10. PLANT PROTECTION IN ANCIENT PERIOD – ITK – HARVESTING – THRESHING AND STORAGE

In the past when Indians were gaining knowledge on the prediction of rainfall, management of agriculture, farm operations, harvesting, and storage, nothing was known about plant protection. The only methods to protect the crop were prayers and mantras. It was believed that the crop is protected if the mantra was written with red lac-dye and tied to the crop. But it cannot be said that the people of that time were unaware of insects and other pests and their damage. Some of the pests (in Sanskrit) affecting crops were gandhi, Shankhi, Pandarmundi, dhuli, and shringari. It is certain that gandhi (offensive odour) is what is called today the gandhi bug (Leptocorisa varicornis F.); shankhi must be a snail (Pila sp.); and pandarmundi means white head which is the typical symptom of the attack of rice stem borer (Tryporyza incertulus Walker). It is certain that they knew the rice stem borer and its symptom of attack. Dhuli means powder and it is possible that this word must have been used for powdery mildew of wheat and barley. The word “shringari” in Sanskrit indicates something adorned with red colour and it is possible that the term was used for rust diseases.

Besides these pests, goats, rats, wild boars, pigs, deers, parrots, and sparrows were mentioned as destroyers of crops. In fact when the damage to crops due to different pests reached the economic injury level, they might have started thinking about plant protection and diverted their efforts to develop protection technology. It is significant that people at that time considered that plants and human beings have similar physiology. Therefore, they divided the diseases of plants into two categories: (1) internal; and (2) external. The internal diseases were those which were caused by “vata”, “pitta”, and “kafa” and external diseases were those which were caused by insects, birds, and weather. These categories can be attributed today to fungi,

bacteria, viruses, and nematodes-internal diseases; and insects, non-insect pests, frost, waterlogging, and drought-external diseases.

Information contained in Surapala's Vrikshayurveda , related to kinds of internal disorders observed in trees, causes and symptoms attributed, and remedies suggested.

Cause given	**Symptoms**	**Cause elaborated**	**Possible causes2**
Vata	Trunk slender and crooked; knots on trunk or leaves; hard fruits (less juicy and sweet); gradual defoliation; flower and fruit drop; generally yellowing of leaves and fruits.	Arid land on account of excessive supply of dry and pungent matters.	Underground mechanical barrier, leaf-galling insects; root-infecting fungi or ematodes;viruses ; saline or alkaline soils.
Pitta	Leaf yellowing; premature drop; decay of flowers and fruits	Occur at the end of summer if trees are excessively watered with bitter, sour,salty and strong materials	Viral disease; salinity in irrigation water; predisposal to blossom blight; fruit decays due to fungal/bacterial infections

Kapha	Fruit-bearing delayed and fruits are tasteless and ripen prematurely; oozing without wounds	Appear in winter and spring if trees are excessively watered with sweet, oily,sour or cold materials	Fungal gummosis / rot;nutrient deficiencies or toxicities ; excessive watering

Today integrated pest management (IPM) is considered a recent approach for plant protection but the so called recent approach was conceptualized and practised centuries ago in India. Some of the practices adopted in those days are given below.

Seed treatment : Seed treatment which is considered an important component of IPM to ensure better germination was given a lot of importance in ancient times. The seed was treated with milk, mustard, sesame-ash, and cowdung for better germination and protection against insect pests.

Fumigation : Fumigation methods were not as developed in those days as they are today but the concept of fumigation was prevalent. For example, diseases of cucurbits were controlled by smoking the bones of cow and dog mixed with the excreta of cat.

Field application : The plant protection appliances of the present era were not developed at that time; sprinkling of aqueous suspension and hand-dusting of various materials were used. For the control of insect pests several ancient recommendations are available. Some of them are as follows:

- Insects infesting trees can be removed by smoking a mixture of white mustard, black peper, asafoetida, vidanga (Embelia ribes), vaca (Zingiberzerumbet), and water mixed with beef, horn of a buffalo, flesh of pigeon, and the powder of bhillata (Semecarpus anacardium).

- Insects infesting creepers can be controlled by sprinkling water mixed with oilcake.
- Leaf-eating insects can be destroyed by dusting cowdung-ash and brick-dust.
- Trees are watered with cold water for 7 days to remove insects from the roots and branches.
- A wound caused by insects is healed if sprinkled with milk after being anointed with mixture of vidanga, sesame, cow's urine, ghee, and mustard.

A new term, eco-friendly pesticides, has been coined recently. In IPM more emphasis is laid on this term and botanicals are being used instead of chemical pesticides. In fact this is not new. Years ago several botanicals and other materials which have biocidal properties were identified and recommended by Surapala to control plant diseases. The famous "panchamula" (roots of five plants) which was commonly used at that time has antifungal, antiviral, antibacterial, and antifeeding properties. Likewise, mustard had been used for all kinds of diseases caused by "kafa". We now know that mustard causes antibiosis in insects; in addition it is antifungal and has nematicidal activity.

Some important products used in pest management during Ancient and Medieval periods in India.

Material	**Author/Period**	**Properties**
Root of vasika (Justicia adhatodaa)	Varahamihira (505-587 AD)	Soothing effect, insecticidal, antifungal, antibacterial, anthelmintic.

Branches and leaves of atimuktaka(Hiptage enghalensis)	Varahamihira (505-587 AD)	Leaf juice insecticidal; bark contains glucoside (hiptagin) and tannins `
Mustard (Sinapis alba = Brassica alba)	Surapala (1000AD)	Insect antixenosis and antibiosis; acaricidal; nematicidal; antifungal
Bidanga (vidanga) (Embelia ribes)	Surapala (1000AD) Someshwara Deva (1126 AD)	Anthemintic; antibacterial insecticidal
Ash	Someshwara Deva (1126 AD)	Dessicates insect eggs on seed; speeds up germination by softening seed coat through mild alkalinity; provides micronutrients
Sesame (Sesamum indicum)	Surapala (1000 AD)	Allelopathic to rice; insect repellent; insecticidal
Mahua (Madhuca spp.)	Surapala (1000 AD)	Insecticidal oil; piscicidal; antibacterial
Kusta (costus) (Saussurea lappa)	Surapala (1000 AD)	Insecticidal (repellents, anti-feedant); antiseptic
Bhillata (Bhallataka) (Semecarpus anarcardium	Surapala (1000 AD)	Insecticidal; antiseptic' termite-repellent;mildew moth-proofing of cloth anthelmintic; antibacterial
Cotton(Gossypium spp) seed oil		

Materials and practices that need our early attention

Milk and milk products : Milk and ghee have been used for centuries. Even buttermilk was found useful. About 40% of total aminoacids in milk are glutamate, leucine, and proline. Milk is reported to contain plant growth promoters. A recent report claimed that milk sprays induced systemically acquired resistance in chilli against leaf curl, a viral disease. Milk (10% aqueous suspension) also has been effectively used for controlling powdery mildews. Besides, milk has excellent sticker-spreader properties.

The aminoacid proline has been found to systemically induce resistance in plants. It stimulates production of antimicrobial phenolics. High amounts of endogenous proline increase contents of cytokinin and auxins. Besides milk, proline is present in the connective tissues of animals including fish.

Application of cowdung : Use of cowdung for dressing seeds, plastering cut ends of vegetatively propagating units such as sugarcane setts, dressing wounds, sprinkling diluted suspension on plants, and applying to soil has been indicated since the time of Kautilya (c.300 BC). Indian farmers continue to use cowdung in various ways, but the agricultural scientists have ignored its use for other purposes except manure.

Briefly speaking cowdung from the cattleshed is a mixture of dung and urine, generally in a ratio of 3:1. Cowdung consists of crude fiber, crude protein, and materials that can be obtained in nitrogen-free extracts and ether extracts. Cellulose along with lignin makes up most of the crude fiber; hemicellulose and pentosans (poly saccharides based on pentose sugars) are also present. Micronutrients too are present in cowdung. The urine portion of cowdung contains nitrogen, potash, and sulfur and only traces of phosphorus. The nitrogenous compounds excreted in fecal matter consist in part undigested or unabsorbed food nitrogen and

in part another fraction called metabolic nitrogen. The metabolic fraction comprises substances originating in the body such as residues of the bile and other digestive juices, epithelial cells from the alimentary tract, and the bacterial residues. In short, fecal residues comprise undigested fiber, debris from sloughed-off intestinal epithelium, some excreted products derived from bile (eg. pigments), intestinal bacteria, and mucus. There are more than 60 species of bacteria and over 100 species of protozoa encountered in the rumen of a cow. A majority of the bacteria are cellulose, hemicellulose, and pectin fermenters. The bile constituents are bile salts, bile acids, and bile pigments. Bile salts confer hydrophilic coat to otherwise hydrophobic droplets, thus acting as emulsifying agents. No bile salt is supposed to be present in the dung because these are reabsorbed through the intestine and are put back in the bile. However, in each such cycle (enterohepatic circulation) involving bile salts, a small part is lost through bacterial degradation in the feces as dyslysin which is the slimy material. Bile salts have antiseptic properties. Two chief bile pigments are bilirubin (reddish / golden yellow) and biliverdin (green). It is the biliverdin ($C_{33}H_{36}N_4O_8$) which is chiefly present in herbivorous animals and gives greenish color to the dung.

Materials recommended by Surapala to control tree disorders and their currently known properties.

Materials	**Properties**
Plant species	
Acorus calamus L.	Antibacterial
Brassica alba (L.) Rabenh/Sinapis alba L.(white mustard)	Insect antixenosis;antifungal;acaricidal; nematicidal;glucosinolate sinalbin “anti-insect” and “anti-nematode” allyl isothiosinate antifungal

Curcuma longa Koenig non L. Curcuma domestica Val. (turmeric)	Antioxidative curcuminoids; antimicrobial
Embelia ribes Burm. F	Anthelmintic; antibacterial; insecticidal (embelinbenzoquinone)
Emblica officinalis Gaertn. (triphala)2	Anthelmintic with other two species of triphala.
Ficus benghalensis L. (banyan)	Latex with good sealing property; tannin
Ficus glomerata Roxb.	Latex; bark 14% tannin; some Ficus spp. are antibacterial.
Piper nigrum L. (black pepper)	Oleoresin antibacterial/antifungal;alkaloid piperin is insecticidal.

Sesamum indicum L. (sesame)	Insecticidal and repellent; oil synergistic to pyrethrums; antioxidative lignins in seed; 17% protein; 800 mg per 100g calcium, phosphorous, and potassium; 14% iron (ash) - highest.
Solanum indicum L.	Fruits/leaves antifungal /antibacterial; glyco-alkaloid solasonine present.

Animal products and other materials

Ash	Particles hygroscopic; absorb moisture from insect eggs and spores; interfere with insect feeding; ash potassium interacts with surface fats.
Cowdung	With urine it is antiseptic; rich in bacteria which compete with pathogens; good medium for biocontrol agents; beneficial to Rhizobium and Azotobacter.
Fish meal	Rich in protein; releases aminoacids including proline.
Ghee	Same as animal fat
Honey	Antimicrobial; protects wounds in plants / animals; proline present; honeybee peptide apidaecin is antibacterial.
Liquid manure (kunapa)	Effects would include : healthy crop/tree; crop tolerance to abiotic stresses such as frost, heat, etc. as well as to insect pests and disease; high yields; high quality produce.

Harvesting and Threshing

Kautilya Arthasasthra states “Grains and other crops shall be collected as often as they are harvested. The threshing of different fields shall be in close proximity. In Sangam literature it is mentioned that paddy was removed from the stalks by beating them on ground or by making

the bullocks to tread on them. Cleaned paddy was collected, measured and stored in proper places. Sickles and swords were used for harvesting millet. For threshing, buffaloes were made to tread or men are used to tread ears with feet. Blackgram was threshed with sticks. Women considerably contributed to threshing and cleaning. A common vessel for measuring grain was referred as “ambanam”

Festivals were celebrated before the commencement of harvest and during the time of harvest. For threshing, Parashara mentioned a levelled threshing “pit” and installation of threshing pillar called “medhi” are mentioned. The wood for the pillar was obtained from a tree that produces milky sap, preferably by silk cotton, Ficus bengalensis, F. glomerata.

Measurement :

`Adhaka’ is wooden vessel made of mango, punnaga (Callophyllum inophyllum) is used to measure grains which is equal to approx. 11 oz or 3.5 Kg.