KNOWLEDGE OF TAXONOMY, ANATOMY AND PHYSIOLOGY OF PLANTS IN SOME SANSKRIT TEXTS OF ANCIENT INDIA

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Abstract

The Vedic Indians developed an intimate relationship with the plant kingdom. They used to prepare various beneficial drugs through processing the roots, barks, leaves, flowers and fruits of the plants. The usefulness of various plants has been enumerated in the Atharva Veda, Caraka SaØhitÂ, Sushruta SaØhitÂ etc. The environmental awareness of Indian seers, right from the Vedic period, was remarkable and commendable. They had enumerated water, air and plants as the basic foundations, which ecological balance stands upon and which sustain all living beings.

Materials for this treatise have been collected from a few Sanskrit works, selected at random. Published essays and books, authored by modern scholars and research workers have also been consulted. The data, thus collected from various sources, have been furnished under the following heads only- (1) Origin of Plants (2) Taxonomy (3) Morphology (4) Anatomy and (5) Plant Physiology.

On the basis of the data presented in the following pages, it may be said that Sanskrit texts of ancient India contain a rich treasure of botanical information. We believe, further endeavours will be made by scholars and researchers to bring to light new materials on this subject and other branches of science and this valuable treasure of wisdom will be utilized by future generations for the welfare of mankind.

Introduction

It is generally believed that although the Indian intelligentsia in ancient times made remarkable contributions in various branches of learning including art, music, literature, philosophy, political thoughts and allied subjects, in the field of science they made very little contribution or no contribution at all. This alleged apathy for the study of science is attributed to over emphasis on religion and philosophy, which is thought to have resulted in a culture of other worldliness. This erroneous impression gained such a wide acceptability amongst the learned people that even an astute scholar like Keith was prompted to remark-"In the great period of Sanskrit literature, at any rate, experimental science was at a low ebb, and little of importance was accomplished in those fields in which experiment is essential." Dutta (1978;348).

Energetic endevours, undertaken by a number of schools and researchers in recent times, however, have brought to light convincing evidence that even in the field of science and technology the contribution of ancient Indian genius is by no means negligible. The scholars of ancient India researched into various branches of science and technology. Available literary evidence, found in Sanskrit texts bear testimony of the profoundity of their knowledge, the depth of their insight and the accuracy of their observations.

In the field of plant-science too, ancient Indian scholars left the imprint of their perseverance and insight. The Vedic Indians developed an intimate relationship with the plant kingdom. They used to prepare various beneficial drugs through processing the roots, barks, leaves, flowers and fruits of the plants. The usefulness of various plants has been enumerated in the *Atharva Veda, Caraka Saṁhitā, Sushruta Saṁhitā* etc. The environmental awareness

of Indian seers, right from the Vedic period, was remarkable and commendable. They had enumerated water, air and plants as the basic foundations, which ecological balance stands upon and which sustain all living beings.

त्रीणि छन्दांसि कवयो वि येतिरे पुरुरूपं विश्वक्षणम्।
आपो वाता ओषधयस्तान्येकस्मिन् भुवन अर्पितानि।।

Atharva Veda 18.1.1 7

That is why plants were accorded a distinguished place of adoration in the *Vedas, Smṛti, Purāṇas* and also in literary treatises. A number of plant species and/or their parts were ascertained to be sacred and essential for the performance of particular sacrifices or other rituals. The *Agnipurāna* (ch.70) lays down rules of *Vṛkṣārāma-pratiṣṭhā* (installation ceremony of plant). In the appendix of Surapāla's *Vṛkṣāyurveda* we find a chapter, named *Vṛkṣotsava-vidhi* (rules for observing plant-ceremony). Ceremonies related to preservation and promotion of plant-kingdom, which are still observed by different ethnic groups dwelling the hills and forests of India, speaks of the impact of the urge for the welfare of plant-kingdom, inculcated in the minds of the common people by the prudent and sagacious sages of this land. The authors of Smrti literature provided for different degrees of punishment against the offenders, indulging in various cruel acts against the plants.

We do not find any single Sanskrit work, devoted exclusively to Botany. But the knowledge of different branches and various aspects of plant-science is borne out by the *Vedas.* the *Purāṇas,* the Great Epic and works on *Àyurveda, Kṛṣiśāstra, Dharmaśāstra, Arthaśāstra* ect. An appraisal of some texts, selected a random, shows that while texts like *Vṛkṣāynrveda* of Parāśara and Śurapāla, *Kṛṣi-Parāśāra, Upavana-Vinoda* etc. reflect on some specific areas of plant-science, texts belonging to other categories (like the *Vedas, Purāṇas,* epics etc.) are also rich in botanical data.

Materials And Method

Materials for this treatise have been collected from a few Sanskrit works, selected at random. Published essays and books, authored by modern scholars and research workers have also been consulted. The data, thus collected from various sources, have been furnished under the following heads only- (1) Origin of Plants (2) Taxonomy (3) Morphology (4) Anatomy and (5) Plant Physiology. Reference to the sources of information have always been made along with the data. The respective names of text, number of chapter(s) and sloka(s) have also been provided. An attempt has been made, wherever possible, to assess the status of knowledge in concerned areas of plant science by making comparison with accepted principles of modern plant science.

Origin of Plants

It has been observed by ParÂïara in his celebrated work entitled Vṛkṣāyureda (1.1.6) that the organic matters emerged from water, containing inorganic matters, under the influence of terrestrial energies. The idea of the origin of plants from the inorganic matters is also indicated in the *Taittirīya Upaniśad* (II.1): तस्माद्वा एतस्मादात्मन आकाशः सम्भूतः। आकाशद्वायुः। वायोरग्निः। अग्नेरापः। अद्भ्यः पृथिवी। पृथिव्या ओषधयः। ओषधीभ्योऽन्नम्। अन्नात् पुरुषः।

The text relates that from the very *Ātman ākāsa* (sky) emerged; from sky air, from air fire, from fire water, from water the earth, from the earth herbs, from herbs food and from food the man came to be. Similiar propositon is also found in the *Chāndogya Upaniṣad* (1.1.2) and the *Bṛhadāraṇyaka Upaniṣad* (VI.4.1).

The *Manu Saṃhitā,* (1.34-41) on the other hand, propounds the theory of Special Creation. According to this book, Brahma (the god of creation) created ten prajapatis (Lords of created beings). The prajapatis created seven Manus as also all the moving and stationary creatures including the birds and

beasts, insects and plants. The *Vāyu Purāṇa* (9.45;75.39-41;78.6-8), *Kūrma Purāṇa* (p. 7.32; p. 7.55), *Vāmana Purāṇa* (17.1-10) etc. also hold that different plants have orginiated from the limbs of some gods and goddesses.

Thus in Sanskrit works, we come across two different views about the origin of plants (i) the origin of living beings from a man under the influence of energy (ii) Theory of Special Creation, i.e., the plants, like other living creatures, were created by the Lord of creation or the gods.

It may be notices that most of the present-day scientists accept theory of biogenesis, but till before the Theory of Chemical Evolution, propounded independently by Alexander Oparin and J.B.S. Haldane in 1920, the concept of Special Creation was an universally accepted proposition among the scientists of those days.

Taxonomy

The word 'taxonomy' means the classification of living and extinct organism. A great variety of distinctions can be noticed in the forms, habits and other characteristics of plants. In spite of their having diverse froms, habits, food-value, taste and other properties, close similarities can be perceived between certain plants in respect of one or two items, mentioned above. These similarities are considered indicative of some relationship between a few plants and as such they are arranged into certain categories or classes or groups or divisions or in certain cases, into sub-divisions. Thus, from the days of yore, keen observers (of nature) in human society have been trying to classify the plants into various broad and small groups on the basis of similarities, observed amongst certain plants. In some Sanskrit texts also we perceive different modes of classification of plants. These classification are broadly based on - (a) habits (b) economic uses (c) habitats and (d) properties.

(a) Classification based on habits:

In the *ägveda,* the earliest work of Indians, terms like *Vṛksa* (tree), *Gulma* (shrub), *Bheṣaja* (medicinal plants) and *Latā* (creeper) occur frequenty in the mantras. In the same *Veda,* plants have again been divided into four classes on the basis of their varied habits-

याः फलिनीर्या अफला अपुष्पा याश्च पुष्पिणीः।
वृहस्पतिप्रसूतास्ता नो मुञ्चन्त्वंहसः।।

(Rgveda, 10.97.15)

(i) *Phalini*-bearing fruits.

(ii) *Aphala*-not bearing fruits.

(iii) *Apuṣpa*-devoid of flowers.

(iv) *Puṣpinī*-having flowers.

Almost similar classification is found in the *Atharva Veda* also (8.17.27) e.g., **पुष्पवतीः प्रसूमतीः फलिनीरफला उत।**

In the *Manu Saṃhitā* (1.46-48), the plants have been classified into eight groups, probably on their mode of growth and morphological characteristics. Manu defines the plants *(Udbhijja)* and broadly classified the same thus:

उद्भिज्जाः स्थावराः सर्वे बीजकाण्डप्ररोहिणः।

i.e. all the immovable creatures, which grow by piercing seeds and soil are called *Udbhijja;* these belong to two main groups-some shoot from seeds, while others develop from cuttings of bough, planted on the soil.

This general category of *Udbhijja* again has been divided into eight groups :

(i) *Oṣadhi*-Plants of this class bear many flowers and fruits, but die after ripening of fruits (1.46);

(ii) *Vanaspati*-plants which bring forth only fruits but not flowers (1.47);

(iii) *Vṛkṣa*-plants in which fruits develop from flowers (1.47);

(iv) *Guccha*-A bunch of many creepers, originating from the same root (1.48);

(v) *Gulma*-plants in which many branches of stem develop just from the top of the root (1.48).

(vi) *Tṛṇa*-grass plants (1.48).

(vii) *Pratana*-plants with tandrils (1.48);

(viii) *valli*-creepers twining round a tree or any other support.

According to Caraka again, plants are of four classes-

Caraka enumerates the different classes thus:

भौममौषधमुद्दिष्टमौद्भिदं च चतुर्विधम्।
वनस्पतिर्वीरुधश्च वानस्पत्यस्तथौषधिः।।

Caraka Saṃhitā-Sūtrasthāna 1.70,

Caraka enumerates the different classes thus:

(i) *Vanaspati*-same as in *Manu Saṃhitā*

(ii) *Vānaspatya*-same as *Vṛkṣa* in Manu.

(iii) *Oṣadhi*-same as in *Manu.*

(iv) *Virudha*-plants with tendrils; same as *gulma, pratana* and *valli* in *Manu.*

The verse, composed by Caraka, runs thus:

फलैर्वनस्पतिः पुष्पैर्वानस्पत्यः फलैरपि।
ओषध्यः फलपाकान्ताः प्रतानैर्वीरुधः स्मृताः।।

Caraka Saṃhitā-Sūtrasthāna 1.70,

Susruta's classification is like that of Caraka, with the only difference that Susruta uses the term 'Vṛkṣa' in place of 'Vānaspatya of Caraka'; cp. तासां स्थावराश्चतुर्विधाः-वनस्पतयो, वृक्षाः वीरुधः, ओषधय इति।

Suśruta Saṃhitā-Sūtrasthāna 1.29.

The Bhāgavata *Purāna* (iii.10.11-23) enumerates six different classes of plants:

(i) *Vanaspati*-Same as in Manu.

(ii) Oṣadhi-same as in Manu.

(iii) Latā-corresponding to *Valli* of Manu.

(iv) Tvaksāra-shrubs which do not entwine other plants and look like clumps.

(v) *Vīrudha*-trees bearing flowers followed by fruits.

(vi) *Druma*-trees bearing flowers followed by fruits.

The *Vāyu Purāṇa* again mentions six types of plants; they are: *Vṛkṣa, Gulmā, Lata, Vallī, Virudha* and *Tṛṇa.*

Cp. वृक्षा गुल्मलतावल्लीवीरुधस्तृणजातयः।
मूलैः फलैश्च रोहिण्यो गृह्णन् पुष्पैश्च जायते।।

Vāyu Purāṇa 8.157

The author of the same *Purāṇa* has given the names of seventeen types of grains, born of osadhi and again fourteen types of grains of the osadhi class. (*Vāyu Purāṇa, 8.150-155*).

The *Vṛkṣāyurveda* (I.1-11) of Parasara classifies plants into four principal groups; viz. (a) *Vānaspati* (plants whose flowers remain hidden) (b) *Vānaspatya* (plants which begets visible flowers and fruits (c) *Vīrudha*-Valli (creepers having tendrils) (d) *Gulma* or *Kṣupa* (plants with short branches and roots, but with no tendril). All these categories have been described in details in the text and have been further subdivided.

It is important to note that in modern classification of plants on the basis of habits, the following classes are recognised: (a) herbs (b) shrubs (c) climbers and (e) creepers. This modern classification is in conformity with the classification given by *Paāŕśāra.* This author of *Vṛkṣāyurveda* also makes a commendable and successful endeavour to provided an elaborate system of classification, based on the morphological characteristics of flowers and fruits. Actually, the author has enumerated nearly thirty flowering families (*ganiyam*) in the text (1.5.64-92). Sensarma (2003 : 8) opines that this effort is unique and deserves to be critically analysed by the modern scholars. Sensarma also says that in the history of classification Carolus Linnaeus (18th Century A.D.) was the first scientist who developed a system of classification of plants, primarily on the basis of their floral characters. [Banerjee Sastri, 2003].

Linnaeus, who made the pompous statement "God created plants and Linnaeus classified them", enumerated nearly 7,300 species of plants and

arranged them in accordance with their sexual system of classification. But a few centuries earlier, *Parāśara* accomplished the marvellous job in the form of enumeration of plant families and their classification on the basis of floral characters and this was no mean achievement.

(b) Classification based on economic uses

Human beings depend on the plants for food, shelter, garments, medicine, fuel and a number of other useful products. With the advancement of human civilization man's dependance on plants increased and efforts were made to identify the plants, having economic uses.

Kauṭilya's Arthaśastra (Kupyādhyakṣa Prakarṇa-2.17.38-4-12) affords a list of various forest produce and categorizes those on the basis of their respective economic uses under the follwing nine groups:

(i) *Sāradāru-varga* (timber yielding plants)

(ii) *Veṇu-varga* (group of reeds or bamboos)

(iii) *Valli-varga* (group of creepers)

(iv) *Valka-varga* (group of fibre-yielding plants)

(v) *Rajjubhāṇḍa-varga* (group of plants constituting raw materials for ropes)

(vi) *Patra-varga* (plants used for writing upon or as utensils)

(vii) *Puṣps-varga* (plants which yield dye from flowers).

(viii) *Auṣadha-varga* (group of medicinal plants)

(ix) *Viṣa-varga* (group of poison-yielding plants)

Sensarma (2003 : 9) remarks that 'Kautilya's classification of plants is more in line with modern economic botany.'

Caraka classifies the plant products on the basis of their respective food value (*Sūtrasthāna, 27.4-304*):

(i) *Śukadhānya-varga*-Those corns which have husk. These have been subdivided into eleven varieties: e.g., sali, vrihi, yava, godhuma etc.

(ii) *Śamīdhānya-varga*-Twelve kinds of corns viz., *mudga, māsa* etc.

(iii) *Śāka-varga*-18 varieties of vegetables belong to this class.

(iv) *Phala-varga*-various type of fruits, having medicinal qualities.

(v) *Harita-varga-adraka (Zingiber officinale), mulaka (Raphanus sativus), Palanduand Lasuna* (Allium *cepa* and *Allium sativum*) etc. belong to this group.

(vi) *Ikṣu-varga-Ikṣu, Vaṁśaka, Guda* etc.

(vii) *Àharayogi-varga*-Oils of sesamum, mustard etc. belong to this class.

Susruta in his *Sūtrasthāna* has divided plant products into six broad classes, on the basis of their food-value. These are-(i) *Śāli-varga i* (ii) *Kudhānya-varga* (iii) *Phala-varga* (iv) *Śāka-varga* (v) *Puṣpa-varga* and (vi) *Kanda-varga* [Suśruta *Saṁhita, Sūtrasthāna,* 46.1-52,139-312]

Suśruta has classified these plant-products into various sub-divisions and has given an extensive list of such produce.

Classification based on habitat

Parāśarā in his Vṛkṣāyurveda (1.2.3-17) has classified the plants into three broad classes on the basis of their normal habitats, viz., (i) *jāṇgala* (ii) *anūpa* and (iii) *miśra*. The classification on the basis of habitats as found in *Caraka Saṁhitā (Kalpasthāna,* 6-9*)* and *Susruta Samhita (Sūtrasthāna,* 35.42*)* is exactly the same; but, in these two works the word *sādhārana* has been used in place of *miśra* of the *Vṛkṣāyurveda*.

(i) *Jāṅgala* (literally means dry place)-this type of habitat is described as a tract almost like a desert with very little vegetation and limited water resources. Caraka says that it is a region of open spaces where a steady and dry wind blows and has few rivers and rivulets. The soil is composed of mainly dry and rough sands.

The *Vṛkṣāyurveda* and *Caraka Saṃhitā* has named the plants that grow in this region, viz., *khadira, asana, dhava, tinisa, śallaki, sāla, vadari* etc.

(ii) Anūpa (literally means marshy or watery region)-Parāśara states that this type of habitat abounds in rivers, streams and lakes. The soil is clayey. Caraka says that this class of region is very difficult to traverse because of its network of rivers. The land is swept by cold air and there is no mountain in this region. Normally, the following plants abounds in this region: hintāla, tamāla, kadali, vetasa and bamboos.

(iii) Miśra or Sādhāraṇa (literally means mixed or ordinary or normal)-According to Parāśara, this region is composed of mixed features of *jāṅgala* and *anūpa* regions. The soil is grey, red or black; the atmosphere is neither too dry nor too moist. The land is fertile and abounds in various types of trees, herbs creepers and shrubs.

In this connection, it may be mentioned that some *purāṇas* like *Vāmana Purāṇa* (85.16-17), *Brahma Purāṇa* (chaps.36,42,68) etc. enumerate the following plants as *jalaja* (aquatic): *Kahlāra, Kamala, Kumuda* etc.

It deserves to be mentioned that in modern plant-science too, plants are classified on the basis of their habitat, as follows:-

(a) Aquatic and wet land dwelers-those which are found in water or in marshy areas.

(b) Terrestrial-those which are found on land.

(c) Xerophytes-those which are found in deserts.

(d) Lithophytes-those which are found on rocks.

(e) Epiphytes-those which are found on tree-tops.

Classification according to properties

Caraka, in Sūtrasthāna (ch.4) broadly divides the plants into two categories viz., (i) *Virecana* (purgative) and *Kaṣāya* (Astringent).

According to him, 600 species belong to the first class (*Virecana*) and 500 to the second (*Kaṣāya*). On the basis of medicinal qualities of plants, Suśruta has divided the entire plant kingdom into 37 classes (*gana*).

समासेन सप्तत्रिंशद्द्रव्यगणा भवन्ति।

(*Suśruta Saṁhitā, Sūtrasthāna,* 38.3)

The author furnished a detailed list of the ganas (groups) in the same chapter.

On the basis of taste, the *Matsya Purāṇa* (217.43-59,62-81) classifies the plants into five following groups (*gana*) :

(i) *Madhurāgana* (sweet)-*jīvaka, ṛṣabhaka, kakoli, āmalakī, kharjura etc.*

(ii) *Amlagaàa* (sour)-*dÂÅima, Âmr Âtaka, amlavetasa, vadari, bhavya* etc.

(iii) *Kaòugana* (pungent)-*pippali, cavya, citraka, kuveraka, sarsapa* etc.

(iv) *Tiktagana* (bitter)-*musta, candan, haridrā, dūrvā, pātali* etc.

(v) *Kaṣāyagana* (caustic)-*haritaki, āmalaki, vibhītaka, priyaṇigu, arjjuna* etc.

The *Vāyu Purāna* (78.9-11) divides the plants according to taste into two groups only, viz., *kaṣāya* and *madhura* (sweet). *Sūāmāka, hastināma, paṭola, agastyaśikhā* etc. are put in the kaṣāya group while nāgara, *dīrghamūlaka, sarjjaka, bhūstṛṇa* etc. are included in *madhura* group.

It may be pointed out here that in the 18th and 19th century, taxonomists based their classification mostly on morphological characters. In the 20th century, while morpholgy remained the prime criterion for classification, chemical constituents of plants, palynology, cytology etc. were also regarded as importnat consideration for classification of plants. It is important to note that in ancient works like *Matsya Purāṇa* and *Vāyu Purana* chemical characters like *madhura, kaṣāya, amla* etc. were considered as taxonomical characters.

Morophology

The term 'morphology' means the science dealing with the form and external structure of plants and animals. A few Sanskrit texts mention various external parts of a plant body. Majumdar (1986: 116-117) informs that different parts of a plant body finds mention in the *Ṛgveda* at many places. He also states that *Atharva-Veda* enumerates the following parts of

a plant-root, stem, flower and fruit. The *Mahābhārata* enumerates different parts of a plant body in two metaphorical verses (1.1.71-72). The text mentions five different parts of a tree, viz. *mūla* (root), *skandha* (trunk or stem), *śākhā* (branch), *puṣpa* (flower) and *phala* (fruit). The *Vishnu Purāṇa* (II.8.37-38) enumerates the following parts of a tree, which originate from the seed of a paddy; all these parts lay in potential state before the sprout comes forth. These parts are-(i) *mūla* (root), *nala* (reed or stalk), *patra* (leaf), *aṇkura* (sprout), *kāṇḍa* (stem), *koṣa* (bud), *puspa* (flower), *kṣira* (milky juice or sap), *taṇḍula* (rice), *tuṣa* (husk) and *kaṇa* (grain).

According to Banerji (1980) and Majumdar (1986), systematic accounts of the arts of a plant can be seen in the *Taittirīya Saṃhitā* and *Vājasaneyi Saṃhita*. According to these Vedic texts, plants comprise *möla* (root), *Tūla* (shoot), *Kāṇḍa* (stem), *valsa* (twig), *puṣpa* and *phala*. Besides these parts, the trees have *skandha*, *śākhā* and parṇa (leaf).

The *Vṛkṣāyurveda* (1.1.14) of Parāsāra mentions the following distinct parts of a plant body-*mūla*, *kāṇḍa*, *patra puṣpa*, *phala*, *tvak* (skin), *ṣara* (heart wood), *svarasa* (sap), niryāsa (exudation), *sneha* (fets and oils), *kaṇṭaka* (pickle), vija (seed) and *praroha* (sprout).

From the above discusion, it becomes clear that various Sanskrit works exhibit different approaches in determining the basic constituent organs of a plant. All the authors of those works, however, think that a plant has the following parts-*mūla*, *kāṇḍa*, *parṇa*, *puṣpa* and *phala*. In modern Botany, a plant is generally thought to consist of a total of five parts-three vegetative parts, viz., root, stem and leaf and two parts connected with reproduction i.e., flower and fruit. Thus, we may conclude that the basic concept about the constituent parts of a plant body, as occurring in Sanskrit texts of ancient India, is still functional.

Anatomy

The word 'anatomy' means the internal structure of animal or plant body. Sensarma (2003 : 12) opins that the study of this science advanced to a considerable extent during the Vedic period'. The *Bṛhadāraṇayaka Upaniṣad* (III. 9.28/1-28/3) compares a tree with the human body. The leaves of a tree have been said to be like the skin, the sap like blood, the innermost layer of the bark like the nerves, wood like the bone and the pith like the marrow (of man). Majumdar (1986 : 118) observes-"This is indeed far more detailed description than what we get in Theophrastus, who is regarded as the father of plant anatomy". It is heartening to note that our ancient people had such an elaborate knowledge about anatomy of plants much before 17th century A.D. when microscope, the basic tool for anatomical investigation, was invented.

Parāśara, in his *Vṛkṣāyurveda* (1.4.27) also gives an elaborate description of the internal structure of a leaf. According to him, the body of a leaf consists of many cells (*rasakoṣa*). The cell-wall is fine, transparents (*sūksmacchapatraka*) and derived from a jellylike substance (*kalalam*) through metabolic processes under the influence of heat.

This description is very much in line with the concept of modern plant anatomy. The cell, the cell-wall and the protoplasm (the jellylike substance) are the structural components of the plantbody.

According to Parāśara, the cell functions as the storehouse of the sap (*rasasyāśraya ādhāraśca*). The cell sap contains the properties of all the five basic constituents (*pañcabhautika guṇasamanvitah*) and colouring matter (*raṇjakayuktam*). Further, the reference to *tvak* (epidermis), *sara* (heart wood), *svarasa* (sap), *niryasa* (exudation) and *sneha* (fats and oils), as found in the work of Parasara, indicates the depth of anatomical knowledge.

Plant Physiology

Physiology consists in the science of functioning of living organisms. Banerji (1972 : 11) informs that *Guṇaratna*, in his commentary on *'Saḍdarśanasamuccaya'* opined that as human body is nourished by milk and

other articles of food, so also fertile land and water contribute to the nourishment of trees. Want of proper nutrition obstructs the growth and impairs the health of both human body and plant body. Ancient Indian scholars observed that it is with their roots, correspondig to human mouth, that trees take the water and that is why they are called *pādapa* (that which drinks with foot). The intake of food by the plants, the distrubution of food over their different parts; assimilation of food and the vital role played in the matter by wind-these have been beautifully described in the *Mahābhārata*.

The *Vṛkṣāyurveda* (1.7.3) of Parāśara also illustrates that the roots absorb the saps of six different tastes from the soil and transport the same to other parts of the plant. The text (1.7.13) further holds that the plant has a circulatory system consisting of *syandanī* (pulsators) and *śirā* (tubular vessels of the body). They are spread out all over the plant body like a net. Through this system the nutrient fluid goes to all the organs of a plant and is circulated both in the inward and outward direction.

According to present-day plant- science xylem and phloem constitute the vascular system of the plant. Water and mineral salts are absorbed by the roots, which are transported to the leaves through xylem. In the leaves plants prepare carbohydrates with the help of carbon-di-oxide taken from air and water, absorbed by the roots in presence of cholorophyl molecules, which capture energy from sunlight. In the Mahabharata (Śāntiparva, 178.18) we find:

तेन तज्जलमादन्तं जरयत्यग्निमारुतौ।
आहारपरिणामाच्च स्नेहो बृद्धिश्च जायते।।

The process of photosynthesis has been very nicely illustrated in the present verse. The prepared food materials are transported to different parts of the plant body through phloem. Thus xylem tubes and phloem vessels form a continuous network in the plant body for effecctive performance of ascent of sap and translocation of food materials respectively. This idea of present-day plant-physiology is exactly in line with the concept found in the Sanskrit text, which is conceived to have been compose several thousands of years ago.

Here we may quote another verse (*Mahābhārata, Śāntiparva*, 178.16) which even indicates something nearer to Dixon's Theory of transpiration pull of the ascent of sap.

वक्त्रेणोतपलनालेन यथोर्ध्वं जलमाददेत्।
तथा पवनसंयुक्तः पादैः पिवति पादपः।।

[As one draws water up through a lotus-stalk with the mouth, the plant, endowed with air, take water with its feet (roots).]

Consciousness of plants

Right from the Vedic period, our ancient people believed that the plants are living organisms. The *Atharvaveda* (6.44.1) holds that the trees enjoy sleep while standing : 'अस्थुर्बृक्षा ऊर्ध्वस्वप्रास्तिष्ठाद्' The *Bṛhadāraṇyaka* Upaniṣad says-"Though cut off by somebody, plants shoots forth from the roots as a newly born creature." Even if the plant, being cut off, dies, it again pierces through the seed and is born again." [3.9.284-5]

Parāśara's *Vrkṣāyurveda* says-

वृक्षः संज्ञो भवेदन्तः सुखदुःखसमन्वितः।

The *Manusaṃhitā* also makes similar observation, almost in identical language-

अन्तःसंज्ञा भवन्त्ये सुखदुःखसमन्विताः।

The *Bhāgavata Purāna* also holds that the plants have unmanifested consciousness and they feel pleasure or pain inside. [iii.10.19]

The *Matsya Purāṇa* refers to weeping (rodana) and smiling (hāsana) of plants as bad omens. 'weeping' is an expression of sorrow and 'smiling' is an expression of joy. Thus the Purana seems to suggest that the plants not only feel pleasure and pain but, they can also express their feelings.

In this connection Majumdar (1986) observes- "Plants have been regarded as living beings since Vedic times. A concise but clear discussion of the

existence of life in plants is given in the Māhābhārata. Further evidence is to be found in Guàaratna's commentary on the *Śukranīti,* Udayana's *Kiraṇāvali,* Śaṅkara Misra's *Upaskara* and the *Bhāgavata Purāṇa.*"

Conclusion

On the basis of the data presented in the preceding pages, it may be said that Sanskrit texts of ancient India contain a rich treasure of botanical information. We believe, further endeavours will be made by scholars and researchers to bring to light new materials on this subject and other branches of science and this valuable treasure of wisdom will be utilized by future generations for the welfare of mankind.

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