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ANCIENT FARMING METHODS OF SEED STORAGE AND PEST MANAGEMENT PRACTICES IN INDIA - A REVIEW

Shaila M. and Nafeesa Begum
Department of Botany and Seed Technology, Sahyadri Science College, Shivamogga Pin code: 577203, Karnataka, India
E-mail: shailamresearchscholar95@gmail.com, nafeesabegum30@gmail.com

ABSTRACT

Ancient Indian farmers evolved nature friendly farming systems and practices. Agricultural activities were designed to ensure ecological sustainability. India developed its own holistic scientific knowledge. It has a number of classical texts related to agricultural science. *Kautilya's Arthashastra, Patanjali's Mahabhasya, Krishi-Parashara, Varahmihira's Brhat Samhita* and *Surapala's Vrikshayur veda* are some of the manuscripts that contain valuable information about agricultural implements. Traditional farming system is an ecologically based age-old farming system developed by ancient farmers through generations of their interaction with nature and natural resources for food, fodder and fiber. Pest control practices of our ancestors are evident from protohistoric, historic and Vedic periods.The Vedas, world's oldest scriptures, form a rich body of traditional ecological and agricultural knowledge. The Vedas represent the grandest homage ever rendered to the environment. Traditional methods of seed storage & protection are becoming more popular because of their eco-friendly & harmless nature for the whole environment. India's agriculture has proved to be sustainable by maintaining the country's fertility and biodiversity over centuries. Hence, a study was undertaken to collect & document the details of various traditional seed storage structures available among the farmers so as to preserve & propagate them for use by the future generations. It is important & need to apply the traditional methods that have been gained from our ancestors to enhance the sustainability of the agriculture in future.

***Keywords*:** Vedic period, Storage, Traditional agriculture, Pest control

Introduction

Agriculture is the major occupation of the people all over the world. More than 70% of Indian population depends on agriculture for their livelihood (Prakash *et al*., 2016). The Vedas, world's oldest scriptures, form a rich body of traditional ecological and agricultural knowledge. It is composed of hymns that reveal the reverence, the respect and admiration Vedic people had for nature. The Vedas represent the grandest homage ever rendered to the environment. The *Atharvaveda*, the fourth Veda, describes the life of the ancient Indian agriculturist community. It is interesting to note that in Vedic times, agriculture was considered the most honourable of human activities. Ancient Indian farmers evolved nature friendly farming systems and practices. (Sundaramari *et al.,* 2009). Agriculture activities were designed to ensure ecological sustainability. India developed its own holistic scientific knowledge. It has a number of classical texts related to agricultural science. *Kautilya's Arthashastra, Patanjali's Mahabhasya, Krishi-Parashara, Varahmihira's Brhat Samhita* and *Surapala'sVrikshayurveda* is some of the manuscripts that contain valuable information about agricultural implements, selection of seeds, land preparation, pest control storage, plant nutrients, grafting, soil selection, plant propagation, diseases and plant protection, mixed cropping, crop rotation, intercropping, shifting cultivation, terrace farming etc. India's traditional agriculture has proved to be sustainable by maintaining the country's fertility and biodiversity over centuries. The Vedic literature gives plentiful evidence to agriculture. In Rgveda there is abundance of data with regard to agriculture. *Mahabharata* informs that the state has to do a lot of things for the well being of agriculture. The state was held responsible for any damage to crops due to its inadvertence or negligence (*Santiparvan*, 88.28). *Abhijnanasakuntala* of Kalidasa (Act V, Verse 9) also supports this view. The ancient Indian cultivators had acquired a wealthy knowledge of climatology, classification and selection of soil, plant physiology, seasonable cultivation and rotation of crops, protection of crops, treatments of seeds and different kinds of manures. *Brhatsamhita, Agnipurana, Vrksayurveda, Arthasastra, Krsiparasra, and Krsi-sangraha* contain advanced knowledge of crops, weather, rainfall, fertilizers, implements etc. The ancient Indians knew the use of manure, and the *Arthasastra*lays down several rules for the management of the state farms which points to a well-developed agricultural technique (Ajesh, 2016).

Traditional farming system is an ecologically based age-old farming system developed by ancient farmers through generations of their interaction with nature and natural resources for food, fodder and fibres. (Karthikeyan *et al*., 2008). It is an indigenous method of cultivating crops using self reliance locally available resources without external inputs. India grain production has steadily increased due to advances in technology, but post-harvest loss is constant at 10%. Losses during storage, accounts for around 6% of the total losses as proper storage facilities are not available. Grain storage plays an important role in preventing losses which are caused mainly due to insect pests, pathogens

and rodents. Traditional practices are passed on from generations and are an outcome of elder's wisdom and experience as a result of their close contact and deep knowledge of their environment (Prakash *et al*., 2016). To overcome the ill effects of synthetic pesticides, the best alternative is to going back for adopting Indigenous Traditional Knowledge for protecting the food grains and seeds from insect pest attacking the seeds. In Ancient farming methods for protection of seed material, the practices of our ancestors are evident from pre-historic, historic and vedic periods. Storage of seed in cylindrical pits dug in earth or in granaries or in containers made of ropes and plastered with mud or in well backed clay pots, scaring away birds with sling balls, initiation of mixed cropping technique, controlled use of water irrigation in fields, etc. are the human tragedies to protect do occur periodically in various parts of the country (Pradeep, 2015). The traditional knowledge left by our fore fathers appears important to protect the seed material at this juncture, which has resulted in availability of different biological preparations, particularly microbial pesticides. Our predecessors have used varieties of plant based products, crop residues like husk, shell, ash, animal products like cow urine and cow dung, milk and minerals like red earh, sand etc. Most of the above materials sayings, information, etc. are available around the villages and proved safe, biodegradable and less persistent (Mehta *et al*., 2010).

Many examples of crop and seed protection such as making din and noise for bird scaring in maize fields to keep away the wild animals. Use of cow dung, milky juice of *Solanum indicum*, coconut water, *Emblicaribes*, cow urine and ghee (butter oil), etc. for treatment of seed material were practiced during vedic era. An ancient Indian text Vrikshayurveda enumerates a large number of plants used as remedies of crop protection. Indigenous botanical knowledge in agriculture with reference to seed treatment, pest control, seed storage, horticulture, etc. was traced records of ancient text of India, viz. *Varahmihira*, *Brihatsamhita* (5AD), *Vrikshayurveda* of *Lokopakara* (5AD) and *Sarangdhara Samhita* (13AD) in respect of plant protection techniques (Narayanasamy, 2002). In the first century B.C. and sixth century A.D. Shih Shary-hanbriught out an encyclopaedia of agriculture in China listing a large number of practices for sustainable agriculture. Roychoudharu enlisted numerous traditional agricultural practices found in Indian ancient texts on Vrikshayurveda (tree medicine), and Asura-Vaidyaka (treatments of horse and animals). Indigenous botanical knowledge in agriculture with reference to seed treatment, pest control, seed storage, horticulture etc. was compiled by Mazumbar, Chandrakanth and Basavaradhya and Vijayalakshmi and Shyamsundar traced records of ancient texts of India viz., *Varahamihira, Brihathsamhita* (5 A.D.) and *SarangadharaSamhita* (13 A. D.) in respect of plant protection techniques. In India during the early period, the knowledge of pest control in agriculture was propagate through folk songs, folklores, proverbs, riddles, street dances etc (Narayanswamy, 2001).

In view of the above, it is very important to promote, document and revitalize the age old traditional remedies, which were eco-friendly and economic for the poor farm communities. In India, farmers dependent up on herbal and other local treatments for control of storage pests in general and particularly for seed material, which they preserve for the next crop season. In order to document the utilization of ancient farming methods of seed storage and pest control practices.

Traditional Seed storage structures

Seed storage is an important process in maintaining the viability and vigour of the seeds during storage period. Different storage structures are available based on the duration of the seed storage. The traditional storage structures are ranging from bamboo baskets to mud structures, gunny bags and modern bins etc. (Karthikeyan C *et.al*., 2007).Indigenous grain storage structures are available among the farmers so as to preserve and propagate them for use by the future generations. These structures protect the stored grains; do not cause health hazards apart from being eco-friendly, cheaper and locally available. The storage of grain is generally done in one of the following storage structures in the different rural and urban regions of India. Some of the grain storage structures made from locally available material are:

Kanaja/Galagi

This grain storage container is made out of bamboo, cylindrical in shape and the height varies. The *Kanaja* is plastered with mud and cow dung mixture to prevent spillage and pilferage of grains. The top is also plastered with mud & cow dung mixture or covered with paddy straw or gunny bags. This structure is common in paddy growing areas of the transition and the hilly zones (Shobhanagnur *et al*., 2004).

Sandaka

Boxes made out of wood are used for storing pulses and seeds, and smaller quantities of grains for home consumption. These boxes known as pettige or sandaka have storage capacity of three to twelve quintals. A big lid is placed on the box and a small outlet is made on the lid to take out the grains. In some cases, partition is also made inside the box to store two or three types of grains. Legs of about 0.3048m are fixed at the bottom of the box to keep it above the ground level to protect it from moisture. The box is quite common in almost all households of the district where the family grows a sizable quantity of grains. (Shobhanagnur *et al*., 2004)

Kothi

This is proper room constructed with a large door for pouring grains. A small outlet for taking out grains is provided at the bottom. This structure is used for storing jowar and paddy. It is found mainly in large landholding households i.e., where large quantities of grains are grown. (Shobhanagnur *et al*., 2004)

Utrani

These are mud pots used for storing small quantity of grains. These pots made up of burnt clay by village potter, are of different shapes and sizes. The earthen pots are placed at the floor level and each pot is kept one on top of the other. (Shobhanagnur *et al*., 2004)

Hagevu

This is an underground structure used to store the grain. It is a simple, dug out pit lined with straw ropes to prevent damage due to moisture. In some cases, hagevu is constructed with stones as an indoor structure. After filling the structure with grains to its full capacity, the jowarsalks are spread on top in a thick layer and the structure is finally

sealed with mud plaster. In some cases, a small square or circular opening is provided at the top. The inlet opening is kept above the ground level. The advantage of this structure is that fumigation is not required for disinfestations. Grain can be stored without damage from insects and moulds for a longer period and it saves space for storage. But it is not suitable for storage of seeds. This storage structure is suitable for dry agro climatic zones where moisture level in the soil is low and is mainly used to store jowar (Shobhanagnur *et al*., 2004).

Gourd

Gourds are made from the hard dried outer skins of fruits from the members of squash or cucurbitaceae family generally found in tropics and sub tropics. Gourds are used for storing small quantities of food grains (5-30) required for home consumption or planting for duration of six months to one year. Gourds are normally kept indoor or under shelter and above the kitchen or places where they are not prone to insect infestation. Gourds used for grains storage are treated with varnish, paint or linseed oil and once the grains are poured in, the lid is covered mud or cow dung to make an airtight storage condition. Gourds are placed on a platform to save the grains from moisture absorption. The benefit of using gourd is that it's economical, stores grain much better than unlined pits and its easy for farmers for checking for insects infestation (Adesina Jacobs Mobolade *et al*., 2019).

Crib

The crib is an improvement on platform structure, which is a rectangular shaped enclosed structure elevated between 0.5 and 1 m above ground, supported on columns and has wee-ventilated sides made of straw, palm leaves, bamboo or wire netting. The entire storage structure could be constructed with wood, bamboo, metal or wire mesh and roofed with thatch straw or iron sheet and faced in such a way that the prevailing winds blows perpendicular to the length. The legs are fitted with rat-proof device to prevent rodent infestation. The crib is designed in such a shape that the drying process continuous during storage because of the free flow of air over the stored produce due to natural ventilation. Traditionally, the crib was used for unthreshed maize cobs storage but presently its use has been extended to include virtually many other crops. This type of storage unit is easy and cheap to make, but offers very little protection against insect pest and storage losses due to insects and rodents are often as high as 40%. Maize varities with husk are protected reasonably well for 3-6 months without the use of insecticides (Adesina Jacobs Mobolade *et al*., 2019).

Bamboo house

Bamboo house is a variant of mud house and made up of bamboo splits joined by carpentry work. It is used for storing large quantities of food grains. The walls made up of bamboo splits are closely fitted with no gap existing between the bamboo frameworks. The walls can be coated with cow dung or sprinkled with cow urine to prevent insects and rodents from gaining entry to the product stored therein. The house can be constructed in rectangular or square shape with 4m X 4m X 3m dimension to give a storage capacity of 100 kg or above and the top is covered with tin roof. After loading with grains, locally available medicinal plants with insecticidal properties such as Artemisia vulgaris, dried chilli, etc., are placed on the corner to prevent insect infestations (Karthikeyan *et al*., 2009).

Obeh

Obeh is a traditional storage structure mostly used by the resource poor farmer for the storage of unthreshed rice. Obeh has a storage capacity ranges from 5.0-10.0 t. These storage structures are made from bamboo sticks interwoven tightly to create an airtight compartment for storing of grains. The structure in appearance looks like an oval shaped storage platform in which the lower portion is in the form of square and tapers on the top. Loading and offloading of the unthreshed rice is through the removable roof (Adesina Jacobs Mobolade *et al*., 2019)

Earthen pot

Earthen pots made of clay to a convenient size are used from olden days for storage purpose. Walls of the pots are coated with clay and the mouth of the pot is closed with stiff cow dung paste reinforced with cloth. Pots are arranged vertically one over other depending upon the size of the pot.

Gunny bags

Gunny bags are used for storing seeds which is durable and inexpensive. They are easy to handle and it allows the circulation of air that keep the seeds cool. They can be stacked in the household area itself. No special storage area is required for storing in gunny bags. Well before storage, gunny bags should be treated with 10% neem kernel solution. Soak the gunny bags in neem kernel extract for 15 minutes and shade dry before use. New gunny bags should be soaked for 30 minutes. Dried bags are used for storing the seeds. Seeds can be protected from pest attack up to 4 months. After 4 months, seeds are to be dried and the bags are to be treated withneem kernel exract again. Capacity of the bag varies from 10-75 kgs (Adesina Jacobs Mobolade *et al*., 2019).

Ancient farming methods of seed treatment and storage practices used by farmers

Seed storage is an important process in maintaining the viability and vigour of the seeds during storage period. Seed storage and pre-treatment are two important factors that affect the quality and quantity of seedlings produced. Proper storage ensures that more number of seeds remain viable for a longer duration. Similarly, best pretreatment procedure guarantees maximum germination percentage. The importance of using suitable storage and pretreatment technique, in order to maintain seed viability and improve seed germination, has been known and appreciated since ancient times. Some of the traditional seed treatment methods for storage practices are documented below (Rakesh *et al*., 2013).

Crop	Method of seed treatment and storage	Scientific interpretation
Paddy *(Oryzasativa)*	Seeds stored for one or two years were immersed in salt water (1:10), stirred , and kept aside (generally for 2 kg of seed, 1 kg of salt and 10 L of water is effective). After an hour, light and chaffy seeds which were floating were removed and hard seeds that settled down were dried in shade.	Adding salt to water increases its density and helps in separation of light and chaffy seeds. This also helps in increasing germination (Johnston *et al.,* 1978).
	Seeds were soaked in water overnight, dried in shade, and placed in a pit containing tree saw dust and sheep manure. The pit was made airtight. Seeds were removed after two days, dried, and used for sowing.	Keeping seeds along with sheep manure in an airtight container creates heating inside the pit which is required for initiation of germination. Chemical reactions inside the seed prefer warm conditions to start (Gashaw and Michelsen, 2002).
	A small bag containing seeds (approximately 10–15 kg) was placed at the entrance of the house instead of a door mat. This can be stored for 1 to 2 years.	Whoever enters the house will step on the bag. This repeated stepping on the bag disturbs insects which are trying to establish and feed on the seed.
Ragi *(Elusina coracana)*	Seed bags of 10 kg were dissolved in 1:10 solution of salt and water. The seeds were dried and used for sowing within 72 hours.	The salt treatment of seed helps in breaking dormancy and tolerating drought stress (Mehmet Demir Kaya *et al.,* 2006).
	Farmers used neem (*Azadirachta indica*) leaves and *thumbai* leaves in the storage of *ragi.* Being very cheap and simple most of the farmer followed this technology to get rid of storage pest than to relay on costlier chemical treatments.	The strong odour of these leaves keep the storage pests like lesser grain borers (*Rhyzopertha dominica*), saw toothed beetle (*Oryzaephilus surinamemsis*) and flat grain beetle (*Cryptolestes minutus*) away. Neem leaves and *thumbai*being organic repellants were also safe to use. (Karthikeyan *et al.,* 2009)
Sorghum *(Sorghum bicolor)*	Seeds were treated with dried cow dung powder and cow urine before sowing. For one kg of seed approximately 100 g cow dung powder and 250 ml cow urine were used for better germination. Cow dung powder was also used for storage of seeds.	Cow urine contains 2.5% urea which is known to break dormancy and improve germination (Kundu *et al.,* 1993). Cow dung powder protects the seed from humidity and hence improves longevity of seed. Cow dung was used with ghee and honey in ancient times for treating seeds as documented by Kautilya in Arthashastra (Nene, 2002).
	Seeds were treated with lime water. One kg of lime was dissolved in 10 L of water and kept for 10 days. The superficial water was collected and seeds were soaked in it overnight. The seeds were dried in shade and used for sowing.	Lime or calcium hydroxide is known to protect seed against seed borne diseases such as smut and bunt (Smith and Secoy, 1976).
Storage of seeds with lime	Good ear heads were selected and kept open in fog in *rabi* (postrainy) season and kept inside a pot containing neem leaves.	The neem leaves protect seed from seed borer and beetles (Karthikeyan *et al.,* 2009). The exposure to fog may result in breaking of dormancy and bring drought tolerance (Shigihara *et al.,* 2008).
Pigeonpea *(Cajanus cajan)*	Good ear heads were harvested along with awns and kept in the center of dried paddy grass heap (called *banave*).	Seed along with awns create hindrance for insect activity and thereby protect seed from insect damage. The selection of good ear heads and drying of seeds is an ancient practice to ensure seed longevity (Nene, 1999).
	Farmers traditionally followed a practice of storing pulse grains along with lime powder. In this practice, farmers dusted about 10 gm of lime	The lime had a property of emitting irritating odour that repelled insects and prevented the grains from damage. By this way, grains could be

	per kg grains. After thorough mixing they stored them in jute gunny bags.	stored for even one year. (Karthikeyan *et al.,* 2009)
Chickpea *(Cicer arietinum)*	Seeds were kept along with horse gram seed and plant dust in an airtight container. Dust and seeds are separated before sowing.	The dust of horse gram is known to absorb excess moisture in the seeds and helps in storage for longer duration.
	Seeds were coated with fine red soil of the village pond or hill, dried in shade, and stored. For 10 kg of seed, 1 kg of soil is used.	The fine red soil smeared on seed creates a hard surface which is impermeable and protects seed against attack of storage pests. It also resists moisture permeability.
Pigeon pea and Chickpea Green gram *(Vigna radiata)*	Seeds were treated with pongamia leaf extract and dried before sowing.	Strong odor of pongamia leaves repels storage insects (Karthikeyan *et al.,* 2009).
	Seeds were kept in a gunny bag along with Guntur chili powder and neem leaf powder.	The chili powder contains capsacin which is known to inhibit lipid peroxidation which in turn slows down seed ageing (Dey and Ghosh, 1993). The *Guntur* type is known for its high pungency. The neem leaf powder acts as a repellent.
	Seeds were kept with powder of bitter gourd or drumstick seed extract for 3–6 months.	The toxic nature of drumstick and bitter gourd seeds not only repels insects but also protects from pathogens associated with seed (Batabyal *et al.,* 2009).
Chili *(Capsicum annuum)*	Seeds were stored along with mint leaves (*pudina*) or sweet flag (*baje*) root powder.	Strong odor of sweet flag repels storage insects (Karthikeyan*et al.,* 2009).
	Seeds were treated with citronella leaf oil, cotton seed oil, soybean oil, or castor seed oil;500mlofoil was used for 100 kg of seed.	The strong odor of these oils repels storage pests and microbes like *Alternaria* and *Fusarium* (Nguefack *et al.,* 2008).
Sunflower *(Helianthus annuus)*	Seeds of these crops were kept along with small millets like pearl millet or foxtail millet or finger millet and stored in an earthen pot. The pot was made airtight by smearing cow dung For 5 kg of seed; 1 kg of millets was used.	The coarse seed surface of minor or small millets absorbs moisture of seed of pulses and helps in better storage. (Almekinders *et al.,* 1994).
Cotton *(Gossypium herbaceum)*	Seeds were kept on a layer of ash in an earthen pot and covered with another layer of ash. Then another pot was kept on it and cow dung was smeared to make it airtight.	The insects inside the seed will be suffocated and die and also the seed can be stored for a longer period since seeds will not absorb moisture from outside (Wambugu *et al.,* 2009).
Vegetables Gourd *(Benincasa hispidia)*	Ten kg of seed was mixed with 250 g chilli powder and 1 kg of *ragi* or finger millet flour, and then kept in a bamboo pot along with paddy husk.	Chili powder provides repellence against storage pests while flours prevent attack of secondary pests. The use of flours to preserve seeds is an ancient practice as mentioned in Varahamihira's BrihatJataka (Suryanarain Rao, 1986).
Bitter gourd *(Momordica Charantia)* **Bottle Gourd** *(Lagenari siceraria)*	Seedlings of chili were removed from the nursery bed and treated with 1:3 solutions of cow urine and water.	Cow urine helps in protecting seedlings against damping-off caused by *Rhizoctoniasolani* (Ashlesha*et al.,* 2011).
	A gunny bag was immersed in hot water and seeds were placed in it and kept for a day. The seeds were then used to sow on the seed bed.	The pre-germinated seed when sown on the seed bed helps to get more usable transplants and improve vigor (Venkatasubramanian and Umarani, 2007).
Tamarind *(Tamarindus indica)*	Seeds were kept inside the dried fruits of sponge gourd after removing the seeds. These fruits were kept in an airtight container.	The fruits of sponge gourd act as protective capsules against insect pests and protect sunflower seed during storage. (Rakesh *et al*., 2013)

	Seeds were treated with ash and cow dung slurry and dried in shade before sowing.	Cow dung slurry helps to remove the fiber attached to the seed and thus facilitate sowing. Ash along with cow dung slurry is known to control diseases caused by *Rhizoctonia solani* (Ashlesha *et al*., 2011). Cotton and other hard seeds were smeared with cow dung before sowing as in Kautilya's Arthashastra (Nene, 2002).
Maize *(Zea mays)*	Vegetables growers stored the seeds indigenously by using cow dung. In this method include pressing the seed with the thumb; biting the seed, obtaining the feel of the grain by smelling a handful and shaking. The collected vegetable seeds were embedded in the cow dung and then dried under sun for 2-3 days. After drying the seeds get sticked on to the *Varati*. These varieties are stored in open/inside wooden boxes. The farmers stored the vegetable seeds by this method even up to one year.	Cow dung has pesticidal property, which would keep the seeds away from storage pests. Also believed that cow dung's immune stimulant properties increased the germination (90%) and viability of the seeds considerably. Fresh cow dung has to be used for effective storage. (Karthikeyan *et al.,* 2009)
Oil storage practices Ground nut oil (*Arachis hypogaea*)	Farmers stored tamarind (*Tamarindus indica*) by mixing salt with it. After harvest, tamarind was removed from its pods and then stored in earthem pots in layers. Farmwomen indigenously practiced spreading of salt in between the tamarind layers. For this practice, about 10gm of salt was used for per kg of tamarind.	Storage pests like beetles and Indian meal moth (*Plodia cautella*) were prevented. Also the salt help in loosening of the tamarind fleh easy for handling during looking. (Karthikeyan *et al.,* 2009).
	Maize seeds are often kept intact along with their outer husk and hang over the kitchen/furnace. Here, Maize cobs are field up in bunches of 10-12 cobs by folding their next to outermost husk and hang over the wooden beams of kitchen and sometimes roof beam in the periphery of the house.	Open air mixed with smoke seemed to inhibit the pest and pathogens as well as the entry of this pest take time through hard husk of maize (Chhetry, 2008).
	Farmwomen practiced an indigenous method of storing ground nut oil by placing tamarind in the oil storage container. In this practice, for storing 5 L of ground nut oil, about ¼ kg of tamarind was placed inside the oil container. The mouth of the container/vessel was then tightly closed with cotton cloth. Some farmers also sealed the small opening in the oil container with the help of tamarind.	This practice reduced the spoilage of oil and preserved the oil for long-term period of 6-12 months. (Karthikeyan *et al.,* 2009)

Ancient farming methods of pest control practices:

The ill effects of the synthetic pesticides are scaling up day by day. The pest problems continue to persist and the human tragedies do occur periodically in various parts of the country. In ancient method farmers used varieties of plant – based products. Crop residues like shell, ash, animal products like cow urine, cow dung, milk and minerals like red earth, sand etc for protection and nutrition of crop plants. Most of these materials, which are safe, biodegradable, less persistent and available in and around farmer's lands, are the locus attention today. The indigenous practices involving these products were carefully planned and have application value even today. Instance of best known plants species used by man during Vedic periods are listed (Narayanasamy, 2002).

Biological, minerals and other materials used in traditional pest control

- Rice flour
- Charcoal
- Goat hair
- Clay
- Rice husk
- Sugar
- Coconut
- Tamarind seed
- Saw dust
- Kerosene
- Cow dung
- Fish oil
- Mercury
- Calcium carbonate
- Kitchen ash
- Tender coconut
- Ragi husk
- Chicken excreta
- Common salt
- Red earth
- Asafoetida
- River sand
- Ox horn
- Cow urine
- Butter milk

Pest control plants of Vedic era

Sl. No	Common name	**Scientific name**
1	Ajasringi	*Odina pinnata*
2	Asoka	*Saraca asoca*
3	Aswatha	*Ficusr eligiosa*
4	Arka	*Calotropis gigantean*
5	Kkadasingi	*Gynandropis pentaphylla*
6	Kuverakshi	*Bignonia suaveolens*
7	Maharksha(Vijra)	*Euphorbia tirucalli*
8	Neem	*Azadirachta indica*
9	Nyagrotha	*Ficus indica*
10	Palasa	*Butea frondosa*
11	Stapuspa	*Anethum sowa*
12	Sikhandi (Juha)	*Jasminum auriculatum*
13	Vidanga	*Embelia ribes*

Important traditional pest control plants

Pest control practices of our ancestors are evident from protohistoric, historic and Vedic periods. Since the use of plant parts in various affairs of agriculture was on the increase and people domesticated varieties of plants around their habitation and agricultural fields (Narayanasamy, 2002). Some of the important traditional plants are documented below.

Plant	Part used	Target pest
Acorus calamus	Rhizome	Ants
Allium cepa	Bulb, leaf	All pests
Allium sativum	Bulb	All pests
Annona squamosa	Leaf, seed	All pests
Azardirachta indica	Leaf, seed	BPH, GLH Alphids
Adathoda vasica	Leaf, flowers, stem	Larvae Stored pests, rice pests
Acacia nilotica	Wood ash	Termites,Stored pests
Agave americana	Leaf	Rice leaf folder
Calotropis giganticea	Leaf	Larvae
Capsicum frutescens	Fruit	Larvae, sucking pests
Chrysanthemum	Flower	All pests
Cinerariaefolium	Flower	All pests
Curcuma domestica	Rhizome	Stored pests, rice pests
Cycas revoluta	Male cone	Rice earhead bug
Datura stramonium	Leaf	Larvae
Ipomea carnea	Leaf	Larvae
Ssp.fistulosa	Leaf	Larvae
Melia azaadirach	Bark,leaf,seed	Sucking pests, Larvae, rice pests, beetles, fruit flies
Nicotiana tobacum	Leaf	Sucking pests, Larvae, rice pests, beetles, fruit flies
Ocimum sanctum	Leaf	Sucking pests, Larvae, rice pests, beetles, fruit flies
Piper nigrum	Seed	Larvae, beetles,
Pongamia pinnata	Oil cake	Stored pests
Tecoma indica	Flower	Stored pests
Vitex nigunda	Leaf	Stored pests, Sucking pests, larvae
Zingiber officinale	Rhizome	Stored pests

Discussion

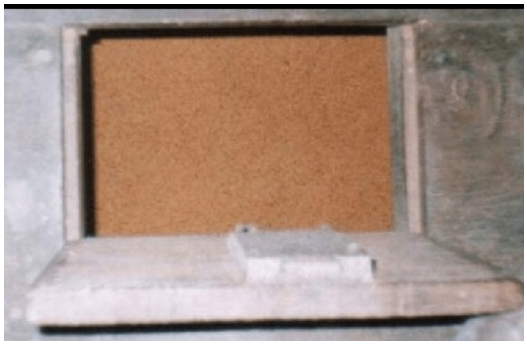
The farmers are used traditional storage structures and pest management methods along with improved seed. These methods have been followed for a very long time and have not changed but improved over the years. These methods were in line with ancient texts which are scientific. The methods were scientifically true and logical. This collection of traditional agricultural knowledge/practices is of great significance in conserving and maintaining sustainability of the environment. Further it requires integration with modern scientific knowledge to generate a wide range of new ideas and practices for the betterment of the mankind. Although these all above discussed traditional agricultural knowledge/practices were available in the tribal setting but now at reducing rate. So there is need to motivate the tribal farmers to use these practices as past to save the agricultural produce. In addition to this, a number of local practices for maintaining viability of stored seeds and increasing germination are also available. Surapala's Vrikshayurveda, where it has been mentioned as an excellent method for storage of all types of seeds (Sadhale, 1996). If the practice

of involving traditional substances along with other biological products is followed for the pest problems, it is certain that the agriculture will be really green and the human kind will live in a very safe and healthy environment. Storage of grains in cylindrical pits in dug in earth or in granaries or containers made of ropes and plastered with mud or in well-baked clay pots scaring away birds by sling balls, initiation of mixed cropping technique, controlled use of water in irrigation of fields etc are some of the practices found in use during these periods. During vedic era. Cultivators kept away birds from cornfields by making din and noise and setting traps or digging pit falls and fix traps in the field to drive away the wild animals. Seed treatment with cow dung, milky juice of *Solanum indicum*, coconut water, *Embelia ribes* and cow ghee, etc were in vogue. Since then use of plant parts in various affairs of agriculture was on the increase and people domesticated varieties of plants around their habitation and agricultural fields.

In this way document and revitalize the age-old agricultural practices of pest control are on the rise. It is in this background; the present paper reviews the status of indigenous pest control and presents the packages of pest control practices.

Seed storage structures

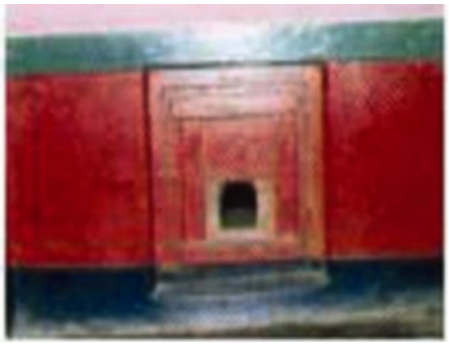
Kanaja/Gaiagi



Sandaka

Utrani

Hagevu



Kothi

Gourd

Cribs

Bamboo Bin

Obeh

Earthenpot

Gunny bags

Underground pit

Bamboo basket

Vegetable storage in house

Maize storage

On ground storage structures

Traditional Seed Treatment Methods for Pest Control

Tank bed silt

Powdering the soil

Puddling the mix

Final stage of poultice

Seeds are treated with cow urine

Seeds are treated with cow dung

Seeds are treated with using botanicals

Conclusion

Ancient farming method of grain storage structures provide excellent moist proof environment to the stored grains. These structures are very cheap in both fabrication and maintenance than the modern storage units. Stored grain pests seriously damage food grains during storage. Several synthetic pesticides were used, but they have shown adverse effects on environment and persist for longer period in form of residues and entered in the food chain after utilization of products by organisms. Most of these practices are indigenous practices enhances utilizations of locally available materials. These methods protect the food grains, do not cause health hazards apart from being eco-friendly, cheaper and locally available materials. Plants which have rich sources ofbio-active compounds. Several more might still be lying unexplored. More concerted efforts are needed to make the available compounds more potent against pests and safer to the environment by way of improved formulations. The farmers still have inhibition in using botanicals because they are under the impression that they are inferior to the modern pesticides as the former do not cause quick knock down effect. Hence, awareness among the farmers needs to be created in this regard.

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