utilize this knowledge bank accrued through long span of time.

It is well known that snakes constitute a food of mongoose. When a mongoose attempts to catch a snake the latter takes defence by attempts to bite the mongoose. A combat continues over a long time. Naturally there may be a chance of mongoose being bitten by the serpent. It is generally believed that the mongoose knows the herb that acts as antidote of snake venom.

The mention of mongoose in the hymn (*A V.*, VIII. 7. 23) reflects the inherent inquisitiveness of the earlier people and their urge for acquiring knowledge even from the animals. The references to birds, swans, wild beasts, kine, goats and sheep in the hymns again conform to the same psyche of the people in the remote past for groping after the remedials of diseases of the living world around.

Regarding the *Serpents* and the *Gandharvas*, some information may be added here (*A V.*, VIII. 7.23).

Serpents: By *Serpents*, probably the Naga tribe is indicated. In *Adiparva* of the *Mahābhārata*, the burning of *Khāṇḍava* forest is depicted[17]. This is a clear picture of clearing the forests for acclamation of land. The *Nāgas, Yakṣas, Rākṣas,* the *Dānavas* and all kinds of beasts and birds were all burnt with fire. The horrifying sight of the burning of *Khāṇḍava* forest indicates the inimical attitude of *Kṛṣna* and *Arjuna* the reprsentative of

Brahmanic tradition towards the forest dwellers, the tribals, the so-called uncivilized people of ancient India. When the forest was set on fire, *Kṛṣna* and *Pārtha* patrolled the perimeter of the forest which was extended about hundred *yojanas* and they kept strict vigil so that no creature could escape. This included the *Serpents* or the *Nāgas* probably the appellation for food-gathering tribes which venerated snakes.[18]

***Gandharvas*:** *Gandharvas* are identified as professional singers of heaven. In the *Mahābhārata, Pañca Pāṇdavas* are addressed as *Gandharva* husbands. The *Gandharva* girls were trained to the art of singing and dancing like the *Naik* girls of Kumaun or *Kānchanis* of the late Mughal court[19]. These fair-complexioned hill-tribes had a religion of their own. A band of *Gandharvas* migrated to the southern side of the Himalaya sometimes after the Indo Aryans had settled in the Punjab and a portion of the Gangetic Delta.

On the basis of the *Puraṇic* evidences Pargiter likes to suggest that both *Pururavā* and *Urvaśī* belonged to the *Gandharva race; the rivers Mandākini* and *Alakā,* the forests *Chaitraratha* and *Nandana,* the mountain *Gandhamādana,* all belonged to the *Gandharva* region, the so called *Ilabritabarsha,* the integral part of the primitive abode of the Aryans[20].

If the identification of the *Serpents* and the *Gandharvas* of the hymn (*A V.,*VIII.7.23) is historically true, then it will not be out of context to comment that the vedic thinkers were well-aware of the fact that the forest living people and the people of mountain region knew much about the edibility and medicinal properties of different plants and herbs which grew in their surroundings. A kind of recognition of their knowledge is explicitly expressed in the verse. We have a reference to a *Kīrāta* girl (*Kāirātikā*) who digs for a herbal remedy on the ridges of the mountains[21]/ The verse is —

Kaīrātikā kumārikā sakā khanati bheṣajam
hiraṇyayībhir abhribhir girīṇam upa sānuṣu

The Aryans were ruthless in destroying the indigenous tribal people for the cause of extension of their settlements. Simultaneously,

they had a realization for imbibing knowledge from their rival camp. Here lies the conflict of history.

Aṅgirasas: The next hymn where *Aṅgirasas* are mentioned bears importance alike. It is traditionally known that the *Brāhmaṇa* families claimed their descent from eight mythical *ṛṣis.* Among the eight, the *Bhārgavas, Vasisthas* and probably *Aṅgirasas* appear to have been the earlierst *Brāhmana* families[22]. *Ayāsya* is the first *Aṅgiras,* mentioned in traditional history. The *Aṅgirasas* are found in connection with the *Vaiśāla* kings as their hereditary priests[23].

The *Aṅgirasa*-priests, whose functions must have centred round the fire cult, whose existence was essentially bound up with *Agni* are naturally thought of as born of *Agni*[24]. There is hardly any controversy among the scholars regarding the brahmanical ancestry of the *Aṅgirasas.* The most important epiphany of *Brāhmaṇa* is found in his *Prajāpati* aspect[25]. He is styled as *Prajāpati,* then in the *Ṛgveda* the epithet is applied to *Savitṛ, Soma, Agni* and *Indra.* In the epic-puranic period it indicated both *Śiva* and *Viṣṇu* and still later the term meant the ten primeval progenitors created by *Brāhmaṇa,* one of whom was *Aṅgiras.*

Thus the hymns which make simultaneous mention of people with erudite scholarship like that of *Aṅgirasas* and the people like *Serpents and Gandharvas* with knowledge direct from nature, bear deeper historical connotation. It may be held that though systematic and scientific experimental process of study did not exist, yet the ancient thinker could realize the necessity of gathering knowledge in all possible ways for the betterment of their condition. They explored all the corners. The study of the intellectuals i.e. the *brāhmaṇas,* the empirical knowledge of the forest or mountain people, the observation of the habits and behaviour of the animal both pet and wild, all were concurrent in the development of a kind of natural science in that remote past. A human physician could acquire perfect knowledge on plants and herbs but that was not an easy task.

There is no denying of the fact that mysticism and speculation were functional in the matter of disease and its treatment. Often trace of

rational thinking in overshadowed by mystic practices and beliefs in super-natural powers. The plants and herbs applied to the diseased did not always bring expected result. It is to be remembered that it was a period of initiation of the process. Rudimentary knowledge, whatever minimal its efficacy was in curing the diseased, was the outcome of a long and incessant quiries and observation of our ancestors. It is generally held, that *Yājñavalkya* is the author of the *Śatapatha Brāhmaṇa* and this text abounds lot of information regarding the formative period of the history of *Āyurveda*[25].

Studies and researches on plants and herbs exploring their different aspects of medicinal properties were continued in the later Vedic period. By the time of the *Śatapatha Brāhmaṇa,* the horizon of knowledge in this area was expanded to a considerable extent (Table II) and the text reveals that near about 39 widely known medicinal plants are used to treat 30 diseases.[26]. Many of the diseases as identified by Prof. Gupta still are familiar to the modern people and regarded as serious ailments.

Different types of cereals such as rice, barley, wheat are mentioned in the text. *Śatapatha* also gives information on some low-valued cereals like *śyamāka, nīvāra, govedhuka, namba, upvāka* etc.[28]. A number of fruits are known from this text; they are *kuvala, karkandhu* and *badara* and identified as three different types of berries[29]. *Āmra* i.e. mango, *udumbara* and *pippala* all are familiar to the modern people and they have got mention in the *Śatapatha Brāhmaṇa*[30]. The people in the period were aware of the efficacy of the plants like *apāmārga, aśmagandhā, udumbara, khadira, pṛśnipaṃi, bilva, varaṇa, vibhītaka. Udumbara* has been described as food and sap. Different uses of *udumbara, aśvattha* and *nyagrodha* trees have been mentioned in the *Śatapatha Brāhmaṇa.* One point in this context is to be noticed that the plants like *arka, kārṣamarya, kṛmuka* etc. find mention in the *Śatapatha Brāhmaṇa* but nothing is said about their therapeutic value which can be traced in the medical texts of the later period. Thus it appears that there was a continued quest for new and newer information, the endeavour steadily developed and culminated into an integrated knowledge system.

Table II : Plant species as referred *Śatapatha Brāhmaṇa* (c. 6th Century B.C.) (Common names and botanical names as could be identified)

Cereals	Pulse	Fruits	Other economic plants		Wood-yielding trees
			Names	Use	
Rice of different varieties such as Plāśuka, Āśu and Hāyara, Wheat, Barley, Low grade cereals such as — Syāmaka, Nivāra, Gavedhuka, Namba and Upavāka.	Māṣa, Kidney bean	Kuvala, Bilva, Karkandhu, Badara, Karīra, Āmra, Udumbara, Pippala.	Apāmarga (*Achyranthes aspera*)	Medicinal.	Aśvattha (*Ficus religiosa*) Kāśmarya (*Gmelina arborea*) Kṛmuka (*Melia azedarach*) Phalguna or Arjuna (*Terminalia arjuna*) Dāruharidrā (*Berberis aristata*) Or Pitudāru Bilva (*Aegle marmelos*) Rajjudāla (*Conlia myxa*)
			Aśmagandhā (*Withania somnifera*)	Medicinal	
			Udumbara (*Ficus racemosa*)	Described as fruit and sap.	
			Khadira (*Acacia catechu*)	Hard and strong wood.	
			Pṛśnipaṃi (*Uraria picta*)	Medicinal.	
			Varaṇa (*Crataeva nurvala*)	Medicinal.	
			Vibhitaka (*Terminalia bellerica*)	Medicinal.	
			Arka plant (Calotropis procera)	Medicinal.	
			Spurjaka (Calligonum polygonoides)	All parts are useful.	
			Haridaru (*Adina cordifolia*)	Medicinal.	
			Tilvaka (Viburnum nervosum)	-	
			Nyagrodha (*Ficus bengalensis*)		
			Palāśa (*Butea monosperma*)	Full of juice and used as spoon.	
			Samī (*Prosopis spicigera*)	Pacifying	
			Vṛtra	Used in sacrifice and as spoon.	
			Kuśa grass (*Demostachya bipinnata*)	Used in garment making.	
			Muñja grass (*Saccharum*	Used as covering of fire pan.	

The simple mention of the plants in the *Śatapatha Brāhmaṇa* without any details, and the mention of the same with information on their medicinal values in the later texts of *Āyurveda* clearly indicate that a systematic process of study was persistently followed and as a result the later medical texts appear loaded with more information. The people of the period possibly possessed fair idea about the qualities of different woods. We find, the *undumbara* being used as post and vessel or sometimes as fuel-wood. *Kṛmuka* tree is described as sweet in taste and red in colour. *Khadira*, according to *Śatapatha* is very strong and compared to bones[31]. *Palāśa* is full of juice and its colour is red. Its wood is used for making spoon.

Though all the herbs have been described as *Bheṣaja*, yet Dr. Ms. Saha has aptly brought out that *Śatapatha Brāhmaṇa* lacks information on the medicinal properties of the plants alluded to in the text itself. Considerable development is noticeable in the medical texts of the later period. There was remarkable progress in the medical science of India through botanical knowledge. The treatment of disease with herbs and plants is borne out by the *Ṛgveda* and the *Atharvaveda*. The practice of treating diseases with plants continued but it took more time to be crystallized into systematic theory which abounds varied information on therapeutic character of individual herbs and plants and their effects on human body and mind. This is evident from the *Āyurvedic* text of the later years. Botany as a systematized branch of knowledge had not yet developed. Nevertheless, by arranging and categorizing the various informations, it is possible to get a fair idea of the notion of the Vedic Indians regarding the morphology and internal structure of plants, their physiology, medicinal properties, growth characteristics and such other related issues.

As to morphology, different parts of plant body such as the root, the shoot, stems, branches, leaves, flowers and fruits are distinguished and clearly named in the *Saṃhitās, Brāhmaṇas* and *Upaniṣads*[32]. In the *Taittirīya Saṃhitā, and the Vājasaneyī Saṃhitā* different parts of the body of a plant have been mentiond. In an oblation it is said:

Oṣadhibhyaḥ svāhā mūlebhyaḥ

svāhā tūlebhyaḥ svāhā kāṇḍebhyaḥ
svāhā valśebhyaḥ svāhā puṣpebhyaḥ
svāhā phalebhyaḥ svāhā |
Vanaspatibhyaḥ svāhā mūlebhyaḥ svāhā
tūlebhyaḥ svāhā skandhobhyaḥ svāhā
śākhābhyaḥ svāhā parṇebhyaḥ svāhā
puṣpebhyaḥ svāhā ||

We may prepare a list of the parts of a plant body from the above quoted verse: *mūla* = root

tūla = shoot
kāṇḍa = stem
skandha = the trunk of a tree
valśa = twig
śākhā = branch
parṇa = leaf.
puṣpa = flower
phala = fruit

Ceaseless enquiry and untiring effort for knowing the unknown opened new spaces and the Vedic people stored more and more information on plant and animal world. It is needless to mention that the people in early period obviously had to depend entirely on nature for livelihood, medicinal remedies, spiritual satisfaction and for each and every need for their survival. This is in no way unnatural that a systematic process of study would continue without cessation and that happened truly here in India. Quoting three hymns (*RV.*, X. 145.1.'; *RV.*, VII. 50.2 and 3) from the *Ṛgveda*, Majumdar gives his explicit opinion that these hymns together constitute 'practically speaking the whole of the science or art, or both science and art of medicine...' He adds, 'but we have a harvest of details bearing on the subject of medicinal plants, their utilities, their classification, the diseases against which they were applied, the association in which they were to be applied and the rest, in the text of the *Atharvaveda*'. In his opinion

'these details seem to be an elaboration of what we get in a synoptical form in the three hymns of the *Ṛgveda* just quoted. There are points of similarity between the two; nay, there is essential identity. The latter seems to be an elaborate edition, a popular commentary of the former. ... Either the details of the *Atharvaveda* must be a development from and a lengthy explanation of the things we get in the *Rik* or the *Rik* hymns give us a summary of the things so universally known'[34].

The *Taittirīya Saṃhitā* mentions the ripening of corn twice in a year. There is indication in the hymns of the *Ṛgveda* that the Vedic Indians had some knowledge on the manufacture of food, the action of light on the process and storage of energy in the body of the plants — a great achievement indeed for our ancestors at that remote age[35].

For tracing the development of plant science in the post Vedic period, *Caraka, Suśruta, Vāgbhata* and their commentaries are of high value. During this period, it appears that Botany developed as an independent science on which were based the science of medicine.

At the early stage descriptive Botany and knowledge on rudimentary plant physiology were essential to the Aryans to whom agriculture was a venerable vocation. But in the following centuries, side by side with the agricultural study, plant science progressed in connection with agricultural study, allied branches of science, particularly medicinal science.

Interestingly, the popularly known word for medicine is *auṣadha* which is etymologically connected with the word *oṣadhi* signifying the annual herbs. The word *bheṣaja* also denotes vegetable drugs. *Caraka* clearly states that it is only the man well acquainted with the names and external features of plants, and able to use them properly according to their properties is to be called an expert physician.

The *Dhanvantari Nighantu* is more specific: 'Sometimes several healing vegetables (*bheṣajas*) bear one name, sometimes one vegetable bears various names according to its class, external feature, colour, potency, function (*rasa*), effects, properties and the rest'. How science

came to be associated with the society at large may be conceived through the following reference:

'The physician does well to master *Bheṣaja vidyā* by acquainting himself with the various names of plants in Sanskrit and Prakrit, consulting all classes of men, by personal observations, by a careful handling, as well as, by a careful consideration of its specific characters and sexuality' (quoted by Majumder). Plants and their products formed part and parcel of the practice of medicine in Vedic times. Quite often their use seems to be rational i.e. based upon proper understanding of their action and effect but more often it is just empirical i.e. based only upon the previous experience of their having been found useful in similar conditions[36]. In this practice may be traced the origin of the trial and error approach, the basic procedure for attaining the truth of science. Possibly initial detection of edible or non-edible ones was made on the basis of platns and herbs accepted or rejected by the herbivorous animals. It is also said that there are many (herbs) which are unknown to the herbalist, they are well known to other beings, domestic animals and beasts of the wilderness birds, insects, etc.

In the exposition of knowledge of the period, what actually was the share of the people living outside the Vedic society, it is difficult to detect. But if science is viewed as culture and part of the social formation of a society, the historians can make a definite intervention and a subjective assessment is possible. 'This perspective is obviously more wide-angled and takes in many facets involving interactions and osmosis, which bear on a particular body of knowledge'[37]

In the life of the science of Botany as in the life of other sciences, there were earlier processes suggesting its possibility. With the establishment of state authority, royal courts began to show its interest in culling scientific knowledge, true to say, for the benefit of the government and as a result we get texts like the *Arthaśāstra, Bṛhatsaṃhita* and *Agnipurāṇa.* Each of the texts has a distinct section dealing with the topics of *Vṛkṣāyurveda.* Ayurveda has been translated by R.C. Majumdar as 'Science of Life'[38] followng which the

Vṛkṣāyurveda may be translated as 'Science of plant Life'. All the three books are non-botanical treatises but they contain certain section dealing with *Vṛkṣāyurveda* in which agricultural bias is predominant and indicates the separate existence of plant science side by side with agricultural science.

With the establishement of Maurya government, a sudden flood of source material becomes available. *Kauṭilya* is generally accepted as belonging to the court of Chandragupta Maurya. During the Maurya period, the new avenues were being searched for more revenue collection. Consequently agriculture, as already discussed, occupied an important area of state economic programme. In the *Adhyakṣa Pracara Adhyaya, Kauṭilya* States[39]:

Sītādhyakṣaḥ kṛṣitantraśulva vṛkṣāyurvedajñastajjñasakhībā
sarvadhānya puṣpaphala śākakaṇdamūla vāllikya
kṣaumakārpāsabījāni yathākālaṃ gṛnhīyāt.

Trans: The Director of Agriculture, himself 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.p. 148). Dr. Basak uses the word *Kṛṣitantra śulvavṛkṣāyurveda* . It appears from the use of the words denoting two branches of knowledge that they were complementary to each other. *Kauṭilya* recognizes that agriculture is essential for producing food-crops, and also as a means of earning revenue. It appears from his discussion on the duties of the Director of Agriculture that there are persons having special expertise in different items of agricultural operations. In *Kauṭilya's* view, production of all types of the crop plants is one of the nine major ways of enhancing the wealth of royal treasury. In describing the essential qualities of the *Sītādhyakṣa, Kauṭilya* states that he should be well conversant with the methodologies of agriculture i.e. *Kṛṣitantra* and the science of plant health i.e. *Vṛksāyurveda.* The Director may seek counsel and assistance from experts in the subject in case of necessity. For successful agriculture, he had to take care of some

other related issues. These are: (1) to collect in time the seeds of paddy, flowers, fruits, vegetables, cormous crops (*kaṇda*), root crops (*mūla), vāllikya* (Fruit-producing twiners), fibre yielding plants and cotton. *Kauṭilya's* instructions relating to agriculture and plants are scattered in different chapters and they deal with the issues like importance of water for plants, seasons of sowing different crops, soil crop relation, treatment of seeds, harvesting and farm-management etc.

From long experience, the people could understand that all types of soils are not equally suitable for agriculture. Some have much yielding capacity and some are bereft of that. Thus *Kauṭilya's* specific instruction, is: A (King) should allot pastures for cattle those land only which are unsuitable for agriculture (*KA.*,II.2.1.p. 59). So there is the mention of basic classification of soil on the basis of its productive qualities. *Kauṭilya* categorizes different kinds of soil according to there suitability for various types of crops (*KA.*, II.24.22 p. 151). Selection of crops for cultivation was made accordingly. This may be shown with the help of the following table.

1. Land bordering river or sea-beaches (*Phenāghātaḥ*)	*Valliphala — pumpkin gourd, water melon etc. i.e. the creeper fruits.*
2. Land overflows by water (*Parivāhanta*)	Long pepper, grapes (*mṛdvīkā*) sugar cane
3. Vicinity of wells	Root crops and vegetables.
4. Low and moist bed of lakes (*haraṇīparyanataḥ*)	Green crops, green grasses.
5. Ridge of earth i.e. marginal furrows between any two rows of crops.	Fragrant plants, medicinal herbs, *uśīragrass, hriberā, piṇḍāluka* etc.

The last suggestion in this *sūtra* deserves special mention. Regarding the medicinal herbs, *Kauṭilya* says that those plants which grow in marshy grounds are to be grown not only in grounds suitable for them but also in pots. (*sthālyām*)[40]. Is it not hinting at the cultural practice of

medicinal plants in artificial bed? The highly needed herbal plants, which were suitable for artificial cultivation, possibly were produced by householders so that they could be available in times of urgency. Besides, along with their domestic use there should have been some economic prospect of the medicinal herbs and plants. In those days when herbs and plants dominated the whole medicinal science, commodification of the herbal items is a mere truth.

Kangle's interpretation is not similar to that of Shamasastry. He mentions: (A region) where the foam strikes (the banks) is (suited) for creeper fruits, (regions on) the outskirts of overflows, for long pepper, grapes and sugar canes, (those on) the borders of wells for vegetables and roots, (those on) the borders of moist beds of lakes, for green grasses, ridges for plants reaped by cutting, (such as) perfume-plants, medicinal herbs, *uśīra*-grass, *hrībera*, *piṇḍāluka* and others. And lands suitable for each, he should raise plants that grow on dry lands and that grow in wet lands (11.24.22 p. 151). He has not referred to any artificial pot for cultivation.

Instructions regarding seed treatment are offered as follows: The seeds of grains are to be exposed to mist and heat for seven nights; the seeds of *kośī* 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 hogs and cow dung; the seeds of bulbous roots (kanda) with honey and clarified butter; cotton seeds with cow-dung; and water pits at the root of trees are to be burnt and manured with the bones and dung of cows on proper occasions. The sprouts of seeds, when grown are to be manured with a fresh haul of minute fishes and irrigated with the milk of snuhi.

The use of fish water for vigorous growth of plants is a popular practice. This is evident in many of the texts related to agriculture and botany of the later period. The ancient Indian cultivators were aware of the utility of organic manure, the developed form of which is *Kuṇapa jalam* which finds mention in different texts of various regions of the country in the later days.

The *Agnipurāṇa* has a distinctive section on *Vṛksāyurveda.* In chapter 282 instructions are given regarding different plant related issues. Mode of planting trees is described in chapter 70. Some verses may be quoted here to get a good idea of the content of the particular section of the *Agnipurāṇa.*

Dhanvantari is spokesman. *Dhauvantari* is known to have been a great mythical medical authority. He is known as physician of the gods. He is said to have been produced at the churning of the ocean with a cup of nectar in his hand[41]. Wheather *Dhanvantari* of *Agnipurāṇa* is identical with any historical person can not be proved. *Dhanvantari* here in the text specifically states that he will describe the science of medicine relating to trees[42]. He suggestes that a *plakṣa* tree should be planted on the north, a barnyan tre on the east, a mango tree on the south and a holy fig tree on the west (of a residence) (*Ag., Pu.,* 1.p.764).

'It is better to have thorny trees on the south near the house. A garden should be near the house. Blooming sesamum plants should be gathered and the trees should be planted after worshipping a Brahmin and the moon. The five fixed asterisms *svāti, hasta, rohinī, śravaṇa* and *mūla* are commended for planting the trees' (V. 2-4) Importance of source of water for growing healthy plants is indicated in the verses. It is said. — the trees should be planted such that they are fed by rivers or should be made to be on the banks of a tank. (The asterism) *hasta, mangha, anurādhā, aśvini, puṣya,* and *jyeṣthā* as well as *śatabhiṣak* and the three *uttaras* (*uttaraphālgunī, uttarāsāḍha* and *uttarabhādrapada*) (are good) for beginning (the construction) of tanks (4b-5, p.765).

It should be done after worshipping (lords) *Varuṇa, Viṣṇu* and *Parjanya.* (Trees such as) *ariṣṭa, aśoka, punnāga, śirīṣa, priyaṅgu,* plantain, *jambū, bakula* and pomegranate (should be planted) as above (6-7a, p.765).

The planted trees should be watered morning and evening in the summer season, on alternate days in the winter season and in the night in the rainy (season) if the earth has become dry. (Trees planted) twenty cubits apart are (deemed as) excellent and sixteen (cubits) apart are

(deemed as) medium. There should be minimum twelve cubits distance in between one tree and the other. Trees (planted) densely would not bear fruits. They should first be pruned with a cutter (7b. 9. p. 765).

Śukrācārya gives a slightly different advice[43]: 'the king should have the domestic plant planted in villages and the wild tress in the forest — the good ones at a distance of twenty cubits from one another, the middling at a distance of fifteen cubits and the ordinary ones at a distance of ten cubits and the youngest at a distance of five cubits (*Śuk.*, IV, 91-93, p.165). There are some variations regarding the measurement of intervals between the plants but the advices given in such texts on plant science reflect a general standard of knowledge of the people of the time in such cultural practices. The issue of distance between two trees is intricately related to the problem of nutrition of plants and trees and that is why almost all the texts on this branch of knowledge from early age to the later period agree to the view that trees if thickly sown are hindered in their growth. Simultaneouly it is the view of the ancient authorities that if they are sown very sparsely they are in danger of falling down even as consequence of mild winds. So in laying out a garden, planting after the method described above is wise.

Rules for manuring the plants are almost similar in all the texts. Regarding fertilizer, the instructions in the *Agnipurāṇa* are: '(The trees) should be sprinkled with cold water mixed with a paste of *viḍaṅga* and ghee. If the fruits get destroyed, (cold water should be sprinkled) with (a paste of) horse gram, black-gram, green-gram, barley and sesamum'(*Agni. pu.*, 10.p.765).

The concept of *kuṇapa-jalam* has a long history. It is said — 'one should always sprinkle with cold water with ghee for (getting abundant) fruit and flowrs. Sprinkling with the excrements of sheep and goat and pulverized barley, sesamum allowed to be soaked in meat and water for seven nights would also increase the bearing of fruits and flowers in all the trees' (*Agni. pu.*, 11-12, p. 765).

The next verse also indicates that general vigour of plants, which may be increased by the application of special organic fertilizer made of

fish, meat *viḍaṅga* and rice, practically protects trees from all diseases. The exact verse is: 'Sprinkling with the washings of the fish would also increase the growth of the trees. Fish and meat mixed with the *viḍaṅga* and rice would make (them) bear fruits. This would universally control the diseases of all the trees' (*Agni. pu.*, 13. p.765). The verses prove that a common formula was made for preparation of a strong organic manure which came to be known as *kunapajala* in the texts of the later period like *Vṛkṣāyurveda* of *Śūrapāla, Upavana Vinoda, Lokopakāra* or *Viśva-Vallabha.* The methods described in all the texts since early days if are examined minutely; it appears that common cultural practices prevailed through the length and breadth of the country since very early days.

Śūkra makes mention of stools of goats, sheep and cows, water as well as meat as ingredients of manure (*Śuk.*, 94.p.165). He gives a long list of trees which bear good fruits. These are: *udumvara; aśvattha, vaṭa, cinca, candan, gambhala, kadamba, aśoka, vakula, vilva, amṛta, kapitthaka, rājadan, āmra, punnāga, tuda, campaka, nīpa, koka, āmra, sarala, dārima, akṣota, śimśapa, radara, nimba, jambira, kṣirika, kharjura, devakaraja, phālgu, tāpinchha, bhala, kudvāla, lavali, dhātri, kramuka, mātulungaka, lakuca, nārikela, rambhā.* Sarkar has provided the scientific names of all the trees (*Śuk.*, 95-102, p.165). The large big size trees mentioned in the *Śukranīti* are:

khadira, asmanta, śāka, agnimatha, syaunāka, vabbuta, tamāla, śāla, kuṭaja, dhava, arjuna, palāśa, Saptaparṇa, śami, tunna, devadāru, vikenkata, karamaṇda, ingudi, bhūrja, visamuṣṭhi, kariraka, sallaki, kāśmari, pātha, tinduka, vijaāsraka (not identified), haritaki, bhallata, sampāka (not identified) arka, puṣkara, arimeda, pitadru, sālmali, vibhitaka, naravela (not identified) *madhuka* and others. (*Śuk.*, 115-122, p.166). There is specific distinction between the trees having thorns and without thorns (*Śuk.*, 113-114, p. 166).

Śukra's specific advice: expansive trees, shrubs and creepers are to be carefully planted in villages if domestic, in forest if wild (*Śuk.*, 123-124, p. 166).

Thus in the *Śukranītisāra* we get considerable information. The text is probably of much later date than the *Kāmasūtra.* But it contains traditional knowledge on plant science. By the days of Kāmasūtra, *Vṛkṣāyurveda* flourished as a distinct branch of study on plant life and possibly for this reason *Vṛkṣāyurveda* is regarded by *Vātsyāyana* as one of the sixty-four *Kalās* or arts. Futher, it is to be noted that the author suggests that this art should be acquired by women[44]. Women's participation in such scientific activities is a very fascinating development in the history of plant science in India.

That the branch of knowledge in botanical science reached a consummate perfection in ancient time is evinced by inscriptional corroboration[45]. In the Second Major Rock Edict of *Aśoka*, it is mentioned:

'The king with charming appearance, the beloved of the Gods in his conquered territories and in the neighboring countries thus enjoins that medical attendance should be made available to both man and animal; the medicinal herbs the fruit trees, the roots and tubers are to be transplanted in those places where they are not presently available, after being collected from those places where they usually grow; wells should be dug and shadowy trees should be planted by the roadside for enjoyment both by man and animal'[46].

From the above, it is evident that by the time of the Mauryas, *Vṛkṣāyurveda* as a branch of knowledge was highly developed and work of transplantation of plants, herbs, fruit trees from their natural habitat to other places for the benefit of the living world was a common state-sponsored programme.

That the ancient people were fully aware of the existence of life in the trees and plants are proved beyond doubt by a series of texts composed by wise personalities appeared at different centuries. Often knowledge on the subject was used for negative purpose. There is a story in the *Mahāvaṃśa* relating the misdoing of the queen *Tissarakhā* who being jealous of *Aśoka's* devotion to the Bodhi-tree, injured the tree by piercing it with a poisonous thorn, thereby causing it to wither away[47]. In

the *Śurapāla's Vṛkṣāyurveda,* this (same) technique of piercing a plant with sharp instrument smoked with fat of tiny fish, marrow of hog etc. is advised to be followed to make the plants bear fruits and flowers. Thus it appears, there continued an incessant process of empirical research on plant science in ancient India.

Scientific knowledge can be used both for benevolent and mischievous purposes. The two references, mentioned above of course reflect different types of human attitudes, sometimes very positive and sometimes very frustrating. As a result different texts on plant science are still available in different languages which will be brought under the scope of discussion in a sequence.

Plant culture has been dealt with by *Varāhamihir* in his *Bṛhatsaṃhitā*. Different aspects of plant culture which have been treated show that some of the practices recorded are more or less followed by Indian peasants even to this day. Preparation of the soil and manuring, reproduction of plant life, plant diseases are some of the main headings discussed by the author. 'A soft soil' it is said, 'is suited to the growth all sorts of trees'.

Green manuring as it is known today was prevalent in this country since early days. It is said in the text, one should sow thereon sesamum which must be crushed when in bloom. This is the first act in the preparation of the soil[48]. Besides a number of ingredients of organic fertilizer having manuring properties have been mentioned. Thus dung of cows, buffaloes, goats, sheeps, clarified butter, honey, *viḍaṅga,* milk, milk water, mud, horse-gram, black-gram, green-gram, barley, groats, rice, roots of certain plants, ashes, paste of alangium fruits, stalement, beef and marrow of hog in various combinations are used as manure.

Fumigation with few substances also was in vogue.

Sowing is described as the simplest method of the propagation of plants. The *Bṛhatsaṃhitā* prescribes that seeds which are to be sown with the addition of pork or venision into the soil. Elaborate method of treating the seeds is described by the author.

In order to ensure sprouting and growth of luxurious stem and foliage, according to the *Bṛhatsaṃhitā* the seeds should be soaked in an infusion made of paddy powder, urad (*māṣa*), sesame and barley which are mixed with decomposing flesh and the whole mass steamed with the addition of turmeric. The soaked seeds are then to be dried in the sun and the process is to be repeated[49].

The method of cuttings was also known and appears to have been widely practised. G.P. Majumdar points out, In addition to the ordinary method of propagation by seeds the methods of propagation by cuttings and grafting were known from time immemorial, so much so, that plants to which these methods can be applied were definitely named'[50].

The '*Bṛhatsaṃhitā* distinctly names the plants and the methods; '*kāuthāl* (jackfruit tree), *aśoka, kadali, jambu, lakooca, dāḍima, drākṣyā pālibata, vijapura, atimuktaka* — these are the plants to be propagated by means of cuttings besmeared with cowdung[51] (*BS.*, 54.4-5).

Varāhamihira regards the method of propagation by grafting as superior to that by cuttings. Two methods of grafting are recorded. It is stated — Better than this cutting method is the method of propagation by graftings. This can be done in two ways — the cuttings of one plant is either inserted on the root of another plant, or on the stem of another plant, the junction of the two in both the cases being covered with a coating of mud. It is thus evident that grafting was known to Indian cultivators in the time of *Varāhamihira* as an established method. Thus the evidence disproves the view of P.K. Gode that grafting was used for the first time on Indian trees by Jesuits of Goa about A.D. 1550[52].

The history of the art of transplantation in India goes back to a very hoary antiquity. We have inscriptional evidence for the days of the Mauryas, as it is already shown.

There is specific instruction on the order of plantation while laying out a garden whether pubic or attached to a homestead. The order of plantation of specific trees in particular side of the residence as suggested in the text, is certainly aimed at improving the aesthetics and

hygienic condition of the surroundings. Watering rules also are given in the *Bṛhatsaṃhitā*. *Kālidāsa* has referred to *secanaghaṭa* in *Śakuntalā*. It possibly means watering jar. Plant diseases and treatments have been also discussed by. *Varāhamihira*. He has made classification of plants and herbs. *Varāhamihira's* botanical classification seems to follow the broadest classification of plant life into (1) trees (*taru, vṛkṣa, druma, pādapa*). (2) succulent shrubs (*gulma*) and (3) creepers (*latā, vallī*) in general. Thus, the ceaseless efforts and enquiry of the scholars resulted in the accumulation of knowledge on plant life which are of scientific value and on the basis of which a number of texts began to be written by the interested researchers in different languages in the sub-continent incorporating information variable from region to region due to different types of soil and climatic conditions.

References

1. Randhawa, M.S., Singh, J., Dey, A.K., Mittre, V., *Evolution of Life*, Publications and Information Directorate, New Delhi, 1969, p 245.
2. Majumdar, R.C., (ed.) *The Vedic Age*, Bharatiya Vidya Bhavan, Mumbai, 1951, p. 108.
3. Mookerji, R.K., *A History of Indian Shipping*, Kitab Mahal Pvt. Ltd. 2nd Ed. Calcutta, 1957, p.1.
4. Chowdhury, A.K, *Botany,* in Bose, D.M. *et al.* (ed.) ACHCI, p. 371.
5. Hawkes, J., and Woolley, L., *History of Mankind: Cultural and Scientific Development,* Vol. 1, London, 1963, p. 156.
6. Chowdhury K.A. and Ghosh, S.S., Plant Remains from Harappa, *in Ancient India,* 7, 1951, pp., 3-19.
7. *Op. cit.,* Chowdhury, K.A. p. 374.
8. Mackay, E.J.., *Further Excavations at Mohenjodaro — Being an Official Account of Archaeolgical Excavations at Mohenjodaro,*

carried out by the Govt. of India between the years 1927 and 1931, Vol. I, Indological Book Corporation, Delhi, 1976, pp. 340-341, 657.

9. Raychoudhuri, H.C., *Studies in Indian Antiquities*, University of Calcutta, 1989, p. 55.

10. Griffith, R.T.H., *The Hymns of the Ṛgveda,* Motilal Banarsidass Publishers, Delhi, 1991, p. 235.

11. *Ibid.*, p. 591.

12. Majumdar, G.P. *Vanaspati: Plants and Plant Life* as in Indian *Treatises and Traditions,* Calcutta University, 1927, p. 151.

13. *Op. cit.,* Griffith, R.T.H., pp. 610-611.

14. Whitney, W.D., *Atharvaveda Saṃhitā,* Vol. 1 and 2, Motilal Banarsidass, Delhi, 1962.

15. Sarkar, B.K. *The Positive Background of Hindu Sociology,* Motilal Banarsidass, Delhi, 1985, p. 126.

16. *Op.cit.,* Mujumdar, G.P. p.2.

17. Sen, S.N., Haldar, G. and Adu, K. (ed.) *Kasiram Das Birochita Mahābharata* (Bengali), Vol.I, *Adiparva.* Saksharata Prakashan, Kolkata, 1976, pp. 127-128.

18. Gadgil, M. and Guha, R.C., *This Fissured Land: An Ecological History of India,* Oxford University Press, Delhi, 1993, p. 79.

19. Sinha, S. N. and Basu, N.K., *History of Prostitution in India,* Cosmo Publications, New Delhi, 1994, p. 127.

20. Pargiter, F.E., *Ancient Indian Historical Tradition,* London, 1922, p. 297.

21. Chatterji, S.K, *Kirata Jana Kriti,* The Asiatic Society, Kolkata, 2007, p. 27.

22. Pusalker, A.D., Traditional History from the Earliest Time to the Accession of Parikshit in R.C. Majumdar (ed.) *The Vedic Age,* Bharatiya Vidya Bhavan, Mumbai, 1996, pp. 280.

23. *Ibid.*, p. 291.

24. Bhattacharji, S., *The Indian Theogony: A Comparative Study of Indian Mythology from the Vedas to the Purāṇas,* Firma KLM Pvt. Ltd. Calcutta, 1972, p. 195.

25. *Ibid.,* p. 322.

26. Gupta, B., Introduction to the book *History of Indian Medicine Based on Vedic Literature: Śatapatha Brāhmaṇa*, by M. Saha, The Asiatic Society, Calcutta, 1999, p. vi.

27. *Ibid.*, p. VII.

28. Saha, M., *History of Indian Medicine Based on Vedic Literature: Śatapatha Brāhmaṇa,* The Asiatic Society, Calcutta, 1919, pp. 23-30.

29. *Ibid.*

30. *Ibid.*

31. *Ibid.*, p. 35.

32. *Op. cit.,* Chowdhury, K.A., p. 376.

33. *Op. cit.*, Mujumdar, G.P. *Vanaspati*, p. 156.

34. *Ibid.*, p. 157.

35. Majumdar, G.P., The History of Botany and Allied Science in D.P. Chattaopadhyaya (ed.) *Studies in History of Science in India,* Vol. 1., Editorial Enterprises, New Delhi, 1982, p. 367.

36. Jaggi, O.P., *History of Science and Tecnology in India,* Vol. 2 *Dawn of Indian Science, Vedic and Upaniṣadic Period,* Atma Ram and Sons, New Delhi, 1969, p. 198.

37. Thapar, R., History of Science and the Oikoumene, in S. Irfan Habib and Dhruv Raina (ed.) *Situating the History of Science,* Oxford University Press, New Delhi, 2001, p. 16.

38. Majumdar, R.C., Medicine in Bose, D.M. *et al.* (ed.) *ACHCI*, p. 213.

39. Kangle, R.P., *The Kauṭilīya Arthaśātra Part II,* University of Bombay, 1972, p. 148.

40. Shamasastry, R., *Kauṭilya's Arthaśāstra,* Mysore Printing and Publishing House, Mysore, 1961, p. 129.

41. Apte, V.S. *The Student's Sanskrit English Dictionary,* Motilal Banarsidass Publishers, Delhi, 2000, p. 268.

42. Shastri, J. L., *Ancient Indian Tradition and Mythology,* Vol. 29, Part III, Motilal Banarsidass, Delhi, 1986, pp. 764-765.

43. Sarkar, B.K., *The Śukranīti,* Oriental Books Reprint Corporatiion, New Delhi, 1975, pp. 165-166.

44. Tarkaratna, P. (ed.) and Bandyopadhyay, M. (extended), *Vātsyāyana Praṇita Kāmasūtram,* Samskrita Pustak Bhandar, Kolikata, 1398 (Beng. Era), p. 46.

45. Thapar, R., *Aśoka and the Decline of the Mauryas,* Oxford University Press, Delhi, 1998, 251.

46. *Op. cit.*, Gadgil M., Guha, R., p. 88.

47. *Op. cit.*, Thapar, *Aśoka and Decline of the Mauryas*, p. 51.

48. Mitra Shastri, A., *India as Seen in the Bṛhat Saṃhitā* of *Varāhamihira,* Motilal Banarsidass, Delhi, 1969, pp. 270-291.

49. Raychaudhuri, S.P., Gopal, L., and Subbarayappa, B.V., Agriculture in Bose, D.M. *et al.* (ed.) *ACHCL*, p. 359.

50. *Op. cit.*, Majumdar, *Vanaspati*, pp. 39, 40, 62, 63.

51. Dvivedi, S. (ed.), *Bṛhatsaṃhitā,* Vizianagram Sanskrit Series, Vol. X. Benares, 1895-97.

52. *Op. cit.* Mitra Shastri, p. 272.

Section II: Later Phase

Vṛkṣāyurveda which literally means 'the science of plant life' is known to have existed in ancient India as a distinct branch of knowledge. Specific references to the *Vṛkṣāyurveda* is found in the *Arthaśāstra,* the *Bṛhatsaṃhita* and in the *Agnipurāṇa.* The earliest of these three texts, the *Arthaśāstra* designates this branch of study as *Kṛṣitantragulmavṛkṣāyrveda* whch makes an implication that during the period of the *Arthaśāstra, Kṛṣitantra* i.e. the science of agriculture and *Vṛkṣāyurveda i.e.* the science of plant developed as a combined subject of study. In the *Kāmasūtra* of *Vatsāyana,* we get *Vṛkṣāyurveda* as a district branch of study being designated as one of the 64 arts that developed in ancient India. The *Vṛkṣāyurveda* of *Parāśara* is a complete treatise on plant science. It has a distinct identity of its own which warrants an elaboration and comparison with the subsequent texts on *Vṛkṣāyurveda.*

The name of *Śurapāla's Vṛkṣāyurveda* is preserved by tradition. The actual text was out of reach till very recent days and historicity and time of the author are also not founded on solid evidences. Notwithstanding *Surapāla* as a writer of *Vṛkṣāyurveda* seems to be on the record of history of ancient Indian medical science. Thanks to Dr. Y.L. Nene, Chairman, Asian Agri-History Foundation. He procured a manuscript of *Vṛkṣāyurveda* of *Surapāla* from the Bodleian Library, Oxford, U.K.

The manuscript is written in an old form of *Nāgari* script. 'The script of the manuscript', says Sadhale, 'represents, most probably, the stage immediately preceding the modern form of *Nāgari*'[1]. There are 325 verses in the text, and a few verses are missing. The work starts with salutation to the Lord *Ganeśa* and concludes with a colophon stating the name of the work as *Vṛkṣāyurveda* authored by *Surapāla* and that of his patron as *Bhīmapāla.* It then proceeds to discuss various topics connected with the science of plant life such as:

(a) Importance of trees

(b) Merits and demerits of trees planted near the residence

(c) Soil

(d) Propagation

(e) Method of planting

(f) Nourishment

(g) Ailments

(h) Treatment

(i) Horticultural wonders

(j) Pleasure gardens

(k) Natural indications of ground water for construction of wells

(l) Plant indicators for crop and animal production

Regarding the identiy of *Surapāla* there is no consensus among the scholars. The manuscript gives no clue to the date or place of the author. The King *Bhīmapāla,* mentioned in the colophon of the manuscript as *Surapāla's* patron, is known in traditional history as the son of *Trilocanapāla.*

But there are two kings of that name belonging to the 11th century, one in *Lāṭa* and the other in Punjab. Whoever the royal patron might have been, the epithet *Śrīvaidyavidyāvareṇya* clears a point that *Surapāla* was a prominent physician. He is said to have earned reputation on account of *Siddhayogas.*

As for external evidence of *Surapāla's* time, it is reasonable to expect his name to be cited in the other texts of *Vṛkṣāyurveda.* In the absence of corroboration for want of such texts, the *Upavanavinoda* which constitutes a chapter of the *Śārańgadharapaddhati* (13th cent A.D.) should have been of great importance in deciding the approximate time period of *Surapāla.* But inspite of overwhelming resemblance between the *Upavanavivoda* and the *Vṛkṣāyurveda* of *Surapāla* there is no mention of *Surapāla* in the compilation of *Śārańgadhara.*

Surapāla was an eminent physician. As the present manuscript of *Surapāla* reflects the application of *Tridhātu* theory to the trees and

plants, (the basic principle of *Āyurveda*), it may be logically conduded that *Surapāla's* work is the original one and the manuscript itself is the best evidence to prove it. It is hard to believe that a great expert in the science of plant life should borrow a lot from compilations the authentic work of *Surapāla* deserves the fame and the tribute that tradition has paid to him. The resemblance between *Upavanavinoda* and *Vṛkṣāyurveda* may be explained by proposing a theory that both have made use of texts of their predecessors in the field.

Soil: It is evident from the study of *Vṛkṣāyurveda* that the people of the day were well aware of the impact of the quality of soil on the growth of trees. Three types of soil with respect to water content were recognized. It is said in the *Vṛkṣāyurveda* of *Surapāla*[2] on soil:

Arid, marshy, and ordinary are the tree types of land; it is further subdivided into six types by colour and savour (*Su.Vṛ.*, V.35, p.45). Black, white, pale, dark, red and yellow are the colours and sweet, sour, salty, pungent, bitter and astringent are tastes by which land is subdivided (*Su.Vṛ.*, V.36, p. 45).

Land with poisonous element, abundance of stone, ant hills, holes and gravel and having no accessibility to water is unfit for growing trees (*Su.Vṛ.*, V. 37, p.45).

Bluish like saphire, soft like a parrot's feather, white like conch, jasmine, lotuses, or the moon, and yellow like heated gold or blooming champaka is the land recommended for planting (*Su.Vṛ.*, V.38, p. 45). Land which is even, has accessibility to water, and is covered with green trees is good for growing all kinds of trees.(*Su.Vṛ.*, V.39, p.45). Arid and Marshy land is not good. Ordinary land is good as all kinds of trees grow on it without fail. (*Su.Vṛ.*, V. 40, p. 45). *Panasa, Lakuca, tāla, bamśa jambeera, jambu, tilaka, vaṭa, kadamba, āmrata, kharjura, kadali, tiniśa, mṛdvi, ketakī nālikera* etc. grow on a marshy land (*Su.Vṛ.*, V.41, p.45).

Sobhānjana, śrīphala, saptaparṇa, sephālika, aśoka, sami, karīra, karkandhu, keśara, nimba and *śoka* grow well on an arid land (*Su.Vṛ.*, V.42, p.45).

Bijapuraka, punnāga, campaka, āmra, atimuktaka, priyaṅgu. dāḍimba etc. grow on an ordinary type of land (*Su. Vṛ.*, V.43, p.45).

If wealth, destiny, and the king are favourable any tree can grow anywhere with special effort (*Su. Vṛ.*, V.44, p.45).

A striking resemblance is noticeable with the verses of the section *Bhuminirupanam* in the *Upavanavinoda*[3]. These are:

Three main types of soil viz. *jāṅgala* (barren), *anūpa* (moist) and *sāmānya* (ordinary) are divided into six on the basis of colour and taste. (*Up-van.*, V. 34, p.71).

Soils having black, pale (shady), blue, red, yellow and white colour or appearance are respectively associated with sweet, acid, salty, sour, bitter and pungent tastes (*Up-van.*, V.35, p.71).

The soils that are poisonous, or stony, or full of ant hills, or barren or full of gravels and that which still remain uneven even when ploughed, or that which has water hidden in its depths are not favourble to the growth of trees (*Up-van.* V. 36, p.71).

Do well to know that the soil which has the brilliance of blue gems, that which is as soft as the feather of the *Śuka* bird, that which is as white as the *conch,* the *kumuda* flower, or the moon, and that which has the colour of melted gold, or that of a blown *champaka* flower, - all these are favourable for the growth of trees (*Up-van.* V.37, p.71).

All kinds of trees flourish in the soil which is even, the soil near which there is water and where the sprouts of trees put on green appearance. (*Up-van.*, V. 38, p.71).

The soil, which is neither barren nor watery, may be said to be ordinary, and there all types of plants grow (*Up-van.*, V.39, p.72).

Panasa, lakuca, tāli, baṃśa, jambīra, jamba, tilaka, vaṭa kadamba, āmrātaka, kharjura, pūga, kadalī, tiniśa, mṛdvi, ketakī and *nālikera* — all these trees grow in *anūpa* soil (*Up-van.* V.40, p.72).

Vījapūraka, punnāga, champaka, āmra, atimuktaka, priyaṅgu, dāḍima and similar other — all these trees grow in the oridinary soil.

The trees which do not oridinarily grow in a particular type of soil may do so if there is wealth hidden under it, or through the grace of gods, or through the grace of sovereigns (*Up-van.,* V.42, p.72).

The similarity between the above mentioned two texts on plant science is so obvious that N.Sadhale in the preface of the translation of the *Vṛkṣāyurveda* of *Surapāla* makes a straight acknowledgement of the help, she drew from the text and translation of *Upavanavinoda* by Majumdar, whenever she felt it necessary due to some defective portions or lapses in the script of the manuscript she was dealing with. Referentially, it may be stated that there is a Marathi version of the *Upavanavinoda.* N. Sadhale also records her debt to this Marathi translation of D.B. Borkar (Pune).

In this context similar information may be cited from *Viśvavallabha,* a sanskrit text by *Cakrapāṇi Miśra* composed about 1577 A.D.[4] . *Chakrapāṇi Miśra* who is said to have flourished under the patronage of renowned brave ruler *Maharana* Pratap Singh of Mewar in Rajasthan wrote three treatises:

(a) *Rājyābhiṣeka Paddhati* dealing with administration. (b) *Muhurtamālā* covering astronomy and portents, (c) *Viśvavallabha* describing the art of agriculture in arid, semi-arid and hilly regions.

Going by the book *Maharana Pratap and His Times*, it may be stated that *Cakrapāni* was a brahmin and well-versed in the *Vedas*, the six systems of philosophy and also in other religious treatises and several branches of science.

The following excerpts relating to soil qualities and propagation of plants as described in the *Tritīya ullāsaḥ* of the *Viśvavallabha* reveal that the synchronization of periods of cultural history with the sequence of political periodization may not always match accurately with all its connotations. Descent of ancient traditional knowledge as embodied in the manuscripts of the later period supports the above statement.

Excerpts from *Viśvavallabha,* Chapter III dealing with soil:[5]

Soil is of six colours viz., dark gray, pallid, black, white, red and yellow. Sweet, sour, saline, bitter, pungent an astringent are the corresponding tastes. But this is an old theory. It is my considered opinion that the savour can be determined only by tasting the soil (*Viś-va.*, III, V. 2-3, p.70).

A piece of land that is infested with ant hills, stones, and holes that which is impregnated with salt, that which is inauspicious, that which is distantly located from water source, and that which is sandy is poisonous for planting trees (*Viś.va.*,III, V.4, p.70).

Land where the soil is soft and water is available nearby is good for plantation. Gardens should be planned on such sites in the interest of both the worlds (*Viś-va.*, III,V.6-7, p.70).

Whether rock-strewn or soft, if the land has the colour of heated gold, plants, flowers, *punnaga, rajadana, campaka* and such other trees grow there without much effort.

Due to divine power and due to extraordinary effort on the part of the rich and the rulers trees and creepers grow even in unfavourable regions yielding fruits and flowers (*Viś-va.*, III, V.12, p.70).

The lines quoted above bear remarkable similarity with the verses given by the author of the *Vṛkṣāyurveda* as well as of the *Upavanavinoda.* This resemblance hints at the extension and descent of a uniform system of knowledge for all practical purposes through the length and the breadth of the vast Indian sub-continent often allowing variations, additions, deductions and alterations due to varying geographical and local ambiences.

Propagation of plants according to the suitability of soil is a mainstay of successful agricultural operation. Naturally most of the authors of the texts on plant science have left prudent suggestions to this aspect in there compositions. Delineation of the instructions given in the texts already mentioned again substantiates the proposition of a uniform knowledge system of the people prevailing in the country through the centuries in the past.

Types of Plants

In *Vṛkṣāyurveda of Śurapāla:*[6] *Vanaspati, druma, latā* and *gulma* are the four types of plants. They grow from seed, stalk, or bulb. Thus the planting is of three kinds (*Su.vṛ.*, V.45,p.45).

Those which bear fruits without flowers are *vanaspati* (type). Those which bear fruits, with flowers are *druma* (types) (*Śu.Vr.*, V.46, p.45).

Those which spread with tendrils are *latā* (types) i.e. creepers. Those which are very short but have branches are *gulma* (types) i.e. bushes (*Su.Vṛ.*, V.47, p.45).

In the *Upavanavinoda*:[7] This text also imparts the same knowledge.

Plants are classified into trees, shrubs, creepers and herbs and they propagate through seeds, cuttings and bulbs (*Up-van.*, V.43. p.72).

The tree which produce fruits without flowers are called *vanaspatis,* and those which produce fruits and flowers are called *drumas* (*Up-van.*, V.44, p.72).

Those that spread themselves on the ground are called *latās* and those tht spread themselves in several branches a little above the ground are called *gulmas* (*Up.van.*, V.45, p.72).

Coming to the section on propagation of plants in the *Viśvavallabha,* same type of directions are met with (Table III).

It is said[8]:

Bījodbhabāḥ kāṅḍabhabāśca cānye kaṇḍodbhabā gulmalatā drumādyāḥ ।

Uktāstathānyepi ca bījakāṇḍabhabā bibhedaṃ kathayāmi teṣām ॥

Eng. Trans: Bushes, creepers, and trees are propagated from seeds, stalks and bulbs. Some are stated to grow both from seeds and stalks. [I shall now distinguishing them accordingly].

Table III : Propagation methods recommended for different plants in different texts

Text	Seeds	Seeds and Stalks	Stalks	Bulbs	Bulbs
Vṛkṣāyurveda of Surapāla 12th cent. A.D.	Jambu, Campaka, punnāga nāgakeśara, tamarind, Kapittha, badari, bilva, kumbhakāri, priyaṅgu, panasa, āmra, madhuka, karamarda	Pātalā, daḍimi, plakṣā karavira, vaṭa, mallikā udumbara, kunda etc.	Tāmbuli, tagara sinduvāra etc.	Ela, padma, utpala	Kumkuma ardra rasona, alukanda
	Seeds	**Seeds and cuttings/stalks**	**Kāṇḍa or portion of stems i.e. cuttings**	**Kāṇḍa and seeds**	**Kāṇḍa (bulbs and such other underground stems)**
Upavanavinoda 13th Century A.D.	Jambu, campaka, punnāga, nāgakeśara, ciñcini, kapittha, vadari, vilva, kumbhakāri priyaṅgu, panasa, āmra, madhuka, karamarda	Pātalā, dāḍima plakṣa, karavira, vata mallikā, udumbara, kunda and others.	Tāmbuli, sindhuvāra, tagara	Ela, padma, utpala,	Kumkuma, ārdra, rasona, āluka.
Viśvavallabha 16h Century A.D. (1577 A.D.)	**Seeds**	**Seeds and stalks**	**Stalks**	**Bulbs and stalks**	**Bulbs**
	Ciñca, āmra, madhuka kapittha, jambu, punnāga, bilva, bakula, aśana, kāncanara, kṣiri, kamu panasa, akṣaka, nalikeri, tāla, tilaka, jambira, nimbuka, sadāphala bijapura, nariṅga, seva, karamardaka, campaka, karṇi vidama, kamala, panduraga, syāmā, atimuktaka etc.	Bimba, snuhi, candraka, sinduvara, śrikhandika, aśvattha, vaṭa, palāśa, plakṣa, munidru, drākṣā, vaṃśa, ela, ambuja etc. (In the other two texts ela is said to grow from seeds and bulbs)	Jāti, gulāla taruni, malli,navamallikā, japa, tarala, kunda, śikhaṇḍI, kubja, tambulika, salila, ketakī, ketaka	Rambhā	Kumkuma, śṛṅgavera, vidarika, śuraṇa pitika.

Text in regional languages: Side by side with the composition of Sanskrit texts on various sciences, initiatives were taken to create such literature on science subjects in regional languages during the early medieval period as regional languages by this time had taken over as means of communication in most of the areas. The knowledge in Sanskrit was accessible only to those who were well versed in the language and a large number of people were gradually segregated from the knowledge of Sanskrit language.

Consequent upon, it may be argued that the rulers in various regions too took an enterprising attitude and encouraged literary activity in regional languages in the interest of the common people. As a result we have in our possession a few technical texts in different regional languages. A number of manuscripts are kept preserved in different libraries and institutions but many of the manuscripts are still lying undiscovered. Among the few manuscripts pertaining to the study of plant science in regional languages, mention may be made of *Lokopakāra* which was originally written in Kannaḍa language in 1025 A.D. by *Cāvundarāya,* a poet in the court of Western *Cālukyas.*

The original work is encyclopaedic in nature. It contains the following chapters:

1. Astrological aspects
2. Auspicious and inauspicious time for various mundane and religious affairs.
3. *Vastu* (Architecture)
4. *Portents.*
5. Water Divining
6. *Vṛkṣāyurveda*
7. Perfumes
8. Recipes
9. Medicine for human and animals.
10. Treatment for snake bites etc.
11. Characteristics of animals.
12. Omens.

The text was written as poetry in the old *Kannaḍa* language i.e. *Halagannaḍa*[9].

The present English translation of *Lokopakāra* is an abridged version of the original text published by the Madras Government Oriental Manuscripts Library, Madras (Adyar Library, Chennai) in 1950.

In Karnataka, the Calukya kings encouraged literary and academic compositions by poets and scholars in various fields. *Mānasollāsa,* the encyclopaedic work, attributed to the western Calukya king *Someśvara,* was composed in Sanskrit but *Lokopakāra* ascribed to *Cāvundarāya,* a poet of the same period and from the same region, was composed in old *Kannaḍa* language. This important development in respect of the use of local languages for better communication with a view to extending benefit of knowledge to the people at grass-root level practically marks a new beginning in the course of historical developmental process.

After a thorough analysis of the contents of the two texts and other literary works of the period Sadhale and Dave made a critical assessment and commented, 'The literary activity of this period can be described as falling mainly in the following categories:

- Compositions of commentaries in Sanskrit on important Sanskrit texts of literature and science.
- Translations of important and popular Sanskrit works into regional languages.
- Creative reproductions of Sanskrit epics, *puraṇas* and classical texts in regional languages.
- Compositions of works of encyclopedic nature both in Sanskrit and regional languages into which was culled together useful information from earlier works'[10]

Lokopakāra according to these commentators falls in the last mentioned category. Rendering information on several useful and interesting topics available till then only in Sanskrit the language of the elite society into the local or regional languages spoken and understood by the common

people was the pressing need of the period. Diffusion of knowledge in different technical and scientific subjects through communicable languages, which obviously incorporated regional languages, exhibits a utilitarian attitude of the society at large.

As for the exact content of the *Lokopakāra,* Chapter V, VI, IX and XI of the text contain valuable information regarding plant science and animal science in early-medieval India. Chapter VI deals with *Vṛkṣāyurveda* i.e. *Āyurveda* for plants and trees which discusses the issues of health management of trees, bushes and creepers. In this context it should be remembered that the contents of the text bear a high utilitarian value from the practical point of view of the common and of the royal people as well. At the same time, the fact remains that it is not an original work rather it may be described as 'a compendium of various sciences' of the time in a concise form.[11] The text has its roots in the traditional classical texts of ancient India. All the subjects dealt in this book were already available in many ancient Sanskrit works like *Bṛhatsaṃhitā, Carakasaṃhita, Mayamatam* etc. The poet himself acknowledges his debt to his predecessors[12]. The treatment of the subject in the *Lokopakāra* is not so exhaustive as compared to that of the *Vṛkṣāyurveda* of *Surapāla* or the *Vṛkṣāyurveda* of *Parāśara.* The name of *Parāśara* has come down to us from the hoary past as an authority on different aspects like *smṛti,* astrology, astronomy, agriculture, meteorology, omens etc. The name *Parāśara* is linked with plants science also. *Bhaṭṭopāla* in his commentary on the *Bṛhatsaṃhitā* cites a verse from *Parāśara* dealing with plants. More light on *Parāśara's Vṛkṣāyurveda* will help to construct a comprehensive picture of the *Vṛkṣāyurveda* or the science of Botany in its archaic form that prevailed in ancient India. The task will be undertaken hereafter.

Now, information may be cited here from the texts of *Surapāla, Cāvundarāya* and *Cakrapāṇi Miśra.*

Seed Treatment: Regarding seed treatment, *Surapāla* suggests:

Seed is extracted from dried fruits which become ripe in the natural course and season. It is then sprinkled with milk and dried for

five days. It is then smoked with mustard seed mixed with *biḍanga* (*Su. Vṛ.* V.52, p. 45-46).

Seeds sprinkled with milk, smeared with mustard and ash of sesame and *bṛhati,* rubbed with cow-dung and smoked with marrow (*Su. Vṛ.*, V. 53, p.46).

Seeds sprinkled with milk, rubbed with cow dung, dried and profusely smeared with *makṣika* (honey) and *biḍanga* definitely sprout (*Su. Vṛ.*, V.54, p.46).

According to the experts, seeds soaked in milk, dried well in shade, and rolled into powder of *bṛhati,* tila and nala (hollow stalks of lotus) mixed with mustard are also excellent for sowing (*Su. Vṛ.*, V.55, p.46).

The seeds of *makanda, jambu* and *panasa* are excellent when wet and treated as stated above. The seeds of *kṣirika* and *bakula* are good when dried and treated as stated above and when the tips are cut (or bent) (*Su. Vṛ.*, V.56, p.46).

The seeds of *urvaru* become fit for sowing when sprinkled with water mixed with plenty of jaggery tied in a leaf-vessel, put on the ground, heated incessantly with fire for three days and then taken out (*Su. Vṛ.*, V.57, p.46).

Seeds which are treated and preserved in this manner are all good for use. Trees grown from such seeds bear forever abundant flowers and fruits of an excellent quality (*Su. Vṛ.*, V.58, p.46).

After sowing, the seeds should be covered with grass and sprinkled with water mixed with milk. Water should be sprinkled after they sprout. Grass should be removed and the soil should be allowed to dry (*Su. Vṛ.*, V.60, p.46).

In the *Upavanavinoda* the instruction as follows: It is said:

One should first of all sow seeds in the seed-bed, spread grass over it and sprinkle milk and water, and then when the seeds germinate, remove the grass, dry the earth a little, and transplant these sprouts

together with there roots and earth attached thereto (*Up.van.,* V. 56, p. 73).

The act of planting and sowing was considered to be very sacred one and it was to be performed by one being properly sanctified. Both the *Su.Vṛ.* and *Up.van.* contain verses reflecting the holy attitude of the people to the act of planting. The social attitude in general is nicely represented in the relevant verses of the texts:

Surpāla states, 'The owner of the farm should wear clean clothes after bath, worship God, offer salutations to his preceptors, offer wealth or land to the worthy, offer salutations to the *Vāstu* deity (superintending deity) and then (he) himself should sow some seeds. The servants should then follow him' (*Su. Vṛ.,* V.59, p. 46).

The same attitude is apparent in the verse no 55 of the *Up. van.* where it is said, 'A person (the master of the household) after taking ablution and putting on well-washd clothes, and after worshipping the gods, and making obeisance to his *Guru* (spiritual preceptor) and giving away earth or money to a qualified Brahmin, and making obeisance again to the presiding deity' of foundation (*Vāstupuruṣa*) should himself sow seeds. His attendants should follow suit *(Up. van.,* V.55, p. 73). Most of the verses in the *Up. van.* are similar to those mentioned by *Surapāla.*

The seed treatment prior to the sowing according to *Lokopakāra* is as follows:

The seeds of a naturally ripened fruit is to be collected, mixed well with cowdung and dried (in shade) for five nights (and days). This has to be soaked in milk for seven days. Afterwards, it has to be coated with the mixture of Indian night-shade (*Solanum* indicum) fruit juice and saltwater. This coated seed is to be fumigated with the powder of *viḍanga* (*Embelia ribes*) seeds and ghee (*Loko.,* V.6. p. 23).

Such treated seed should be sown in the pits at auspicious timings (muhurtas) and auspicious ascendants. The pits have to be sprinkled with *kunapa water.* Such seeds will sprout and grow well (*Loko.,* V.7).

A comparative examination of the verses of *Vṛkṣāyurveda* given in different texts makes it clear that same type of cultural practices were going on in different regions of this vast country.

Constellations for Sowing: Regarding favourable constellations for sowing *Sūrapāla* states:

'*Viśakha, Mṛga, Mula, Citrā, Uttara, Uttarāsādhā* and *Uttarābhādrapada, Anurādhā, Jyeṣṭha* and *Kṛttika* are good stars. Steady *Lagna* is good (*Su. Vr.*,V.62, p. 46).

Much the same statement is made in the *Up. van.* with slight variation. The relevant verse is quoted here: Dhruba (*Rohinī, Uttarāphālgunī, Uttarāṣāḍā* and *Uttarābhādrapada*), *Mṛdula* (*Citrā, Anurādhā, Mṛgaśirā* and *Revatī*), *Mūla, Viśākhā, Puṣya, Śrāvaṇā,* Aśvinī *and Hastā* — all these constellations are characterized as mild and they are favouralde to the planting of trees according to the sages (*Up.van.*,V.58,p.73). *Cāvundarāya* specifies the eight ruling constellations during which seed sowing should be done. These are: *Rohiṇī, Mṛgaśirā, Māgha, Hastā, Citrā, Viśākhā, Mūla* and *Śrāvana*. But *Viśvavallabha,* written by *Cakrapāṇi Miśra* does not specify any constellation which is according to Y.L. Nene, 'most likely because of the uncertainty of rains in Rajasthan in Western India'[12].

Instructions for following favourable constellation for sowing seeds were largely based on observation of stars. How far the observational statements pertain to science is a controversial question. However, the whole issue of favourable asterism may be examined with a rational approach in which the situation along with its time frame is considered as determinant factor.

As for *Viśvavallabha,* the rainy season is recommended by the author for sowing all types of seeds and planting trees. Autumn and spring are considered as mediocre seasons for the purpose. Winter and summer are both contraindicated for plantation. Experience of aged people engaged in this vocation is highly valued in the text. Practical knowledge of the local people attached to the particular region, often came into use for fruitful operation. The *Up.van.* also prefers the rainy

season as the season for sowing of seeds because it is the best sprouting season. The exact instruction is: Seeds (of trees and other garden plants) should be sown during the months of *Āṣāḍha* and *Śrāvaṇa;* and some opine that they may be sown in any season of the year except summer (*Up. van.* p. 74). Referentially it may be noted that *Āṣāḍha* and *Śrāvaṇa* constitute the main showering period in a year in northern and eastern India. This is clear from the instructions given in different texts as mentioned above that the cultural practice is looked as a total scheme ranging from soil preparation, sowing, watering, manuring, treatment of ailing plants etc. to ripening of the fruits. Naturally, experience, expertise, labour, strict vigilance, care, compliance of specific methods all these lead to successful return from the whole operation.

That all the texts related to agriculture and cultural practices are imbued with pragmatic philosophy is evident from each and every section dealt with in these works. Obviously, sections containing portents, omens or other fortuitous elements in such texts, claimed to belong to scientific category, often create big confusion on the fundamental nature of the works. But, from the perspective of history, to get a justification of co-existence of scientific and unscientific elements is not unlikely. Whatever may be the degree of wisdom of the people of a society, their proneness to fortuitous beliefs can not be distracted. Natural science, as a result is traditionally mingled up with speculative elements which apparently seem to be prating to the theme. A sense of pragmatism always dominates the discourse in all the texts. They all agree that extra effort, investment, royal support along with good fortune can bring success even if operations are carried on in unfavourable soil and in an area not endowed with natural source of water and even out of favourable season.

Distance between Plants

Now it is time to examine the rules for maintaining distance between two plants or bushes (Table IV). It is specifically mentioned both in the *Up.van.* and the *Sū. Vr.* that trees if thickly sown are hindered

in their growth and if sown very sparsely they are in danger of falling down even in consequence of mild winds; hence for lean plants, in the laying out a garden, planting after the method is wise (*Up.van.*, V.66, p. 74). So the recommendation is: one should plant trees at an interval of 10 cubits in the lower level of the garden, and at 20 cubits in the higher and at 16 cubits in the middle; but if the surface of the garden be plane one should plant grass-like plants at an interval of 2 cubits, trees at 4 and gulmas at 3 cubits.

Table IV : Distance between two plants recommended in different texts for plantation

Text	Type of plants and /or land	Distance		
		Superior	Medium	Inferior
Vṛkṣāyurveda of Surapāla	For trees For bushes	20 forearm length 4/5 forearm length	16 forearm length - 	14 forearm length-
Upavanvinoda	For trees on relatively high land	20 cubits	-	-
	For trees on land of middle height	16 cubits	-	-
	For trees on land of low height	10 cubits	-	-
	On plain and leveled land:			
	(i) For trees	4 cubits	-	-
	(ii) For gulmas	3 cubits	-	-
	(iii) For grass like plants	2 cubits	-	-
Lokapokāra	For trees	16 cubits	14 cubits	10 cubits
Viśva-vallava	For tall trees with wide diameter (Superior)	20 Karas	-	-
	For trees of medium height and diameter (Mediocre)	16 Jaras	-	-
	For trees of low height and diameter (inferior)	12 Karas	-	-
	For bushes	3 Karas	-	-
	For grasses	4 Karas	-	-
	For creepers.	2 Karas	-	-

Likewise in the *Up.van.*, the similar arguments have been extended by the authors of the texts under discussion.

Surapāla says: The distance between two plants is fourteen, sixteen or twenty fore-arm lengths. These distances result in inferior, mediocre and excellent yield of trees respectively. (*Su. Vṛ.*, V.64, p. 46).

Distance between two bushes should be four or five fore-arm lengths. Puga etc. are planted carefully at a distance of two to three fore-arm lengths. (*Su. Vṛ.*, V. 65). A clear sense of caution is expressed in the next verse:

If planted at farther distance there is the danger of strong winds. But if planted closer than this (2-3 fore-arm lengths) there is no yield. So one should strictly adhere to the correct distance for proper yield from the trees (*Su. Vṛ.*, V. p.66).

We may now turn to the old *Kannaḍa* text *Lokopakāra* where *Cāvundarāya*, the author, gives brief but clear instruction as follows: The distance between two pits should be maintained such that the branches of the two trees do not overlap each other. The distance of sixteen cubits is superior; fourteen is moderate; and ten is inferior. (*Lok.*, VI.4.p.23).

Healthy growth of plants and trees depends on several factors and it is noticed that the writers of early period pay much attention to all the issues related to cultural practices. Same type of wisdom spreads through out the vast territory of the country and descends down from generation to generaton till the introduction of the modern western scientific techniques. Percolation of traditional knowledge through treatises composed either in Sanskrit or in regional or local languages has been in practice since long. Naturally commonness in the content of these texts is obvious. Thus we notice, instructions in the *Viśvavallabha* are not very different from those mentioned in other texts already discussed. Directions on the issue of distance between plant and plant resemble to a large extent the instructions extended by the earlier authors in their works. For our proper understanding a few verses are cited here. Mediocre, superior and inferior types of trees should be planted at a distance of sixteen, twenty and twelve *karas* from each other respectively. But this is an old theory (*Viś-va.*, IV, V.17, p. 74). The last sentence in the verse bears extra connotation. 'Old theory; certainly

implies the conventional knowledge prevalent up to that point of time when the author undertook the task of composing this book. So a fact is clear that alterations and additions were continuously found out in the process of evolution of knowledge through trials. Hence after referring to earlier practices,

Cakrapāni Miśra expresses his own preference for distance to be maintained between the trees. First he mentions the existing rule set by others on this issue, then he expresses his own view. This approach is very rational. He says: Big trees should be planted at a distance of twenty, medium ones at a distance of sixteen and smaller varieties at a distance of twelve ***karas***. Such is the rule made by some others regarding interim distance. But in my opinion — ***kaṃi, bādāma, lakuca, āmalaka, bijapura*** and ***dāḍima*** should be planted leaving a distance of five, seven and ten ***karas*** in between, ***campā*** and others of its class should be planted with seven, ten, and twelve ***karas*** distance in between and ***cinca, rasala, rajadanaka*** at a distance of sixteen and twelve ***karas*** from each other (*Viś-va.*, VI, V.19-20. pp. 74-75).

From the above survey, it becomes clear that the ancient authors set these rules keeping in view two prime considerations: (a) adequate availability of nutrients from soil, and (b) sufficient availability of sun light for each plant. It needs no explanation that maintenance of proper distance ensures growth and vigour of the plants and hence the best yield. But simultaneously it comes to our vision that a subtle change towards lowering the intervening distance between the plants is functional. This is perhaps because of the fact that the experience of years had made the people conscious of prudent and intensive use of land and hence changes are noticeable in the prescribed formulas to avoid redundancy in land use for space in between the trees. Besides, the fact should not be ignored that conversion of forested land into cultivable plots involved much of labour and money. Naturally, unnecessary wastage of man-power and thereby investment might have been few factors that inspired deductionist approach in the spacing.

Designing and Layout of Planting

Designing and laying out of the trees and plants as per the instruction in the texts is strictly adherent to the architectural principles of Indian *silpa śāstra*. In this context, it may be remembered that most of the diagrams in the Indian temple architecture are designed with a proper attention to the maintenance of structural balance and projection of light and shade along with their outer beauty and religious significance.

In the *Śu.Vṛ.*, the designs prescribed for planting trees are: *maṇḍapa* (canopy), *nandyāvarta* (quadrangle with an opening to the west), *swastika* (famous diagram of religious significance), *caturāśra* (square), *sarvatobhadra* (a square enclosing a circle), *vithi* (line), *nikunja* (arbour) and *puñjaka* (cluster). (*Su.Vṛ.*, V. 94. p. 48).

The same verse is represented in the *Upavanavinoda*. The application of the architectural design in the scheme of planting the trees is probably intended with the purpose of providing proper sun-light for the vigorous growth of branches and foliages and thereby enhancing the aesthetic attraction of the whole arrangement.

In the *Viśvavallabha* a few designs have been recommended with regard to grass, bush and creeper e.g. *vithi, swastika* and circle. (*Viś-va.*, IV, V.18, p.74).

Surapāla categorically mentions that pits should be prepared well in advance. The length, breadth, and the depth of the pits should be a forearm measure uniformly. They should be properly dried, filled with cow bones and cow dung and burnt.

Continuous researches on the basis of observation and application of new techniques evolved knowledge of improved methods. Planting proved better yield than sowing of seeds in some cases. As for specific instance the following verse is quoted: Sowing seeds for *makanda, dāḍima, kuṣmānda* and *ālambuka* is good but planting is even better (*Su. Vṛ.*, V. 69. p. 47).

The method of sowing and planting in the *Su.Vṛ.*, is more elaborate and exhaustive in its treatment. Distribution of the verses

numbering 325 in total (including the missing nos. 184,202 and some lines) in the text under different appropriate headings reflects the technical perfection of the text.

It is said: Large seeds should be sown singly but smaller ones should be sown in multiples. The seeds of ***naramga*** should be sown in a slanting position with hand. (*Su.Vṛ.*,V.72, p.47). The instruction for laying the seed in slanting position in the pit is a clear example of minute attention of the author for every detail of the science of cultivation.

In case of propagation by stalk, the prescribed rule is — The stalk should be eighteen *aṅgula*, not too tender nor too hard. Half of it should be smeared with plenty of cowdung and then (it) should be planted with three fourth part in the pit and should be sprinkled with water mixed with soft sandy mud. (*Su.Vṛ.*, V.76, p.47).

The lower part of the stalks of *Śatapātrika* should be planted in a carry and drenched with water for about two months (*Śu.Vṛ.*, V. 77, p.47).

As a result the stalk will be covered with leaves and there will be no crisis if uprooted and transplanted elsewhere according to choice. But transplantation is advised to be undertaken in the beginning of rains. Small trees are suggested to be transplanted by day time but in case of big trees, evening is considered as perfect.

Watering of Plants

The advices given in the texts relating to agricultural sciences touch all aspects of plant life for the healthy growth from the very beginning, and recommendations for watering the plants are more or less similar in all the works.

According to *Surapāla*: Newly planted trees in arid land should be watered every morning and evening for a period of fifteen days until the soil is fully soaked (*Su.Vṛ.*, V. 109. p. 49). But for marshy land the instruction is obviously different. Here, watering should be restricted to only once in five days. In ordinary soil, watering should be done for ten

days every morning and evening, but the quantity of water should be limited (*Su.Vṛ.*, V.110, p.49).

Watering should be in keeping with the nature of the season and also the size of the plants and hence the rule is:

Well rooted plants should be watered every alternate day in winter, every evening in spring and thrice a day in summer (*Su.Vr.*, V. 111, p.49).

A Slight difference in regard to drenching of water is marked in the *Up. van.* In case of newly planted trees, watering twice is recommended, once in the morning and another in the evening. Watering rules vary from season to season. In the autumn and in the winter it should be done every alternate day but everyday in the spring.

Regarding summer, there is clear difference between the *Su.Vṛ.*, and the *Up-van.* The instruction here for watering in the summer is twice, not thrice like that in the *Vṛkṣāyurveda*[13].

The *Lokopakāra* sets the guideline quoted below:

Such newly sown plants should be watered twice in the morning and evening regularly in summer. The moisture content of the soil should be observed in rainy and winter seasons and watering should be done accordingly (*Loko.*, V. 8, p. 23).

Water management is also dealt with in the *Viśvavallabha* but with a little more details.

It is said: A newly planted tree should be sprinkled every morning and evening if it does not rain. It should be supported with sticks etc. fixed close to it so that it is not disturbed by a stormy wind (*Viś-va.*, V., V.1, p.75). Provision of digging basin around a plant for storing water at the root for its good growth is not unfamiliar in traditional Indian plant science. Circular ditch around a tree is mentioned both in the *Up.van.* and the *Viś-va.* but with a caution that trees suffer from indigestion if the water in the ditches is not dried up, hence one should not pour fresh water in it till that is the case. (*Up.van.*, V. 75. p. 75).

The same thing we notice in the *Viś-va.* where it is said: When water is filled in the basin, it does not dry even after being used by the tree (after considerable time), the next watering should not be done again till the water remains. The wise call this the retention of water as 'digestive disorder'. (*Viś-va.*, 111.3, p.75).

Excess of water storage in basin around the plants proves harmful for development and growth of plants. Hence advices are extended in these technical texts so that the people concerned with the vocation of plantation or agriculture may avoid some health related problems of the plants and incur benefit by good return from the trees and plants.

Kṛiṣisukti: Side by side with the instruction on watering, a number of verses are found in the *Kāśyapiya Kṛiṣisukti* which contains information on irrigation. *Kāṣyapiya Kṛṣisukti* was translated into English in 1985 by G. Wojtilla and was published in Hungary. But the translation is not easily available. The second translation, which is proving to be of much help to the present researcher is the work of S.M. Ayachit[14]. Wojtilla has stated 'the date of the work in its present form is uncertain but there is a good: reason to date the core of the work to the 8-9th centuries A.D. There are numerous interpolations belonging to a later age. Even some quite modern passages occur.' Whatever may be the antiquity of the text, there is hardly any doubt that kernel of the text bear the tradition of old wisdom. Much emphasis is given on royal initiative for creating water reservoirs and wells in the village settlement.

Kāśyapa says, 'It [=village] should be equipped as a rule by the king, with wells and reservoirs of water, adorned with gardens etc. and enclosed by agricultural fields' (*Kā.Kṛ.*, V.64.p.76).

A reference to *ghatiyantra* for lifting water is furnished by the author. The verse runs thus: The water raising contrivance is manifold — the best is that plied by bullocks; the middle [type] would be worked by elephants with their trunks etc. with the help of strong chains and [lastly] the meanest [type' is that operated by human beings (*Kā.Kṛ.*, V. 169b-170, p. 82).

Inscriptional evidences also support the use of *ghaṭiyantra* or *araghaṭṭas,* water wheels operated by oxen containing several buckets for drawing water from wells. The earliest reference is available in a 7th century inscription and it was probably adopted from Persia[15].

To quote Sharma, 'the new contrivance was slow to find favour with the Indian peasants because of their usual conservatism in a practically stagnant agrarian society. But during the next four centuries it gained in popularity, for the *Cāhamāna* inscription of the twelfth and thirteenth centuries found in south and south eastern Marwar, point to the wide spread use of wheel operated wells, which may have helped the production of such cash and commercial crops as sugar, cotton and hemp.'

B.D. Chattopadhyay says that by the word *araghaṭṭa* meant also deep well. Ibn Batuta on his way to *Kāmrup* from Chittagong witenessed water wheels which were probably same as *araghaṭṭa.*

The reference to the contrivance in the *Kāśyapiya kṛṣisukti* naturally makes us curious for knowing the eco-zone dealt with in the text.

According to Randhawa, *Kāśyapa* possibly was a resident of *Kośala* (Oudh in central U.P.). Wojtilla suggests that *Kāśyapa* followed the *vaiṣnava* tradition of South India and wrote the text sometime during 700 to 800 A.D. Nene's view is that although *Kāśyapa* possessed wide knowledge with regard to agriculture of several regions of the Indian sub-continent, his main focus was on the *Kriṣnā-Godāvarī* deltas and the adjoining northern regions.

Kāśyapa has repeatedly stressed the need for a genuine support to farm activities by the ruler concerned. The ruler's support is to be provided in identifying land for agriculture, building water-reservoirs, planting trees on the banks of water reservoirs, constructing canals and wells, water harvesting, making seed available, ensuring sustenance, giving donation of land and subsidies to weaker people, arranging markets, standardizing weights and measures, aforestation, locating mines producing metals and collecting taxes.

Kāśyapa makes another important statement that agriculture is a virtuous profession, and all people, regardless of their status and castes should practice agriculture. In the context of early medieval India, the attitude contained in the text towards the vocation of agriculture bears uncommon historical significance. *Kāśyapa's* composition strengthens the observation of Chattopadhyaya on the pattern of economy from the ninth-tenth centuries onwards. His exact expression is — '... but agrarian production witnessed several features of growth such as expansion of areas of cultivation, increase in the use of well and tank irrigation and perhaps a recognizable shift to the production of certain items of commercial agriculture which began to enter into networks of exchange'[17]. Of the 606 verses in section one of the *Kāśyapiya Kṛṣisukti,* 180 verses have been spent on building water reservoirs, canals and wells and emphasis on water-harvesting. In fact, verse 178 implies that rain is assured in all places.

It is said:

Megha pracārakāle tu bṛṣṭiḥ sarvatra niścita ।

Daivayogānmunīndrāṇām saṅkalpādapisarvathā ॥

It means — by the will of God or by the divine power of the great sages rain during the time of movement of clouds is assured in all places (*Kā.Kṛ.*, V. 178. p. 82). *Kāśyapa* extends suggestion to the king in respect of proper utilization of rain water which implies government's responsibility for developing infrastructural facility for steady growth of agriculture and other plantation works in the country. The relevant verses say:

The king should arrange to fill up the reservoirs with cloud water in due time for ensuring (overall) well-being. (*Kā. Kṛ.*, V. 179, p.82).

That water (therefore) should be preserved by all (sorts of) efforts, as agriculture is said to depend on water. Hence, kings and [other] eminent persons should obtain water by exerting everywhere in the seasons and conserve it — thus spoke the great sage *Kāśyapa* (*Kā.Kṛ.*,V.180-181,pp.82-83).

Nourishment of Trees and Plants

In *Upavanavinoda* it is explicitly expressed that merely planting or sowing will not bring return from the trees or plants. Nourishment is essential for getting expected yield. For this purpose the ancient authorities offer some rules relating to nourishment of plants.

Nurturing of trees with manure is suggested in all the texts like *Vṛkṣāyurveda* of *Surapāla, Lokopakāra* (Kannaḍa), *Kṛśiparāśara, Kṛṣi-gītā* (Agricultural verses in old *Mālayālam* language), *Kāśyapiya Kṛṣisūkti, Viśva-vallabha* and others.

All the texts mentioned above emphasized the application of organic manure which included cow-dung, goat dung or tendrils of creepers i.e. green manuring. Besides, many other components were used as nutrients of the plants. A few rules relating to nourishment of plants may be quoted here from different texts to get an idea of different types of manures used during the time.

In the *Upavanavinoda,* this section is called as *Poṣanavidhi.* This section contains 26 verses covering the nutrition method for all trees and plants belonging to any category like timber yielding, fruit yielding or flower yielding. It is mentioned:

For the (growth of) old *āmalaka* trees the pulse *māṣa* is extremely beneficial, for young *tinduka* trees application of water and milk is very helpful; powders of barley help the growth of cocoanut trees; and all trees rapidly grow if in the planes (*Up.van.*, V.149,p.81).

Constant efforts were in vogue for improvement of taste and qualities of fruits. The instance of mango or *dāḍima* may be drawn. The relevant verses are: Mango trees bear very fragrant and sweet fruits at an early date if they are watered with decoction made up of milk, *pañcapallava* i.e. leaves of mango, *aśvattha, vaṭa, plakṣa* and *yajñadumura* together with the fat of deer, boar, jackal, elephant, horse, etc. (*Up.van.*, V.150, p.81).

The next verse is related to *dāḍima:* A decoction made up of clarified butter, *kuṇapa* water, *vaca* and pig's stool — is extremely

favourable to the development of fruits of *dāḍima* trees. And water or decoction made up of powders of *kulattha* is favourable to the roots of the same tree.

To enlarge the size of the fruits with scanty number of seeds in them was also the target of the *practitioners* of plant science as is revealed in these texts of plant science. It is said — If one, after besmearing the trunk of a pomegranate tree with *saphari* fish and powders of *triphalā* (fruits of *āmalaka, haritaki* and *bayeḍā*) applies to its roots the powders of above three fruits and mango paste and also fumigates with frankincense, the fruit of the said tree is sure to be as large as the palmyra fruit. (*Up.van.*, V. 152).

For reducing the number of seeds to a minimum in *vilva* fruit the recommendation is: If *kapittha or vilva* tree be watered with clarified butter, milk and honey, it bears fruits which are sweet to the taste, full of fleshy substance containing scanty number of seeds. (*Up. van.*, V. 156).

A plum tree bears fruits which are as sweet as sugar when its roots are developed through being watered with the decoction of *tila* and *yaṣṭimadhu* and with *kuṇapa* water (*Up.van.*,V.158, p.82). In this verse, we notice an effort for reducing the sour taste of plums. There are striking resemblances between the verses of the *Up.van.* and the *Su. Vṛ.* In the matter of nourishment of trees there are some variations; the variations are not elementary but compositional, but all pertaining to the group of organic manure. The suggestion in the *Su. Vṛ.* will show that the basic principle of manuring the mango tree is same though difference in components is discernible. The relevant verse is quoted here. 'The mango trees are nourished well and loaded with sweeter and bigger fruits if treated with water mixed with ripe fruits of *ankolha, ghee,* honey and marrow of a bear (*Su. Vṛ.*, V. 123.p.50). In the *Su. Vṛ.*, the cases of coconut, orange and other fruits have been taken into consideration for improvement in the qualities and quantities of production.

Varieties of flower plants and creepers like *ketaki, lotus, syāma, mādhavi, karavira, kuraṇṭa, mallikā* and many other types of flowering

plants have been discussed in both the texts. Besides a number of vegetables like *birbhati, alambu, karkaru, trapusa* etc. are mentiond.

In all ages and in all times easy livelihood obviously depends on the success of agriculture espacially in an agrarian country like India. So constant researches for agrarian development have become the part and parcel of scientific activities of India from the time immemorial.

Kuṇapa Jalam

In a discussion on nourishment of plant life *kuṇapa jalam*, i.e. organic liquid manure should be treated with special emphasis.

In verse nos. 113-114, *Surapāla* refers to the use of *Kuṇapa jalam*. In the *Up.van.*, the procedure of preparing this liquid organic is given as follows:

One should boil the flesh, fat and marrow of deer, pig, fish, sheep, goat and rhinoceros in water, and when it is properly boiled, one should put the mixture in an earthen pot and add into the compound milk, powders of sesamum oil-cakes, *māṣa* (pulse) boiled in honey, the decoction of pulses, clarified butter and hot water. There is no fixity as to the amount of any of these elements; when the said pot is put in a warm place for about a fortnight the compound becomes what is called *kuṇapa* water which is very nutritious (*Up.van.*, V. 171-174, p. 83).

The *Viśva-vallabha* also gives the recipe of this liquid nutritient of the trees and plants. The composition as well as preparation method is almost the same.

The dictionary meaning of the word *Kuṇapa* is 'smelling like a dead body', 'stinking'[18]. The manure *kuṇapa jala* was used since the ancient times. Documented references to the said liquid manure are found in the above mentioned texts. *Surapāla* adds, 'This *kuṇapa* is highly nourishing for the trees. This is as stated by the ancient sages and I *(Surapāla)* repeat it here after verifying the same'.

In the *Lokopakāra*, there are no details of preparation. It is said that the pits (for sowing) have to be sprinkled with ***kuṇapa*** (fermented liquid prepared from flesh etc.) water. The seeds will sprout and grow well. (*Lok.*, V. 7. p. 23).

In the *Viśvavallabha* the preparation technique is given but at the same time the author does not forget to acknowledge *Śāraṅgadhara* in this context. Thus from various texts, it appears that this organic composition was the outcome of long experience and trials. The method of preparation was truly not comfortable, it involved animal waste and foul odour. *Surapāla* mentions waste from animals like cow, porpoise, cat, birds, deer, elephant etc. But it is evident in the same text that the author at the same time suggests to store animal waste underground perhaps to control bad odour in the air. Y.L. Nene claims that preparation and use of *Kuṇapa jala* was virtually forgotten. But V.S. Ayangarya, a mathematician, experimented with ***kuṇapa jala*** in the recent years and published a short note titled ***'herbal kuṇapa'*** in the journal *Asian Agri-History* in 2004. He reported excellent results when ***kuṇapajala*** was applied to mango and coconut.[19]. He continued his experimentation in Arunachal Pradesh in North East India. He developed herbal ***kuṇapa*** and called it *śasyagavya*. Following the instruction of *Vṛkṣāyurveda* he prepared ***kuṇapa jala*** by fermenting aerobically safari fish in cow urine. In 2006, Ayangarya reported formulation of ***muṣika kuṇapa***. In Tamilnadu, Natarajan popularized the use of ***panchagavya*** the components of which are cowdung, urine, milk, card and ghee. This is actually prescribed in *Garuḍapurāṇa* and *Varāhapurāṇa*. A person takes it as sip for purifying himself from sin. Use of ***panchagavya*** as manure is not documented here. Natarajan adds other ingredients like sugarcane juice, coconut water, banana etc. Further the mixture is allowed to ferment aerobically for a week and automatically proves to be highly nutritious and may be called as ***panchagavya kuṇapajala***.

It is generally stated in almost all text books that plant roots utilize chemical fertilizers faster than organic manures. This is true when the organic manures which are soft and semi-dry, are scattered in the field. ***kuṇapa jala*** and its application are very different from the application of

other organic manures. *kuṇapa jala* is a liquid and therefore ready to reach root zone in a short time. Secondly, the ingredients of *kuṇapa jala* when fermented, the big organic molecules such as protein, carbohydrate and fat are broken down into very simple molecules almost ready for absorption by plant roots. In contrast, the solid organic manures require considerable time for further transformation by soil micro-organisms into simpler forms absorbable by the plants. It is only the farmers and sages of ancient India who took pains to formulate and use improved organic manure for perennial plants. If we go by the definition of *Vārttā* in the *Arthaśāstra,* we will definitely mark that constant observation, experiments, trials which in a sense form the basics of empirical science were instrumental for its prospect and development.

In the discussion of manuring, it is important to make some idea of the Ancient India's notion about plant physiology. *Guṇaratna* in his commentary on the *Ṣaḍdarsana samuccaya* very aptly describes the influence of soil and food upon the system of the plants in producing health and disease. It is said: 'Just as the human body receives sustenance through the assimilation of the mother's milk, dishes, etc. so also the vegetables ,assimilate food according to the nature of the earth soil, water, etc.' 'Just as the human system is at ease and is diseased according as it takes wholesome or unwholesome food so also plants grow or decay by assimilation of suitable and unsuitable food'. Thus connected with the nourishment of plants the most important factor is the soil — the principal source of sustenance[21]. G.P. Majumdar, who is a renowned modern botanist with sound knowledge in ancient botanical texts of India, delineates the whole process of absorption, transport, transpiration and assimilation of food in the plant-body. He has explained the etymology of *pādapa* lucidly but aptly, and at the same time, discerned the underlying scientific understanding of the ancients. He states that plants draw food materials from the soil with the help of the roots which constitute exactly what mouth is to man, and thus another name for tree being *pādapa* meaning that which drinks through roots. He adds that the food materials from the soil enter plant organs, in the form of liquid and not solid, and the ancient etymology has evidently

anticipated the accuracy of the modern scientists. Majumdar also says, 'besides the full-fledged development of the scientific knowledge of nutrition, we have in some of the provincial proverbs attributed to the mythical *Khanā*, the depository of the wisdom of ages, a distinct knowledge of the function of leaves in the maintenance of plant-life presupposed'. The following aphorism of *Khanā* is shown by Majumdar in support of his view regarding *Khanā*:

'After you have planted the plantain trees, do not cut off their leaves, and this will bring you both bread and clothes'

(*Lāgiye kalā nā kāṭa pāt, tātei kapaḍ, tātei bhāt*)[21].

'The paddy develops day by day owing to sunshine by day and water by night'. (*Dine rod rāte jal, din din bāre dhāner bal*).

The modern scientific explanation of the fact would be, to quote Majumdar 'that during day time with the sunshine food is prepared, assimilated and stored and during night time the growth of the organism takes place, and for this a supply of water is needed.'

Vṛkṣāyurveda: The science of the treatment of plants may be traced in the *Bṛhatsaṃhitā* and *Agnipurāṇa*. But the tradition of medical treatment of trees and plants developed as a separate branch of knowledge. Earlier *Vṛkṣāyurveda* constituted a section in the texts like *Bṛhatsaṃhitā* and others but steadily the subject developed as full fledged branch and full text on plant treatment emerged. We have already got the name of *Vṛkṣāyurveda* of *Surapāla*. But besides this, a full text on plant science has been discovered and the most significant point in this context to note is that the manuscript of the text has been found in Coochbehar, the capital of the Koch Kings in northern part of West Bengal. Besides, *Vṛkṣāyurveda* has been dealt with in the *Upavana vinoda*. The section dealing with the treatment of plants is named as *Tarucikitsā*. It is explicitly stated in the beginning of the section — Trees, like men, get diseases through the affections of *vāta* (wind) *pitta* (bile) and *kapha* (phlegm) — the three pathological humours. One should diagnose the

diseases through their symptoms and cure them radically. (*Up. van.*, V. 175, p. 83).

The author has made a clear cut distinction between the ailments of trees due to outside factor and the trees attacked by internal diseases. The treatment prescribed for these two different types of ailments of the trees are not same. The external causes for ailments are defined as follows: When a tree is consumed by insects, burnt by fire, broken by storm, struck by thunderbolt, - one should cut away the affected parts, but in case of diseases the operation is to be of a different nature.

From the verses, it appears that for want of nutrition *vāta, pitta* and *kapha* act as the root cause of all diseases. In addition, there grow the worms at roots of plants. Decoction of cow's urine, clarified butter, *viḍanga*, mustard and sesamum are advised to be applied to the trunk. Fumigation is also advised. *Kuṇapa* water and milk also are to be applied in case of sicknes of trees for repeated production of fruits and flowers. Excess of water causes digestive problem in the trees. Treatment with the mixture of *viḍaṅga*, clarified butter and milk is suggested.

Like surgical treatment of human body, trees may be treated in the same way. *Surapāla* clearly tells of two types of diseases of trees: internal and external. The internal ones are those which are caused by *vāta, pitta* and *kaph* and external ones are those which are caused by insects, cold weather etc. Some common symptoms of diseased platns are detected, as for example — yellowness of leaves, untimely dropping of fruits, dryness and paleness of leaves, flowers and fruits etc. Striking with an axe creates injury in the body of tree and causes dryness of the tree.

Surapāla describes and suggests that various diseases of trees should be diagnosed by the above-stated respective indications. *Surapāla* tells in details regarding diseases; verses 165 to 184 are spent on the diseases. Treatments are given in verses 185 to 222 of the text. In case of diseases caused by *vāta,* flesh, marrow and ghee have been suggested as antidote. The sprinkling of *kuṇapa* water is also advised in such cases. Besides, prescription is given for fumigation of the mixture of fat of the

hog, oil of the Gangetic porpoise, ghee, hemp, hair of the horses, and cow's horn — boiled and set to a decoction.

The second type of diseases generates from ***kapha*** and is to be treated with bitter, strong and astringent decoctions made out of ***panchamula.*** Besides, the paste of white mustard should be deposited at the root and the trees should be watered with a mixture of sesame and ash.

A scientific look out is clearly reflected in a verse where a measure is advised to get rid of infection following a rational method. This is as follows: In case of trees affected by the ***kapha*** disease, earth around the roots of the trees should be removed and fresh, dry earth should be replaced for curing them (*Su.Vṛ.,* V.189, p.54). The ***kapha*** diseases of plants may be due to attack by bacteria, viruses or fungi. In damp soil these diseases occur mostly. Hence the curative measures have been suggested by uprooting the plants and replacement of original soil by fresh and dry earth. This practice is very much popular still now particularly in banana cultivation.

Pitta type of diseases are to be treated with cool and sweet substances. To protect the plant from insect infestation, sprinkling the trees with cold water for seven consecutive days is suggested (*Su.Vṛ.*,V.193, p.54). The scientific rationale behind this advice perhaps is to wash away the eggs and tiny insects so that their population is suppressed to a sub-threshold level.

The worms accumulated on the trees adversely affect the health of plant. In order to get rid of, suggestion is that the trees are to be fumigated with mixture of suitable ingredients so that the worms are destroyed or run away.

It is further added that any of the remedial measures when fails to cure, the plants should be transplanted to special sites. The underlying principle may be that in the original site the soil is deficient in some essential micro-nutrients causing the ailment of the plants. In special sites the nutrients may be in existence. This is a sort of experiment or trial for a remedy.

Lokopakāra: In the *Lokopakāra,* the author *Cāvundarāya* says, 'the plants should be sprinkled with curd-rice for protecting them from hailstones. Plants have to be fumigated with the ash of a tree burnt by a thunder bolt for protecting them from the frost. Fumigation of the plants with fish meat, mustard and plantain leaf helps them to grow vigorously and stoutly' (*Loko.*,V.10, p.24).

Regarding smoking of trees the prescribed formula is, 'Fumigation of trees with mixture of the powders of following ingredients makes them disease-free. They also bear abundant fruits. The ingredients are *vidaṇga,* Indian bdellium, fish meat, turmeric, mustard and arjun flowers'(*Loko.,* V. 12, p. 24).

In the next verse it is said, - 'If shoots or branches are broken, wounded, bleachd or dried, it indicates a disease has affected the tree. The diseased parts should be smeared with hot ghee and filled or pasted with *vidaṇga* powder and black soil. The tree gets cured and grows well' (*Loko,* V. 13. p. 24).

Suitable season for transplantation is also fixed by the author of the *Lokopakāra.* The instruction is like this: The well-grown trees have to be transplanted in winter (*Mrigaśira-puṣya* i.e. December-January); that with fruits in the rainy season (*Śrāvana-Bhādrapada* or August-September); and the young trees in the post-winter (*Māgha-Phālguna* or February-March). The plants transplanted as above grow vigorously in an astonishing manner.

Viśvavallabha: In this text, the traditional three main causes are detected as the sources of ailments of the trees and plants. It is clearly said, 'Trees may acquire disorders of *vāta* (wind), *pitta* (bile) and *kapha* (phlegm) due to pungent and strong, bitter, heat generating and salty and (excessively) sweet, sour, oily and salty decoctions'. Wind related bile related, phlegm related, all the diseases along with other various diseases have been described in the text with their medicinal remedies. Other diseases described are — diseases of indigestion and over medication, insect related disorders, forest burn, fire burn and lightning related disorders are the main. Measures are suggested for avoiding contact with unhealthy

trees e.g. 'The (unhealthy) tree located in the midst of other trees) should be cut off, as a result of which other affected trees can be cured quickly. Alternately, if the affected tree is young, it should be shifted to a new place' (*Viś-va.* Chap. VIII, p. 85). Furhtermore, antidote for wrong medicine is suggested. This is as follows: 'If the tree comes in contact with wrong medicines etc. the wise planter should remove the old soil and fill the basin with fresh soil' (*Viś-va.*, Chap. VIII, p. 86). So we find that more or less uniform system of medicinal treatment was prevalent throughout the vast country for centuries, even up to present days, where people still are following the indigenous rural traditions.

Vṛkṣāyurveda of Parāśara: The *Vṛkṣāyurveda* of *Parāśara* is a very important treatise on plant science. A manuscript of the *Vṛkṣāyurveda* of *Parāśara* was discovered by Vaidyasastri Jogendranath Visagratna. An article under the title An Introduction to the *Vṛkṣāyurveda of Parāśara* of N. N. Sircar, son of Jogendranath was communicated to the Asiatic Society of Bengal by G.P. Majumdar and it was published in the journal of the Society in Vol. XVI. No.1,1950[22]. In this article a preliminary account of the manuscript and of the contents with a list of technical terms and their English equivalents are furnished. N.N. Sircar informs us that Vaidyasastri Jogendranath Visagratna who lived in Navadwip became a great scholar in *Parāśarian* Botany by its appliation in actual nature study. He also made a Bengali translation of a portion of the manuscript.

A more curious information which bears much significance for the people of North Bengal is supplied by D. K. Kanjilal in the foreword of the book *Vṛkṣāyurveda* of *Parāśara*[23]. The manuscript was probably traced from Coochbehar where Jogendranath spent long span of his life. Coochbehar under the rule of the Maharajas from late 13th century onwards grew up as a centre of study where scholars from distant parts of India assembled[24]. Coochbehar under the rule of the Maharajas experienced a prosperous cultural life. Roma Sarkar informs us that Vaidyasastri J.N. Sircar was an Aurvedic physician in the erstwhile princely State of Coochbehar in Bengal (North Bengal). The manuscript was discovered sometimes before 1928. The manuscript is written in the

sūtra style. The style became so dominant a feature that this was adopted by the writers of different philosophical schools. The language used in this text is of course classical Sanskrit. The manuscript even with its simple linguistic structure contains words and expressions which suggest its basic antique character[25]. It is already noted that *Vṛkṣāyurveda* is known to have existed in ancient India from a very early period. N.N. Sircar held that *Parāśara* of the *Vṛkṣāyurveda* is identical with that *Parāśara* cited in the *Carakasaṃhitā*. There is enough evidence to show that the branch of knowledge on plants and plant life was intricately related to the art of healing, since the most ancient days. In the hymn of the *Ṛgveda* the poet makes mention of 107 applications of plants to make people free from diseases. A same tone is apparent indicating the importance of knowledge on plants and their use in the *Carakasaṃhitā*. *Caraka* comments, 'it is only a person well acquainted with the names and external features of plants and able to use them properly according to their properties is to be called an expert physician (*Carakasaṃhitā* Chap. I. 56). The treatise *Vṛkṣāyurveda* evidently made the basis of botanical teaching preparatory to medical studies in ancient days.[26].

As an illustration, may be cited the story of *Jīvaka* given in the Buddhist canonical texts about Jivaka's final test after completion of his study at the University of Taxila. *Jīvaka* studied medicine at Taxila for the prescribed period of 7 years[27]. But before he was given the license to start his career as medical practitioner he had to undergo a unique test of his knowledge. He was given a spade by his celebrated teacher, *Bhikṣu Ātreya* and was asked to collect from the area, a *jojana* round the city of Taxila, any plant which was devoid of medicinal properties. But *Jīvaka* could discover no such plant devoid of medicinal properties and came back empty handed. The teacher was satisfied with the perfection of knowledge of his student and allowed him to leave for his home town. *Jīvaka's* episode confirms that ancient Indian medical science was intricately related to the study of plant life.

The text of the *Vṛkṣāyurveda* is divided into six parts[28].

1. *Bijotpatti kāṇḍa*

2. *Vanaspati kāṇḍa*
3. *Vānaspatya kāṇḍa*
4. *Gulmakṣupa kāṇḍa*
5. *Vīrudhavalli kāṇḍa*
6. *Cikitsita kāṇḍa*

The last portion of the said work dealing with the treatment of plant disease is found missing. The *Vīrudhavalli kāṇḍa* which seems to be incomplete, enumerates only twenty three different creepers. The manuscript here ends abruptly. The first part i.e. *Bījotpatti kāṇḍa* is again subdivided into eight chapters and the information presented in the various chapters bear upon the following topics: Origin of life, ecology, description and distribution of forests in India (Fig.....), morphology of plants, classification and nomenclature, histology and physiology. The nomenchlature of the eight chapters is as follows:

Bijotpattisūtrīyādhyāya, Bhūmivargādhyāya, Vanavargādhyāya, Vṛkṣāṅga sūtrīyādhyāya, Puṣpāṅga sūtrtyādhyāya, Phalāṅga sūtrīyādhyāya, Aṣṭaṅga sūtrīyādhyāya and *Dviganīyādhyāya.*

In the *Bijotpattisūtrīyādhyāya*, there is a reference to a conference of the sages which was held in the *Caitraratha* forest. The sages under the leadership of *Bharadwāja* assembled for a conference and asked *Maharṣi Parāśara* to give an account of the herbs and plants that were beneficial to the mankind[29]. The verse describing the event is quoted here:

Ete kṣitiruhāḥ sarve jagato hitakārakāḥ |
Vane Caitrarathe ramye sametāḥ puṇyakarmanaḥ ||
Bharadvājādayaḥ sarve ye cānye munisaptamāḥ |
Gñātumicchantāḥ papracchuḥ Parāśaram maharṣayaḥ ||
Pṛṣṭeṇa munibhiḥ sarvaiḥ Parāśaroabrabittataḥ |
Atharvāṅgam pravakṣyāmi Brahmoktaṃ
vṛkṣa vaidyakam[30] ||

Eng. Trans: In order to acquire knowledge about the plants beneficial to the world, performers of holy rites like *Bharadwāja* and other foremost

of the sages assembled in the beautiful *Caitraratha* forest (in the Himalays) and questioned *Parāśara* (to enlighten them).

From the above passage, it is beyond any doubt that wise and knowledgeable personalities in antiquities, in their pursuit of knowledge followed rational methods which are much similar to those followed by the scholars still now. The evidence of such a thematic dialogue in an academic assembly bears a full proof testimony to the rational mind and scientific attitude of the people of the day.

The whole speech by *Parāśara* in reply to the queries of the sages like *Bharadwāja* and others is a fascinating account of the development of plant science in India in the ancient time. The *Vṛkṣāyurveda* of *Parāśara* is quite different in nature and in all probability, the manuscript under consideration is the single one, bearing testimony to the existence of a thorough and comprehensive account of morphology of different parts of plants and germination, that befit modern terminologies. The hope for tracing any independent text of *Vṛkṣāyurveda* was given up by the scholars. G.P. Majumdar who edited and translated *Upavanavinoda* says in his introduction, 'the science of plant life, *Vṛkṣāyurveda* was a distinctly comprehensive science, a branch of which dealing with the construction and maintenance of gardens, is only referred to here. It is pertinent to enquire, where is this science — the *Vṛkṣāyurveda*? It must have been there at one time, but it is, like the *Dhanurveda or* the Science of Archery and many other sciences, practically lost. A reconstruction at the present state of our knowledge is out of the question; but we have significant references scattered throughout Sanskrit literature, from which it is possible to have a glimpse of it'[30].

The despair of this great scholar certainly was converted into optimism when he came to know of the discovery of the manuscript from N. N. Sircar and could communicate it to The Asiatic Society in 1950. This episode in the History of Botany is also very important to the scholars in this field. Now we may turn again to *Parāśara. Parāśara* in his reply to the queries of the sages, stated, 'I shall narrate to you the *Vṛkṣāvaidyaka* (i.e. *Vṛkṣāyurveda*) embodied in the *Atharva veda* and

as revealed by *Brahmā*, the creator. [Verse, 4]. The genesis of the plants, their nature and form as influenced by variation of land characteristics along with their care and treatment, and delineation of the essential features of the trees, shrubs, creepers, grasses, seasonal flowers (*Ṛtu puṣpa*) and annual plants (*Oṣadhi*) on the surface of the earth – what all the Lord *Caturānan* told me I shall now narrate the same' [Verse. 5].

In course of the discourse, *Parāśara's* text gives an exposition as to how the first living cell (*Ādibīja*) came into existence. It states that water transforms itself into a jelly like substance (*kalalaṃ*) within which a dense organic mass (*piṇḍasthānukaṃ*) is formed, which in course of time, being regulated (*vyuhan*) by terrestrial energy (*vasunā)* is converted into germ cell (*Bīja*).

N.N. Sircar states, 'In the *Vṛkṣāyurveda* cotyledons are termed *bījamātṛkā* and seeds having two cotyledons, *dvimātṛkabīja;* and one cotyledon, *ekamātṛkabīja.* These two terms are used in the description of the seeds and seedlings when they come out with one or two cotyledons (leaves) respectively'.

In the manuscript it is said:

Bījamātrikā tu bījaśasyam ।
Bījapatrantu bījamātṛkāyā madhyasthamādipatrañca ।
Mātṛkācchadastu tanupatrakavat mātṛkācchādanañaca
kañcukamityācakṣate. (Verse 5)
bījantu prakṛtyā dvibidhaṃ bhabati ।
ekamātṛkaṃ dvimātṛkañca ।
Tatraikapatraprarohāṇāṃ vṛkṣāṇāṃ bījamekamātṛkaṃ bhabati ।
Divipatra prarohāṇāntu dvimātṛkancā ॥ (Verse 6)

Parāśara then makes his discourse on the morphology of different parts of a plant viz. *patram* (leaves), *puṣpam* (flowers), *phalam* (fruits), *mūlam* (roots), *tvak* (cortex), *kāṇḍam* (stem), *sāram* (heartwood), *svarasam* (sap), *niryās* (excretions), *kaṇṭakam* (spines and prickles), *bījam* (seeds) and *praroham* (shoots). He also makes it clear that from the resemblances

and differences in the characters of these plant parts, the classification of plants is possible. The exact lines in the manuscript are:

Athāto vṛkṣaṅga sūtrīyamadhyāyaṃ byākhyāsyāma ityāha Parāśaraḥ ||

Iha khalu sarbeṣāṃ vṛkṣavallī gulmānāmaṅgapratyaṅgaiśca gaṇa samgraho yathodeśamabhinirde kṣyāmaḥ ।

Tatra vṛkṣavallīgulmānāṃ patrapuṣpa phalamūlatvak kāṇḍa sārasvara saniryāsasnehakaṇṭakabīja prarohaścetyaṅgāni bhabanti ।

Aṅgaiścetaiśca vṛkṣavallīgulmānāṃ sādharmyaṃ baidharmyaṃ tulyātulya prakṛtimabhisamīkṣya gaṇabibhāgamu padekṣyāmaḥ ।

English meaning: *Parāśara* said: I shall now discourse upon the *Vṛkṣangasūtrīyas* – dealing with the different organs of the plant. I will deal with classification of trees, creepers and shrubs on the basis of their different organs.

Thus the text of *Parāśara* contains elaborate morphological information on the plant parts. Accuracy of observation is astonishing.

It is logical to think that practical need led to the development of knowledge with regard to precise identification of plants and we find a system of nomenclature of plants based upon the salient morphological characters is an essential feature of various texts like *Caraka* and *Suśruta Saṃhitās.* It is interesting to note that the set of plant organs that comes under detailed consideration in this text are found exactly mentioned in the *Caraka-Saṃhitā* as plant parts for medicinal importance. The knowledge of plant science as embodied in this text is both extensive and intensive. The author makes an indepth study on classification and nomenclature of plants, their morphology, anatomy as well as physiology. In addition, the text describes quite in detail the modes and mechanism of germination of seeds. One unique feature of the text is that the author in the remote past conceived an idea of origin of life and first cell on the earth from water and soil, a concept that has bean established in modern days most scientifically by Oparin, a famous Russian biochemist.[32]

The present text records a fair knowledge of the internal organization of an ovary. The ovary is recognized to be divided into chambers (*puṭaka*) and to contain the placental tissue (*puṣa*) inside. Terms like *prapuṣa* and *triputa* are traditionally known. Sircar and Sarkar think that the derivative meanings of the terms seem to suggest that the internal structure of an ovary was noticed even at an early priod[33].

The text contains developed knowledge of the anatomy of the leaf and rudimentary concept relating to the fluid transporting system inside the plant. It is stated that there are innumberable cells in a leaf which serve as a store house of sap. The leaves take in air, heat and the colorific principles. High degree of precision in expressing scientific concepts is conspicuous by the use of proper terms like *rasasyaca-ādhārasca, pañcabhautic guṇa, anavasca, rañjaka kalābeṣṭitena* and other likely terms.

The meanings of some of the terms are like these:

Rasasyaca ādhārasca — store house of sap.

Pañcabhautic guṇa — elementary properties.

Patrapakṣam — leaf blade

Vṛntam - petiole

Patraśira — veins

Rasakoṣa — cells

Mārhi - rachis

Vistāra — tendril

Paṭṭika — leaf sheath.

In order to get a specific notion of the scientific researches on plants an example may be cited[34]. Regarding *rasakoṣa* it is said:

Patre rasakoṣastu rasasyāśraya ādhāraśca |

Khalu vṛkṣapatre rasakoṣāstū parisaṃkhyeyāḥ santi |

Te kalābeṣṭitena pañcabhautikaguṇa-samanvitasya rasasyā śayaśca |

Ete rañjaka yuktamaṇavaśca |

Kalā tu sūkṣmācchapatrakā yā bhūtoṣmāpācitā kalalādupajāyate |
Āśaya ādhāraśceti |

English Translation: The leaf cells are the reservoirs of the fluid. The cells are also called *aśaya* which means a receptacle. A leaf is made up of innumerable cells, each being surrounded by a membrane (*kalā*), containing the fluid constituted of the five elements of the *pañcabhautic guṇa*. Cells are microscopic (*aṇavaśca*) and contain a kind of coloured substances. The membrane of the cell is fine and transparent. It is derived out of the *kalalaṃ* (jelly like substance) as a result of the metabolic changes under the influence of the heat energy (*bhūtoṣmā*).

The information contained in the verses just mentioned above is a clear proof of acquirement of knowledge of the botanical scientists of the past. The accumulation of knowledge in sciences is of course an endless process. That *Vṛkṣāyurveda* developed steadily by the efforts and observation of the scholars in this field is merely a fact. More examples may perhaps jumble our historical discourse. But the whole content in the present text leaves no doubt that the ancient people had made a long headway in this branch of study.

Arbori-Horticulture: The science of arbori-horticulture developed during this period as a distinct discipline, though fundamentally it is a part of the *Vṛkṣāyurveda*, it deals with the construction and maintenance of gardens and parks for health, recreation and enjoyment of the public. The existence of this science in a rudimentary form can be traced to the *Ṛgvedic* times.

With the emergence of the state system, the concept of public parks and pleasure gardens took a concrete shape. Government's initiative is indicated in the *Arthaśāstra, Kāmandakinīti* and *Śukranīti*.

In the *Arthaśāstra* it is clearly mentioned — A forest should be provided with only one entrance, rendered inaccessible by the construction of ditches all round, with plantations of delicious fruit trees, bushes, bowers and thornless trees, with an expansive lake of water, full of harmless animals and with tigers, beasts of prey, male and female

elephants, young elephants, and bisons — all deprived of their claws and teeth — shall be formed for the king's sports[35].

According to *Vātsyāyana,* all big houses and palaces of kings had a pleasure garden. It is said: *Tatra bhavanamāsannodakaṃ vṛkṣavāṭikāva-dbibhakta karmakakṣaṃ dvibāsagṛhaṃ kārayet* (*Kām.*, Su., IV 4. p. 55).

The instruction for erecting *vṛkṣavāṭikā* with source of water is extended in the verse[36].

In the *Śukranīti,* the requisite knowledge of the superintendent of parks has been defined. It is said, 'The superintendent of parks and forests is he who knows of the causes of growth and development of flowers and fruits, who knows how to plant and cure the trees by administering proper soil and water at the suitable time, and who knows of their medicinal properties. (*Śuk.*, II. 317-319, p. 80).

Śukrācārya calls the superintendent as *Ārāmādhipati* which corresponds to superintendent of Botanical Gardens of modern times. This officer in charge of the forests as well as parks had to know all the ins and outs of plant life[37].

The author also mentions the functions of the gardener. The gardener is to collect flowers and fruits after having duly nourished the trees with care. He is also entrusted with the duty of collecting taxes.

From the text it appears that some fruit and flower gardens were built and maintained at the initiative of the government[38].

In the *Rāmacarita, Sandhyākaranandi* gives a glowing description of the city of *Rāmāvatī* which was decorated with pleasure gardens and with vegetable and fruit gardens as well. Verse 12 in Chapter III tells us:

Paramabirala kandābalimayamabirala kalakaṇṭha kūjanmukham ।

Pṛthula kuca śrīphalakampanasahitaṃ lolamañjulavalīkam ॥[39]

English Translation: *Varendrī* (was) ownig the good pleasure garden containing the bulbous roots, bread fruit trees, *bilva* and jack fruit trees and the entrance being reverberated with the coos of cuckoos and ornate

with nimble and delicate creeper. Verse 13 too in the same Chapter also echos the same tune. Glowing description of the garden and the parks is given by *Sandhyākaranandī*. The garden was full of birds, deer (belonging to the kandala type) and humming bees. By sweet-smelling breeze and nagaranga trees the garden surpassed the beauty even of the paradise of Indra[40].

Thus, we find that arbori horticulture was a long known practice in India. The construction of a garden and its dedication to public use is mentioned as early as in the vedic period. (*R.V.*, III, 8. 11).

Though the *Śukranīti* is of much later date, we find, apart from pleasure gardens adjoining a dwelling house, there were parks and pleasure gardens which came to be regarded as important features of the social life in ancient India. The art of arbori-horticulture gave rise to special classes of skilled artisans who were given patronage and protection by the State. The artisans used to construct parks, artificial forests and pleasure gardens. The parks were meant for health, recreation, enjoyment etc. This is clearly mentioned, 'the planting, grafting and preservation of plants constitute an art.' (*Śuk.*, IV. III,144. p. 157).

It it is already mentioned that *Vātsāyana* tells of *vṛkṣavāṭikā* or *puṣpavāṭikā* and gives direction for making gardens attached to the house. The house that the *nāgaraka* builds for his residence shows his taste and love of beauty. The house is to be built in close proximity to a supply of water and is divided into two parts. There is a number of rooms, each set apart for its special purpose and attached to the house there must be a garden with wide grounds, if possible, where flowering plants, fruit trees and kitchen vegetables can grow. The verses relevant to arbori-horticulture are quoted here to have a glimpse of the general concept of the contemporary people regarding the utility of developing the practice of garden culture. It is clear instruction to the house mistress. She is to procure seeds of kitchen vegetables and medicinal herbs. The relevant verses are:

Paripūtesu ca haritaśākavaprāniksū stambāñjīrakasarṣpājamoda śata puṣpātamāla gūlmāṃśca kārayet (*Kām.*, III. 1.6.p.113).

English Trans: In the even and stone less ground green vegetables, sugar-cane cumin, *jiraka, sarṣapa, ajamoda, śatapuṣpā, tamāla* and bamboo should be produced.

Regarding flower garden *Vātsāyana* suggests:

Kubjakāmalaka mallikā jātī kuraṇṭaka navamālikā tagara nandyāvartta jabā gūlmāna nyamśca bahupuṣpān vālakośīraka pātālikāṃsca vṛkṣavātikāyañca sthaṇdilāni manogñāni kārayet (*Kam.*, 7., p. 114).

The next quoted verse is related to green vegetables:

Mūlakāluka pālaṅkī damanāmrātakairvāruka
trapusavārttāku kuṣmāṇḍ ālabu sūraṇa śuka nāsā svayaṃguptā
tilaparṇikāgnimantha-laśuna-palāṇḍu-prabhṛtīnaṃ
sarbbauṣadhīnāñca vījagrahaṇaṃ kāle vāpaśca ॥ (*Kam.*, 29, p.116).

That the women possessed a good deal of knowledge is evident from the text. The garden should be in charge of the mistress of the house. She is to duly procure seeds of common kitchen vegetables and medicinal herbs. Thus it is evident that the house wives bore the responsibility of producing a number of vegetables which constituted the everyday dishes.

Verse 29 mentions a number of vegetables to be produced. These are *mūlaka, trapusa, āluka, pālaṅkī*, damanaka, *āmrātaka, ervāruka, vārtāka, kuṣmāṇda, alāvu, sūraṇa, śukanāsa, svayamgupta, tilaparṇika, agnimantha, laśuna, palāṇḍu* and such others. The direction is also given as to how greens and vegetables are to be reared in specially prepared beds, sugar cane in clumps, stunted shrubs of mustard, *jīraka, ajomoda, śatapuṣpa* and similar herbs in patches, and the dark *tamāla* trees in groves. The flowering plants comprise *kubjaka, āmalaka, mallikā, jāti, kuraṇṭaka, navamallikā, tagara, nandyāvarta, jabā* etc.; the shrubs include *bālaka, uśīra* and other grasses which yield fragrant leaves and roots. The garden is also to be provided with bowers and vine groves with raised platforms here and there for rest and recreation. A swing is to be

fitted on a spot well guarded from the sun by a leafy canopy. The text speaks indeed of an abundance of various flower plants to be artfully arranged, here and there. It is said —

Svāstīrṇā preṅkhādolā vṛkṣavāti kāyāṃ sapracchāyā sthaṇḍilapīthikā ca sakusumeti bhavana vinyāsaḥ | (*Kam.*, 15, p. 56). Like all the texts dealing with *Vṛkṣāyurveda* or the art of gardening, *Kāmasūtra* also gives emphasis on the sources of water and hence the suggestion in it — *kūpaṃ vāpīm, dirghikaṃ* ba *khānayet* i.e. a well or tank, large or small, should be excavated (in the middle) (*Kam.*, 16, p. 114). Thus arbori-horticulture became a part and parcel of city life and domestic life in the past.

An interesting corroborative evidence regarding the horticultural knowledge of the women in the past is furnished by the *Deopārā inscription* of *Vijayasena*[41]. The translation of the relevant verses runs thus: through his grace the *Brāhmaṇas* versed in the *Vedas* have became the possessors of so much wealth that their wives have to be trained by the wives of the town people (to recognize) pearls, pieces of emerald, silver coins, jewels and gold from their similarity with seeds of cotton, leaves of sāka, bottle-gourd flowers, the developed seeds of pomegranates and the blooming flowers of the creepers of pumpkin gourd respectively. From the above quoted portion of the said inscription, one thing is clear that the women had to bear the responsibility of supervising the kitchen gardens attached to their houses and thereby they developed practical knowledge in this branch of science[42]. This cultural practice was a special area of interest of the women in the past and they were traditionally associated with this area of scientific activities[43]. In the *Up-van.* there is a distinct section on 'construction of a garden house'. *Up-van.* constitutes a chapter of the encyclopaedic work *Śāraṅgdhara Paddhati* dealing with a variety of subjects along with arbori-horticulture.

The construction of a garden and its dedication to public use is mentioned as early as in the Vedic period we know. In the *Gṛhyasūtra* of *Sāṅkhāyana,* there is mention of a Vedic ceremony — 'the consecration of a garden'. The *Matsyapurāṇa* also enjoins that 'some space should be

left all round the house. The front is not to be covered with trees, in a building but the back should be so covered with them. Apart from the pleasure gardens adjoining a dwelling house, the parks and public gardens used to feature the social life in Ancient India. In the *Up-van.* the construction of a garden is termed as *Upavana — prakriyā* . There are some similarities in the process of construction of the garden described in differents texts. Verse 83 of *Up-van.* has a striking similarity with the verse 15 in the Chap. IV of the *Kāmaśutra.* It is said, one should make a swing out of the strong creepers attached to the branches of two trees, fit for a couple to sit (*Up-van.*, 83, p. 75).

There are provisions for swing, artificial but fine cave decorated with branches of trees, leaves and creepers, peacocks, rows of trees, ponds of transparent water, steps to the lake, pleasure-boats and flower plants in the pleasure garden.

A pleasant picture is drawn in the following verses — 'In places one should construct artificial lake with such eye-delighting water in it that the reflection of the moon-beams in it causes the illusion of a garden in water' (*Up-van.*, 89. p.76).

'One should plant trees bent down under the weight of sweet flowers on all sides of the white and well ventilatd houses as white as the peak of the Himalayas-built inside the artificial lake referred to above. And in places of the garden one should construct circular seats as white as marble, and should make bowers of plantain trees in places where there is gentle breeze'. (*Up-van.*, 90 p.76).

'In places of the garden deep wells, paved on all sides with stones with sweet water in it should be dug with the water of which all the trees of the pleasure garden may be well watered' *(Up-van.*, 91. p.76). A very interesting information is obtainable from the verses 92 and 93. They bear a testimony to the concern of the people for getting pollution free water. This is of course an indication to rational and scientific thinking. How much the method is full proof, is to be experimented. Concept of pollution of water and its remedials are evident in the following verses:

'If the water of the well be polluted, and become pungent, bitter, tasteless, salty or malodorous, *añjana, musta, uśīra, nāgakeśara, kosātaki,* powdered *amalaka* together with *katakaphala* should be thrown into it; and this will make the foul water transparent, tasteful and fragrant, and in addition will confer on it many other good qualities' (*Up-van.*, 92-93, p.77). Consciousness for utility of pure water and different vegetal remedial measures as prescribed, are remarkable achievements of Indian people in the past.

Horticultural Wonders

Continuous trials had been going on since the ancient times to improve the qualities of fruits as well as creating some botanical uniques.

We see in the *Upavanavinoda* the use of clarified butter milk and honey to improve the sweet taste of *vilva* with scanty number of seeds. Creation of botanical marvels is named in the text as *Vicitra Karaṇam.* The botanical marvels are:

A tree bearing scentless flowers may be converted into tree bearing fragrant flowers by applying decoction of dhava and khadira barks and besmearing it with sandal dusts and then fumigating it with clarified butter and frankincense (*Up-van.*, 196, p. 85).

By applying barley, sesamum, *niśā* and powdered bark of *palāśa* tree to the root of a cotton tree, fibers of red colour like burning fire may be produced (*Up-van.*, 197. p. 85). Again fibers of yellow colour as the feather of a *Śuka* bird may be produced by the application of *śālmali* barks, turmeric, indigo, *triphalā, kuṣtha and rock salt and wine* (*Up-van.*, 198, p. 85).

Blue fibres also may be made with the paste made of *mañjiṣṭhā, tila, yava, pitasāra*, leaves of *jivanti,* powdered *manaḥśilā* mixed with milk applied to the root of a cotton tree (*Up-van.*, 199. p. 85).

Thus by the application of decoction produced from variant herbal ingredients and minerals to the cotton root, fibres of different colours can be procured.

There are also provisions for producing flowers out of season, fruits without any seeds.

Ripening of fruits may be delayed. Speedy sprouting and fructification are said to be possible by adopting some measures as suggested in the text. Colours of water lily may be changed, and even the text claims that the seeds of water lily may sprout as *karavīra* trees if the seeds receive a special treatment.

Different methods are prescribed to improve the size of gourd, brinjal, *patola* and such other plants.

There is a verse in the text which indicates that a plantain tree may bear pomegranate fruits if the tree is treated with infusion of the blood and fat of boar and *ānkola* oil. Castor seeds if treated likely, may give birth to *kārañji fruits.*

Even *nimba* fruit is said to develop sweet taste if it is treated with paste made up of *viḍaṅga, yaṣṭimadhu,* molasses and milk. Among the botanical marvels, the art of 'bonsai' is very important. It is said 'If one digs a pit in the ground with bricks all around, 4.5 cubits deep and plants a tree in it (pit), it (the tree) always remain dwarfish and bears flowers and fruits (*Up. van.*, p. 88).

Sūrapāla's vṛkṣāyurveda is more or less identical with the Upavana. *Sūrapāla* says, 'If a tree is planted and grown faithfully with efforts by a person, in a pit as deep as man's height and properly covered from inside with new bricks it blossoms even in a dwart condition (*Su. Vṛ.*, 261, p. 58).

The author of the *Viśvavallabha* says: Dig a pit deep enough for a man-height. Cut it off from the rest of the soil by casing its walls internally with bricks on all sides. The tree planted in it bears fruits and flowers even as it is dwarf, always being a source of astonishment to the world (*Viś-va.*, 14. p. 88). In the present days 'bonsai culture has important economic prospect due to decorative value. People with aesthetic sense are ready to spend a lot for collection of miniature trees with all the characteristics of grown up trees. Thus different botanical

marvels have been described in different texts like the Upavana, *Surapāla's* text and the *Viśavallabha.*

Lokopakāra also contains prescribed formulas for bringing changes in the quality, size, taste, smell in the fruits like mango, plantain etc. (Loko. 25, 26, 27, 28, 39, p. 25). Different types of flowers with a common rhizome can be produced with special treatment. Art of grafting is also described in the *Lokopakāra* (*Loko.*, 22, 23, p. 25). Thus ancient Indians' knowledge on different aspects of plant life is clearly evident in a number of texts.

References

1. Sadhale, N., *Surapāla's Vrikshayurveda* (Eng. trans., Science of Plant Life by *Surapala*), Asian Agri-History Foundation, Secunderabad 1996, p. 36.
2. *Ibid.*, p. 45.
3. *Majumdar, G.P.* (ed. and trans.) *Upavana-vinoda* (chapter in the *Śārañgadhara Paddhati*, 13th Century A.D.). Indian Research Institute, Calcutta, 1935. pp. 71-72.
4. Sadhale, N. (Trans.) *Viśvavallabha by Cakrapaṇi Miśra* (*Dear to the world: Science of Plant Life*). Asian Agri-History Foundation, Secunderabad, 2004. pp. 70-71.
5. *Ibid.*
6. *Op. cit.*, N. Sadhale, *Vṛkṣāyurveda*, p. 45-46.
7. *Op. cit.*, Majumdar, G.P. *Upa-van*, p. 72.
8. *Op. cit.*, N-Sadhale, *Viśvavallabha*, p. 35.
9. *Ayangarya, V.* S., (Eng. Trans.) *Lokopakāra* (by Chavundaraya 1025 A.D.), Agri-History Bulletin No. 6., Asian Agri-History Foundation, Secunderabad, 2006, p. 3. **Note:** Halagannaḍa-Old Kannaḍa language; Hosagannaḍa-current Kannaḍa language.
10. *Ibid., commentary by N. Sadhale and S. Dave*, pp. 68-69.
11. *Op. cit.*, Ayangarya, V.S. p. 3.
12. *Ibid.*

13. *Op. cit.,* Majumder G.P. *Up-van.,* p. 75.

14. *Ayachit, S.*M. (Eng. Trans.) *Kashyapiya Krishisukti* (A Treatise on Agriculture by Kashyapa), Bulletin No.4, Asian Agri-History Foundation, Secunderabad, 2002, pp. 76-83.

15. Sharma, R.S., *Indian Feudalism,* Macmillan India Limited, Madras, 1980, p. 204-205.

16. Nene, Y.L. (ed.) *Glimpses of the Agricultural Heritage of India,* Asian Agri-History Foundation, Secunderabad, 2007, p. 138 (GAHI).

17. Chattopadhyaya, B.D., *Studying Early India: Archaeology, Texts and Historical Issues,* Permanent Black, Delhi, 2003, p. 225.

18. Apte, V.S., *The Student's Sanskrit English Dictionary.* Motilal Banarsidass Publishers Pvt. Ltd., Delhi, 2000.

19. *Op. cit.,* Nene, Y. L. p. 320.

20. Majumdar, G.P. *Vanaspati: Plants and Plant Life as in Indian Treatises and Traditions,* Calcutta Unviersity 1927, pp. 30-31.

21. (a) *Khanar Bachan,* Akshay Library, Collected by S. Choudhury, Kolikata; (b) *Khanar Bachana,* Vattala edition, Calcutta.

22. Sircar, N.N. *An Introduction to the Vṛkṣāyurveda of Parāśara,* Journal of the Asiatic Society of Bengal. Vol. XVI. No.1. 1950 pp. 123-139.

23. Kanjilal, D.K., *Catalogue of Sanskrit Mss in the Sahityasabha of Coochbehar,* Sahityasabha, Coochbehar, 1977.

24. Sircar N. N. and Sarkar, R., *Vṛkṣāyurveda of Parāśara,* Sri Satguru Publications, Delhi, 1996, p. ii-iii.

25. *Ibid.*

26. Majumdar, G.P. *History of Botany and Allied Sciences (Agriculture, Medicine, Arbori-Horticulture in Ancient India)* (c. 2000 B.C. to 100 A.D.), in D.P. Chattopadhyay (ed.) *Studies in History of Science in India,* Vol. I, Editorial Enterprises, New Delhi, 1982, p.375.

27. Mookerji, R. K., Education in R.C. Majumdar (ed.) *The Age of Imperial Unity,* Bharatiya Vidya Bhavan, Bombay,1990, p. 588.

28. *Op. cit.,* Sircar, N. N. and Sarkar, R., p. XVII.

29. *Op. cit.,* Sircar, N. N., pp. 125-126.

30. *Op. cit.,* Majumdar, G.P. *Upavana-vinoda,* pp.1-2.

31. *Op. cit.,* Sircar and Sarkar, XIX.

32. *Oparin,* A. I., *The Origin of Life on Earth,* Academic Press, New York, 1957.

33. *Op. cit.,* Sircar and Sarkar, p.xxiv.

34. *Ibid.,* p. 21, 29.

35. Shamasastry, R., *Kauṭilya's Arthaśāstra,* Mysore Printing and Publication House, Mysore, 1961, p. 48.

36. *Op. cit., Kāmasūtram,* p. 55.

37. Sarkar, B. K., *The Sukranīti,* Oriental Books Reprint Corporation, New Delhi, 1975, p. 80.

38. *Ibid.,* p. 81.

39. Basak, R. G., *Gauḍakavi Sandhyakara Nandi Birochita Ramacarita,* General Printers and Publishers Ltd. Kolikata, 1953. p. 79.

40. *Ibid.,* 80.

41. Majumdar, N.G. (ed.) *Inscriptions of Bengal,* Vol. 3, Varendra Research Society, Rajshahi, Bengal, 1929, p. 54.

42. Bagchi, A., Involvement of women in some scientific activities in ancient India in I. Sarkar (ed.) *Women in Changing Society,* Serial Publications, New Delhi, 2008, p. 63.

43. Bagchi, A.,Vignan charcha o prachin bharatiya nari—ekti samiksha, in S. Chattopadhyay (ed.) *History of Human Development in India* (in Bengali), New Alipur College, Kolkata, 2007, p. 36.