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# Krishi Udyan Darpan

(Innovative Sustainable Farming)

## In This Issue

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# Potential Use of Insect Frass for Soil Nutrient Dynamics

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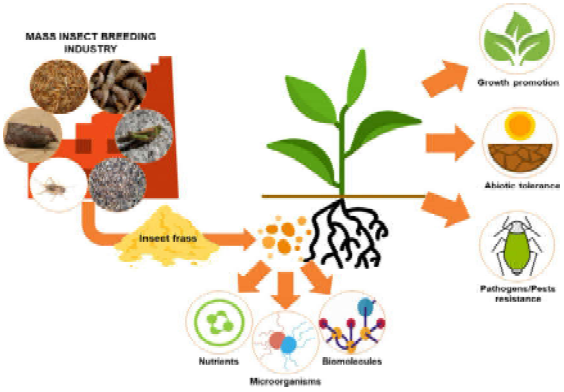
## Introduction

With the increasing trend of global population, it is estimated that in 2050 the world population will reach 9.7 billion, with a consequent increase in the demand for resources such as water, food and energy. Given this scenario, food production will need to increase by roughly 70% by 2050 and double or triple by 2100, while trying to decrease the environmental impact of food production activity. Apart from potential adverse environmental impacts such as greenhouse emission, the unsustainable depletion of water and soil resources also needs to be addressed. The excessive use of inorganic fertilizers not only causes environment degradation, human health issues but also increased the cost of cultivation. There by considerable reduction in farm profitability and leads to vicious cycle of poverty of cultivators. Hence timely measures are needed so as to the food demand of an increasing global population while protecting the environment.

## Mass Insect breeding industry

In recent years, the use of insects as food and feed is receiving more and more interest, increasing the numbers of scientific publications and private enterprises engaged in producing insect products. The number of companies in the world working on insects as food and feed, not including insect industry organizations and insect advocacy organizations, was estimated in April 2019 to be more than 250 (Van Huis 2020). Scientifically, the use of insects as food and feed provides hundreds of publications each year, being constantly reviewed by various authors (Sogari *et al.,* 2019).

The design and operation of a mass insect breeding industry requires the adaptation of industrial processes to the lifecycle of the insect to be multiplied, although there are aspects common to all of them noted by several authors (Cohen 2018). A very important part of the mass rearing process is the production of frass (insect excreta) by insects, which supposes an important end product within the system. For this reason, in




**Insect frass from mass breeding of insects for feed and food as an organic fertilizer in sustainable agriculture.**

these industrial systems, frass has been considered as an organic fertilizer and even as food for other livestock farms (Ortiz *et al.,* 2016). To get an idea of the amount of frass that this type of industry can accumulate daily,

it has been determined that yellow mealworm (*Tenebrio molitor*) can consume 220 g of food in the form of corn and carrots, supposing an insect biomass production of 4 g and 180 g of frass and residues, respectively (Wang *et al.,* 2018)

Among the plant nutrients, Nitrogen is often a limited resource for plants due to low soil nitrogen levels resulting from poor farming practices, biological processes such as denitrification and microbial competition, or soil erosion. The research studies for instance in cabbage plants, the cabbage moth insect frass increases total nitrogen concentration, and accumulated inorganic nitrogen and ammonium nitrogen in the leaves in response to the application as fertilizer . There are numerous examples of defoliating insects whose droppings contribute nitrogen to the plants they feed on, such as the grasshoppers . In a 2-year cumulative study, the eucalyptus defoliating beetle *Paropsisatomaria* and the lepidopteran *Doratiferaquadriguttata* were determined to be capable of producing between 160 and 270 kg/ha of frass, depositing 2 to 4 kg/ha of nitrogen (Gherlenda *et al.,* 2016). Along with nitrogen, other nutrients are returned to the soil through insect frass in the field, such as carbon through frass from the defoliation moth on red oak, increasing total carbon, total nitrogen and ammonium in soil, also favoring the microbial activity in soil.

## Case Studies

Poveda *et al.,* (2019) was able to demonstrate the role of meal worm frass *(T. molitor*) in lettuce resistance to abiotic stresses under field conditions. These frass treatments were exposed to salinity, drought and flooding stress. Typically, fertilisation improved survival and performance in stress conditions. This indicates that meal worm frass can provide equivalent support for crops under stress conditions as compared to a conventional fertiliser.

## Chemical characterization of meal worm frass

| Organic Cgkg$^{-1}$ | Total Ngkg$^{-1}$ | Total Kgkg$^{-1}$ | Total Pgkg$^{-1}$ | Total Cu mgkg$^{-1}$ | Total Zn mzkg$^{-1}$ |
|---|---|---|---|---|---|
| 393 pH | 50 ECdS m-1 | 17 Soluble fraction % Corg | 20 Hemicellu-lose-like fraction % Corg | 10 Cellulose -like fraction% Corg | 94.2 Ligin-like fraction %Corg |
| 5.8 | 5.3 | 49.3 | 31 | 15.2 | 4.4 |

Chemical characterization of meal worm frass revealed that it had concentrations of N, K and P as high as those found in farmyard manure and, especially, poultry manure, which confirms its high fertilizer potential. By contrast to conventional mineral fertilizer, frass also contained small concentrations of micronutrients (i.e., Cu and Zn), which may be further beneficial for crops.

## Microbial metabolic activity and diversity

Microbial metabolic activity and diversity were assessed through the measurement of Average Well Color Development (AWCD) and *S* and *H* indices in BIOLOG EcoPlate. AWCD reflects the oxidative capacity of soil micro-organisms and may be used as an indicator of soil microbial activity. Similar to other organic amendments, the incorporation of frass, either at 50% or 100%, resulted in an increase of the AWCD and/or *S* indices compared to the NPK treatment.

## Effect of Soil Fauna on fertilizing effect of Insect Frass

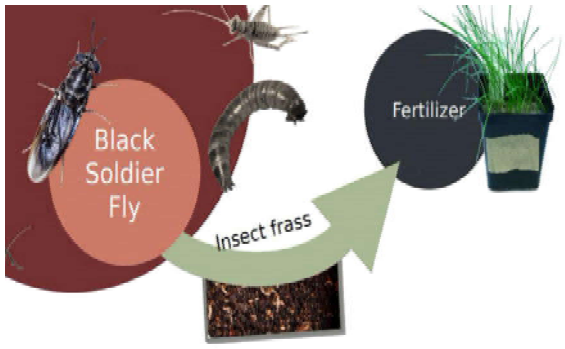
There exists a synergistic effect between frass and earthworms since the Frass + Earthworms treatment displayed the highest N concentration in barley shoot. It is due to very rapid mineralization of frass after its incorporation into soil. Besides increasing microbial metabolic activity, frass, like other organic amendments, might also have promoted earthworm activity, which could further increase N mineralization.

**Maize defense gene expression in response to European corn borer frass**

European Corn Borer herbivory is known to induce defenses in crops such as maize and tomato. ECB larvae feed in enclosed host tissues such as the maize stem or the maize whorls where frass may accumulate in close proximity of fed tissue over extended periods of time. The defense is due to transcript abundance of herbivore-induced *lipoxygenase3* (*Zm-lox3*) and *maize protease inhibitor* (*Zm-mpi*) in response to ECB frass proteins.

**Insect frass collected from black soldier fly frass used as a fertilizer**

The larvae of Black soldier fly have shown a great promise in transforming organic wastes into a more valuable larval biomass. Hence, this BSF larvae is used in entomocomposting of organic wastes such as poultry waste, brewery waste or green market waste. After harvesting of the insects, the remaining by product comprised of spent substrate and frass, which could be used as a potential bio fertilizer.




**Effects of insect frass and distiller's grains on physicochemical properties of saline alkali soil**

Guo *et al.,* (2021) studied the effect of BSF feces and distiller's grain on physico chemical properties of saline alkali soils. They conducted pot experiment with BSF amended wholly and also in combination with distiller's grain. Combined application of insect frass and distillers grain effectively lowers the pH of saline alkali soil. Insect frass has strongest effect on increasing the phosphorus and potassium content of soil.

**Frass of saproxylic insects suggest a role in micronutrient cycling**

Concentrations of 22 elements in pinewood were compared with that in frass produced by insects representing the following taxa: r- Reticulitermes spp, z- Zootermopsis spp, i-Incisitermes spp, y- Hylotrupes spp, p- Ptinid spp, e- Heterobostrychus spp, l- Lyctus spp. Percent Approximate Digestability is interpreted as a fraction of consumed dry wood mass in insect feces. This survey of elements in frass indicates that saproxylic insects are importantly not sequestrating but rather recycling (releasing) the store of micronutrients in wood biomass, with the greatest potential contribution to soil nutrient cycles.

**BSPR as an innovative ingredient for growing media**

Setti *et al.,*(2019) studied how the black soldier fly larvae processing residue (BSPR) can act as an innovative ingredient for growing media. The experimental treatments included commercial peat and synthetic fertilizer amended along with BSPR. The results of the experiment indicate that BSPR can be used as an innovative peat-based GM, in any proportion up to 20%, might promote the growth of baby leaf lettuce, basil and tomato potted plants, reducing peat utilization and not requiring further addition of synthetic fertilizers.

**Conclusion**

The insect frass activates tolerance and defense responses in plants against biotic and abiotic stresses. It provides high nutritional content thereby considerably reduces the use of agro-chemicals. Compounds or microorganisms present in frass are capable of promoting plant growth. The insect excreta,

being up to 40 times greater than the production of animal biomass, could be effectively used as organic fertilizer to replace the use of synthetic fertilizers and agrochemicals. The insect frass could contribute nutrients to the soil, mainly nitrogen, easily assimilated by plant tissues and also could add biomolecules and microorganisms that promote plant growth. Finally, the increased tolerance to abiotic stresses and resistance to pathogens and pests due to the presence of different compounds and microorganisms. Thus, the usage of insect frass could be a viable alternative for enhancing soil fertility as well as for the development of sustainable agriculture and a circular economy.

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# Detection, Identification and Management of Pulse Beetle (*Callosobruchus Chinensis)* During Quarantine Processing

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## Introduction

The members of the family Bruchidae have long been reported to destroy the seed of the leguminous plants but a number of them are now known to attack the seed or are associated with the flowers or leaves of plants belonging to other families such as Compositae, Malvaceae, Convolvulaceae, Anacardiaceae, Rosaceae, Umbelliferae, Papaveraceae and Arecaceae. They are not only serious pests of the edible pulses, beans, lentils and peas but also attack the pods and the seeds of the wild forest, medicinal and ornamental plants. The available literature on bruchidae shows that over 1,500 species have so far been recorded from different parts of the world. The bruchidae fauna of India, however, has not been properly explored and very few species are represented in the collections of the Indian Agricultural Research Institute, New Delhi and Forest Research Institute, Dehradun and even these are neither properly identified nor adequately described. At NBPGR, the world bruchid literature was compiled and a database on bruchids developed. It also included digitized keys for their identification Research work has accordingly been carried out and collections have been made of bruchids from different parts of North-West India with a view to study and establish the identity of the various species, listing their host plants, determining their specific ranges and assigning them to their appropriate systematic positions. The present study was undertaken to detect the presence of bruchid infestation in mung bean, cowpea and gram seeds through X-ray image analysis and to identify the retrieved.

**Collection of infested seed materials**

Four infested seed samples namely: mung bean, cowpea, gram and pigeon pea were collected from the division of germplasm conservation, NBPGR, New Delhi. The seed samples were brought to the Entomology laboratory of division of plant quarantine at NBPGR, New Delhi for further study.

**a. Mechanical cleaning:** All the seed lots were cleaned mechanically (hand picking) by removing the insects, stages thereof, infested, discoloured, deformed and shriveled seeds.

**b. Grain material for standardization of X-ray radiography:** Experiments for standardization of radiography were under taken on mung bean, cowpea, gram and pigeon pea.

**c. X-ray machine:** The X-ray machine available at National Bureau of Plant Genetic Resources is standard cabinet X-ray machine of Faxitron series. The machine gives soft X-ray radiation enough for studying seed in smaller quantities. The machine has all built in safety features protecting those working in the vicinity from exposure to the radiation (Fig.1).

**Fig.1 Faxitron SR MX 200 real-time X-ray machine for detection of hidden infestation of bruchids in seeds. The seeds are spread in a small plastic tray and exposed to soft X-rays generated at 19-26 kv. For 19-25 second depending on the seed size using the real time X-ray machine, Model No. Faxitron SR MX-200. As the machine is real-time, it automatically gives the X-ray radiograph on the monitor (Fig.2).**

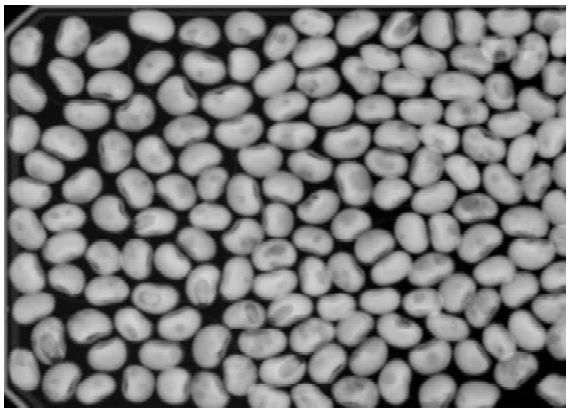

**Fig.2 Image of seed plate after X-ray exposure**

Infested seeds are clearly distinguishable from healthy ones on the monitor. The exposed plate is gently removed from the X-ray machine without disturbing the seed geometry. The infested seeds (as seen in the X-ray radiograph) are then handpicked from the seed sample with original geometry retained an X-ray tray/ plate.

**d. Identification of interceptions:** The infested seeds separated by handpicking after X ray radiography are soaked overnight, the seed teased open and the insect removed from inside (Fig.3).

**(a) Mung bean** **(b) Cow pea**

**(c) Gram** **(d) Pigeon pea**

**Fig.3. Infected seed collected through X-ray Radiography machine and after soak in water**

Examined the insect stage by binocular microscope to identify the taxonomic and morphological characters with the help of identification key (Fig.4)

**Fig.4 Examined the insect stage by binocular microscope**

**Taxonomic characters of *Callosobruchus chinensis***

**a. Head:** Brown or black broader at posterior and frons craniate, its surface covered with white setae. Eyes bulbous, strongly emarginated and surface of canthus covered with white or golden setae, maxillary palpi black, protruding. Antennae dark brown, segments 3-11 serrate in female, pectinate and often margined with black in male.

**b. Pronotum:** Sub-conical, dark brown or black, its surface covered with light brown setae, with two medium prominent callosities in its posterior region, callosities covered with shining white and orange setae.

**c. Scutellum:** Squarish and covered with white setae.

**d. Elytra:** Elongate, quadrangular, rounded at apical margins, their ground colour entirely reddish or red intercepted by black spaces, striae punctuate, striae 3-8 abbreviated at apex, a pair of tubercles present at the bases of 3rd and 4th striae, humeral callosities well developed, surface of each elytron covered with three transverse rows of setae, a broad row of golden setae in the anterior region and two narrow rows of white setae in the middle, the rest of the elytral surface not covered with setae.

**e. Legs:** Usually reddish with the pretarsi black, sometimes dark brown with the coxa and hind femora black, bicarinate on inferior margins, each carina bearing an apical tooth, outer tooth larger and blunt, inner tooth narrow and pointed, hind tibia produced into a spine at its internal apical end.

**f. Pygidium:** Dark brown or black, vertical, uniformly covered with pale setae in male, oblique and with distinct median row of white setae and scarce pale setae elsewhere in female (Fig. 5).

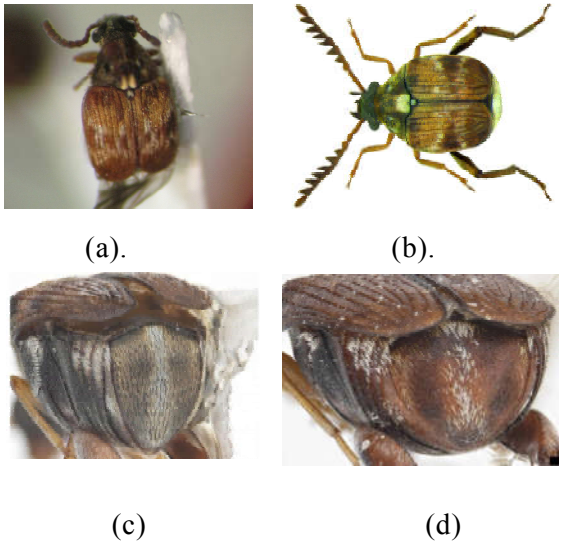


**Fig.5. *Callosobruchus chinensis* identified in infested mung bean seed through stereobinocular**

Microscopic observations (a). Male, (b). Female, (c). Male pygidium and (d). Female pygidium

**g. Phallus:** Narrow, elongated, 1.73 mm long, parameres flattened at their distal ends, each provided with a distinct apical papilla carrying a pair of setae, success devoid of setae, with a pair of lateral chitinized toothed plates, exophallic valve acuminate, proximal lobe of the spermatheca broad, distal lobe short and narrow.

**h. Size:** Small sized 3.23 to 3.36 mm in male and 3.43 to 3.56 mm in female.

**i. Distribution:** Widely distributed in plains and hills all over India.

**Life cycle of Bruchid**

Adult beetle is 3-4 mm long, female being larger, brownish in colour, broader at shoulders and rounded posteriorly. There are dark patches on elytra and thorax. Adults show sexual dimorphism. Males possess deeply emarginated or indented eyes and prominently serrate antennae, while in female these characters are not distinctly marked. Tip of abdomen in females is exposed while in males

it is covered by elytra. They are active beetles and readily fly when disturbed. Fecundity is about 100 eggs per female. Eggs are whitish, elongated and stuck on the grains or on pods and sometimes on the surface of the container. Incubation period is 3-6 days. Grubs are scarabeiform or cruciform, plump and with short legs and yellowish in colour. First instar larvae bear functional legs and a pair of thoracic plates to facilitate boring into the seeds. They feed on the inner contents of the grain and may damage several grains during development. Larval period may vary between 12 and 20 days. Pupation takes place inside the grain and pupa is dark brown in colour. Occasionally, pupation may take place outside the grain in a cocoon made of excretory matter. Completion of life cycle takes 4-5 weeks and there may be 6-7 overlapping generations in a year (Fig. 6).

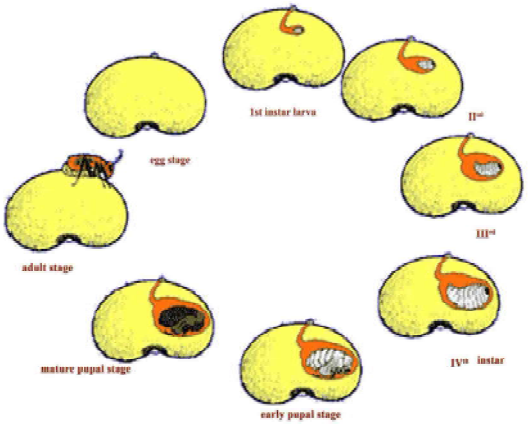


**Fig.6. Life cycle of bruchid**

## Management of common storage grain insect pests during quarantine processing

The dose as per the schedule is calculated on the basis of the volume of the space containing the commodity and not the volume of the commodity. The volume of the fumigant (when dose is represented in grams) is calculated as below.

$$\text{Volume of fumigant} = \text{Required dose (grams)} \times \frac{\text{Volume of container (litres)}}{\text{Specific gravity of fumigant}}$$

## Methodology

**A. Atmospheric fumigation:** Atmospheric fumigation of seeds with ethylene dichloride-carbon tetrachloride against stored grain insect-pests:

- Preparation of the fumigant e.g. Ethylene Dichloride-Carbon Eetrachloride (EDCT) which is mixture of two in th ratio of 3:1 (by volume). For the preparation of one litre of the mixture, 250 ml of ethylene dichloride is put in the bottle. To this, 750 ml of carbon tetrachloride is added. It is mixed thoroughly and stored in a brown bottle.
- Packets are opened, loaded and properly arranged under Normal Air Pressure (NAP) airtight chamber so as to facilitate the circulation of the gas in the container as well through the material.
- Measured volume of dose is dispensed from a measuring cylinder onto the cotton into small evaporating pan. The cotton easily absorbs the required amount of the fumigant, EDCT (a fumigant in the liquid form), to be released slowly. As EDCT is heavier than air, it is kept on the top of the material as its vapours move downward.
- Atmospheric fumigation is generally done for 48 hrs to facilitate proper penetration of the fumigant and it also saves the fumigant as the dose depends upon the concentration x time product, i.e., 320mg/ liter for 48 h and 640mg/ lit. For 24 hours.
- Aeration or ventilation of fumigant after treatment is essential so as to remove the fumigant from the space and the material for the safety of the commodity as well as the environment.

**B. Vacuum fumigation:** The number of fumigant which may be safely used in vacum fumigation is limited due to various technical considerations. E.g., methyl bromide - a general purpose fumigant in this field can be used for vacuum fumigation. But under no condition phosphine can be used in vacuum fumigation as it is unstable at reduced pressure.

- Air pressure in the loaded chamber is reduced by vacuum pump. Which evacuate the chamber by removing the air in the specially designed fumigation chamber, which helps in hastening the penetration of the fumigant through tightly packed material or internal infestation.
- Fumigant is then introduced causing usually only a small rise in pressure. Treatment may last 1.5 to 4 hours.
- Atmospheric pressure is restored by allowing air to enter.
- Fumigant air mixture is then pumped out
- The cycle of air introduction and evacuation is repeated several times, a process termed as 'air washing' until it is considered safe to open the door for unloading.
- Air washing' until it is considered safe to open the door for unloading.

**C. Safety Precautions:** As all fumigants are highly toxic to all living forms, it is imperative to take all the necessary safety precautions while undertaking any fumigation

- A fumigator must know the threshold limits of the exposure above which it is hazardous; protective clothing including gas masks must always be used.
- Gas leak detectors viz., Riken gas indicators or thermal conductivity meter, concentration monitoring units, first aid, a Self-Contained Breathing Apparatus (SCBA) and anti-dotes should always be kept readily available.
- The use of SCBA is mandatory when within 10 m of fumigation site, which should be cordoned off and labeled.

## Conclusion

The genus *Callosobruchus* has been of concern as the major pests of legumes in field as well as in storage. The *C. chinensis* was taken up for studying their detection, identification and management. Since these insects cause hidden infestation, the detection was done through X-ray radiography using MX 200 Faxitron machine which is for real-time detection of insects inside the grains. After detection, the insects were retrieved and mounted for their identification upto species level. The identification was undertaken based on morphological characters of the four species. The differentiating characters including those of antenna, elytra, hind leg, pygidium and genitalia were studied for all the three species. Management options available such as mechanical cleaning, salvaging through X-ray, fumigation using EDCT (Ethylene Dichloride Carbon Tetrachloride) mixture at Normal Atmospheric Pressure (NAP) and ambient temperature and vacuum fumigation have also been discussed.

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# Scented Local Land Races of Rice: Exploring Potential In Northwest Himalayan Region

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## Introduction

It is because of vast genetic resources that agriculture scientists have been able to develop outstanding region and location specific varieties with desired traits in many crops (Padulosi *et al.,* 2009). Local land races play a crucial role in this regard because of high adaptability and some special traits. These strains are therefore of enormous significance to the breeders as well as to the farming community. When we talk about paddy, around 1.5 lakh stains are reported all over the world and around 1.0 lakh strains are being conserved at IRRI. People all over the globe are now realizing the importance of such traditional and local land races and efforts have been intensified over the past two decades to check the genetic erosion and to conserve this precious germ plasm. Thus under changing climate and market scenario, conservation and cultivation of indigenous crop varieties is turning out to be very essential (Mubarak, 2022). In view of these Protection of plant varieties and Farmers' Rights Act 2001 for instance is a timely intervention by Government of India.

## Land Races and their Features

In temperate Kashmir valley located in the northwest Himalayan region, more than 100 local land races of paddy suited to different agro-ecological situations have been reported and most of them are being conserved at Mountain Research Centre for Field Crops, MRCFC-SKUAST-Kashmir. Two among them are Mushk Budji and Kamad, which belong to short grained *japonica* type, with awned grains and Kamad with awn less grain are very famous for aroma in the state and beyond ( Sofi *et al.,* 2020 ). In addition to aroma a desirable taste and texture make them consumer's first choice in local markets, especially during festivals and marriage ceremonies.

## Area and Ecology

These two land races are well suited to the mid altitude belts of the valley ranging between 1850- 1950 meter amsl. These intermediate ecologies are relatively colder than the lower belts but comparatively much favourable than high altitude regions of valley for their cultivation and higher rice yield (Mubarak 2019 a). In lower plains these could not be successful due to heavy incidence of blast disease and in high altitudes there is problem of sterility and maturity.

## Revival Programme Initiated By SKUAST Kashmir

Mushk Budji and Kamad were at the verge of extinction and pushed to few pockets of the valley because of high susceptibility to

blast disease, non-uniformity of the produce, lack of quality seed, poor yield potential due to mixing of strains and also due to area expansion under high yielding paddy varieties released by state agriculture university time to time over the past few decades. In this background an initiative

was also undertaken by SKUAST-Kashmir for revival of Mushk Budgi and Kamad through MRCFC for genetic purification together with development of package of practices especially IDM module to tackle the problem of blast disease plus popularization through participatory mode involving all stakeholders. This revival programme started way back in 2007 with the survey of niche areas were these strains could be traced out through different sources. Some villages in three districts of valley, district Anantnag, Budgam and Bandipora known to be the niche area for cultivation of these land races were selected for this survey. A team of scientists from MRCFC, SKUAST -Kashmir collected 350 samples of these two races and did a wonderful study in which they could categories samples in four categories based on main trait of aroma i.e., a) no aroma, b) low aroma c) moderate aroma and d) Strong aroma. Five identified promising lines, three of Mushk Budgi and two of Kamad with strong aroma were then selected out of 350 samples and studies for traits other than aroma. Finally two strains, one each of Mushk Budgi (Mushk Budji-11) and Kamad (Kamad-7)with a yield potential of around 5t/ha were identified as best out of lot. These strains were then put to different studies for development of comprehensive package of practice especially with regard to the IDM module for the management of blast disease. Under the revival programme village Sagam and adjoining villages were identified in district Anantnag for demonstration on purified Mushk Budji and Kamad rice. In the process of popularizing variety among farmers in mid belts of district Anantnag an excellent example of coordination between SKUAST-Kashmir, department of agriculture and the farming community could be seen.

### Testing In Other Similar Ecologies

Taking into consideration the impact in Anantnag, a crop testing programme was initiated in non-traditional area of similar ecologies in other districts of valley including Kulgam. Krishi Vigyan Kendra (KVK) Kulgam in collaboration with MRCFC in year 2016-17 tested these two strains at 35 locations in the mid belts of district.

### Cultivation Practices

Like other paddy varieties they are grown in kharif season starting with sowing of seed from last week of April to 1$^{st}$ week of May. Transplanting time ranges from 25$^{th}$ May to 10$^{th}$ June. Rest of the management practices are almost same except lower dose of nitrogen and at least 3 fungicide sprays preferably with tricyclazole @ 6g/10 litre of water or Ediphenophos @ 1ml/liter of water. Crop matures between last week of September to first few days of October.

### Commercial Value

During the investigation by scientists it was observed that productivity of these varieties was at par with the existing varieties grown in the mid belt, but returns were reasonably high owing to high market price for milled rice of **Mushk Budji** and Kamad ranging from Rs.120 to 150/ Kg. After the successful revival programme of landraces through MRCFC, **Mushk Budji** growers of Sagam zone of district Anantnag have earned crores of rupees since 2013 from the cultivation of Mushke Budji. Plant Genome savior Community Awards worth 10 Lakh rupees was also conferred to farming community of Sagam village in 2017. Experimentation in other

similar ecologies also depict its potential. Ab. Salam, a marginal farmer from a remote village Ladgoo belonging to district Kulgam for instance could earn higher returns Rs. 171000/ha with an additional income of Rs. 109000/ha over his existing rice farming by selling un-milled rice grain @ Rs. 4500/q which is around three times more than income he obtained from variety K-39 he used to grow earlier (Mubarak 2019 b). So identification of similar ecologies suitable for their cultivation and area expansion through agriculture extension machinery existing at district level will help increase the production of these varieties and boost the income of the farmers associated with rice farming by more than double.

## Future Prospects

Since Mushk Budji is highly susceptible to blast disease, farmers in the lower plains, despite great interest can't grow it as the microclimate in plains is congenial for outbreak of disease. Efforts made by the scientists of Mountain Research Center for Field Crops (MRCFC)-SKUAST-Kashmir has helped to achieve blast resistant version of Mushk Budji with almost same traits excluding blast susceptibility. MRCFC shall be coordinating with KVKS and agriculture Development department of Valley in near future for area expansion under new version of Mushk Budji after seed is available in plenty. Working on market linage is also equally important and for that processing, packing and branding is going to play a crucial role.


## Conclusion

Way the things are evolving and scenarios changing, conservation and cultivation of indigenous crop varieties is turning out to be very essential. Protection of plant varieties and Farmers' Rights Act 2001 is therefore a timely intervention by Government of India. In the background of changing climatic conditions and global trade, we must encourage and adequately appreciate the farming community in their quests to conserve the local land races and indigenous strains of different crops.

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# Border Crops: The Effective Strategy to Control the Diseases and Pests

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## Introduction

Border crops are being used since the early 1950's as a cultural control strategy but it has not gained such popularity till today. Though, it has colossal influence on crop cultivation in terms of protecting the main crop. Natural pest control offers a safer and much more sustainable approach for managing pest populations and excessive use of chemicals to the crops is hazardous to our health, keeping this in view use of border crops may be helpful for crop cultivation.

## What is border crop?

Border crops are those plants that are planted along the perimeter of a main cash crop field which act as barrier or wall to protect the cash crop from the attack of various insect-pests and hinders the spread of disease by disturbing the movements of the different vectors. Various findings suggests specific border plants for a particular cash crop. Maize, wheat, sorghum, garlic, mustard are some example of border crops used in different crop field.

## Important characteristics to be considered for selecting border crops

- An ideal border plant must attain enough height which is more than the main crop.
- It should be a non-host for the viruses of the main crop and also a non-host of the vectors that affects the main crop.
- It should attract the natural enemies of the occurring vectors and allow the vectors to probe before taking off. In that case, the vector loses its infectious virus charge (Toba *et al*., 1977; Difonzo *et al*., 1996).
- It should be green, well fertilized, well irrigated and attracting to the incoming vectors.
- Rough textured leaves of the border crop helps to prevent the entry of insects and vectors in to the main crop field.

## Sowing procedure of border crops

Generally sowing of the border crops are practiced one month before the main crop sowing or transplanting. During that phase the border crop attains required height to act as a barrier. Sowing should be done densely with minimum spacing. It may be single rowed or double rowed according to the requirement.

## Different types of border crops and their use

### For Chilli

One of the major diseases of chilli is the leaf curl disease. The vector of this chili leaf curl virus is white fly (*Bemicia tabaci*). To prevent the white fly infestation maize (*Zea mays*) or sorghum (*Sorghum bicolor*) can be used as border crop. Two to three rows of maize or sorghum is planted along the periphery of the main chilli field. This border crop is sown 25-30 days prior to the chilli transplanting. Along with the border crop, use of silver mulch in the chilli field helps in restricting this disease. Appropriate variety of

the barrier crop should be chosen so that it attains enough height and the variety must be suitable for that region.

The white fly cannot aviate above the 30 cm height from the ground level and its movement is restricted by the dense maize plants. The rough textured leaves of the maize also hinders the movement of the white fly. As a result, these flies cannot enter the main field and devastation of white fly is reduced.

**For Potato**

It is reported that Potato virus Y (PVY) is transmitted by at least 25 species of white fly worldwide. In 1996 Difonzo *et al*., examined that soybean (*Glycine max*) or sorghum can be used as protector crop against this aphids to reduce the spread of the PVY virus. In an experiment in Bangladesh, use of wheat (*Triticum aestivum*) and mustard (*Brassica rapa*) as barrier crop against the vector aphid was successful. It reduced the incidence of potato leaf curl disease.

**For Okra**

The major constraint in increasing per unit production of okra is the damage done by the insect-pests and diseases occurred through the vectors. Yellow vain mosaic disease of okra is one of the most devastating diseases. This yellow vain mosaic virus spreads through the white fly.

The symptoms of YVMV includes alternate green and yellow patches, vein clearing and vein chlorosis of leaves. The yellow network of veins is very conspicuous and vein and veinlets are thickened. Another insect leaf hoper also affects this crop severely. The leaf hopper sucks the sap from the leaves and gradually leaves become yellowish, crinkled. Sujayan and *et al.,* (2016) reported that using maize as barrier crop and coriander as intercrop reduced the infestation of both the YVMV and the leaf hopper in the okra field.

**For Cabbage**

Production of cabbage is hugely hampered by the devastating attack of the Diamond Back Moth (DBM) (*Plutella xylostella*). Hasheela *et al*., (2010) showed in her study that mustard and coriander resulted better as barrier crop than tomato, kale, radish in terms of reducing the number of immature DBM in cabbage field.

**For Chickpeas**

Chickpea is severely affected by the attack of cut worm, aphids and white flies. According to, Farhat *et al*., (2014), in her experiment, use of garlic plants as barrier crop along the periphery resulted successful against these insects.

**For Cucurbitaceous crops**

Cucurbitaceous crops can be protected from the attack of the fruit flies, aphids and white flies by using maize as a border crop.

**Advantages of using border crops**

Planting of border crops is a cultural technique to reduce disease pests with advantage of increase in yield of the main crop. According to Cerruti and Fereres (2006), these borders visually or physically hamper the movement or migration of insect pests into the main crop and can be helpful to reduce the spread and transmission of insect-vectored viruses. This border crops allows using less amount of chemicals. Although, the application of chemicals brings down the pest damages, but the residual effects of excessively used chemicals are one of major concerns. It is not only that but also the pests become resistant to commonly applied pesticides and this leads to the problems like pest resurgence, destruction of natural enemies etc. Wan *et al*., (2018) reported that the presence of a border crop and neighbouring crops (maize, eggplant and Chinese cabbage) increased predator richness, reduced the infestation of pests and dependence on insecticides and increased economic profits through increasing the production. With the practice of border crops, the cost of cultivation of chemical pesticides can be reduced and farming becomes more eco-friendly. Another very important aspect of planting barrier crops is the extra income generation from this

secondary plants. The produce quality is also improved by using the barrier crops, which enhance the export quality of the products. Along with this, the border crops help to reduce the soil erosion of the crop field.

**Limitations of using border crops**

Findings from several studies reported that protector plants can be effectively used to reduce yield loss caused by non-persistently transmitted viruses. Although, there are some limitations of using this approach. In case of perennial crops or crops grown through out the year may have continually strong virus load from year to year and barrier plants may not be very effective under these situations. However, under this circumstance selecting a barrier plant species that is attractive to natural enemies of the vectors may be helpful. It should be kept in mind that the barrier crop should not compete with the main crop in terms of nutrition uptake. If the main crop field is too large, the barrier plants may become unsuccessful to protect the entire crop field, so barrier plants may be planted in the inter rows of the main cash crop field. Proper care and management of the protector plants should be taken.

**Conclusion**

Vegetable production is a part of Indian farming system and this farming is very much susceptible to several insects and pathogenic factors. Among them, the losses by the attack of numerous insect pests and viral diseases are very much destructive. To reduce the pesticide load and to make the farming more environment friendly the use of border crops are very much helpful, not only that but it also can fetch extra money out of it. Ultimately, this healthy cultivation practice intentionally safeguards the ecological resilience of the farming systems and are a core component of sustainable food systems (Hamm 2009; Hoy *et al*., 2016).

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# Water Hyacinth Organic-based Fertilizer and Compost

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## Introduction

Over the last few centuries human activities have spread a large number of animal and plant species from one region to another. One of these species is the Water Hyacinth (Eichhornia crassipes) a free-floating aquatic invasive that is native to South America but is currently found in more than 50 tropical and subtropical countries around the world. Outside South America these Water Hyacinth lack natural enemies and this has allowed them to grow and spread uncountably, which is disrupting the local ecosystem and affecting the people that depend on ecosystem.

This is not an indigenous species but was introduced to India during the British colonial rule as an ornamental aquatic plant from south America because it produces beautiful purple flower that have high aesthetic value. But in no time the plant turned into serious nuisance.

Water Hyacinth "Terror of Bengal" referred to as the most problematic aquatic plant in the world's water can be successfully turned into useful organic fertilizer and compost enhancing the soil fertility as well as soil's productivity. Water hyacinth has been used as green manure and compost in various countries as stated by Henrylito and Tacio, 2001.

We can turn the threat to useful resource by making various products out of water hyacinth and it can generate income through the sale of those products helping small farmers and villages.

## Why Water Hyacinth is considered as weed?

**"The plant is far more productive than the crops that have been carefully cultivated by man under ideal conditions of fertilizers, irrigation and pest control"**

**– John Bunton.**

The invasive plant doubles itself within 5-15 days. They cover almost entire surface of the lake. Such rapid proliferation or growth threatens sunlight penetration into water. Water Hyacinth also reduces biological diversity, impacts nature submerged plants, alters immersed plant communities by pushing away and crushing them, and also alters animal communities by blocking access to water. It clogs waterways, making all other water activities impossible to perform.

Controlling the spread of water hyacinth through physical, chemical and biological method is not worth it because due to its nature, it travels fast and recovers faster in place than it has been removed. The best way to menace is by looking for weed uses and using it as a raw product for compost and biofertilizers.

## Why water hyacinth should be used to make organic fertiliser and compost?

Efforts to control the growth of water weeds were attempted by methods such as physical removal, chemical and biological control, but all of them failed miserably. researchers have realised that only hope lies in economic utilisation of these 'natural resources' by economically viable techniques the concept of eradication through utilisation.

Water hyacinth is a copious consumer of nutrient and it decays those nutrients back into the soil. However, the primary benefit is in the positive effect of the plant has on the soil texture. Water hyacinth has distinctive fibrous qualities and soil amended with water hyacinth fertiliser were more aerated and had superior moisture drainage than their chemically amended counterparts. These findings are encouraging in the face of so much unwanted, yet prolific water hyacinth growth.

**How to make a good organic fertiliser and compost with Water hyacinth?**

Making an organic based fertiliser and compost from the water hyacinth is extremely easy. The aquatic plants have relatively shallow roots so harvesting them from affected ponds, lakes or any standing water is simple enough. Once harvesting them, we need to dry them for several days. Once they are out of water, they die. Basic precautions should be taken during this process because the seeds of water hyacinth can disperse to some new place and can infest on another standing water. In windy or particularly moist climate it is recommended that the plants be dried on tarps in a location shielded from the winds; the water hyacinth can grow from the cuttings and is robust enough to make its way back to the body of water it came from if basic precautions are not taken during the procedure. The dried water hyacinth should be blended at a composting with ash, manure, animal waste and soil. Regular composting practices such as occasional turning and enclosing with wire in large, seal-able bin should be employed to speed the decomposition of materials. To improve the quality of water hyacinth organic based fertilizer and compost, it can be applied with the bio-activator *Trichoderma sp.* which functions to produce liquid bio- organic fertilizer with high nutrients for plant growth and production. Based on the results of various experiments, it showed that the dosage treatment of water hyacinth bio-organic fertilizer with the bio-activator *Trichoderma sp* had a significant effect on plant height, leaf width and the number of leaves .To increase the growth and production of agronomic crops and other horticultural cultivation processes, it is advisable to use liquid bio-organic fertilizer for water hyacinth with the bio-activator *Trichoderma sp* as an alternative to natural, environmentally friendly liquid organic fertilizer.

After 2- 3 months a rich, fibrous organic compost will be ready to be tilled into soil for fertilisation. The high nutrient content and unique aeration and drainage qualities will greatly enhance crop yield in amended soil while helping to clear away the ecologically damaging plants from the wild.

**Effect of water hyacinth based organic fertiliser and compost**

In current agricultural practices, farmers are way too much dependent on the chemical fertiliser. As a result, due to extensive use and improper use of chemical fertiliser in the soil is degrading to an alarming rate. To avoid it we can adapt ecologically oriented resource conserving technologies. Applying water hyacinth compost to the soil showed positive effects on the microaggregates of the soil. Water holding capacity also increases significantly with increasing content of water hyacinth compost in the soil.

On the other hand, water hyacinth organic fertiliser also increases the vegetative growth due to its high nitrogen content. Water hyacinth based organic fertiliser approximately contains abundant organic minerals (78%), mainly carbon (21%), nitrogen (0.28%), phosphorus (0.001%) and potassium (0.016%). These values may vary based on the origin and location of growth as well as the technique used to produce organic fertiliser. Regardless of the variation, all previous research found that carbon and nitrogen are the two most abundant

organic material available in water hyacinth based organic fertiliser. Due to its high nitrogen content and unique aeration and drainage qualities will greatly enhance crop yield in the amended soil while helping to clear away the ecologically damaging plant from the wild.

## Conclusion

Heavy usage of agrochemicals and pesticide for the growth of the crop are dangerous. To overcome this problem, agro-scientists are working on various biofertilizer and has come out with the new idea of water hyacinth.

The biofertilizer and compost made from water hyacinth has great potential. The need for more environment friendly agriculture practices like the use of compost and biofertilizer are necessity for this practice to be achieved. Compost made from water hyacinth is a source of biomass and has potential for providing a source of phosphorus and exchangeable potassium ion for crop production. Water hyacinth based organic fertiliser act as a source of nitrogen to the plant increasing the vegetative growth hence increasing the productivity of plant as well as soil.

The study recommends that the government should encourage the production of liquid organic fertilizer from hyacinth and involve the community in its production. This is because it is a better fertilizer than the chemically produced ones and it will not only empower the community economically but will help rid the lake of the menace of water hyacinth.

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# Drip Irrigation System: Water and Nutrient Conservation Approach to Sustainable Crop Production

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## Introduction

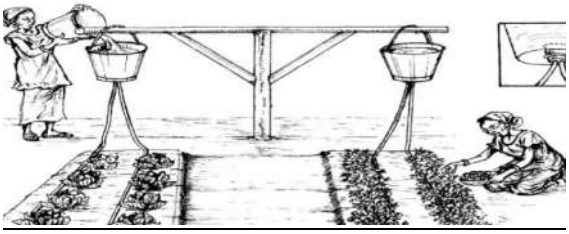
Drip irrigation system is a most efficient and modern technique of irrigation, this method is used in those area where there is a scarcity of water, In this technique generally water and nutrient are allowed to deliver directly to the root zone by controlling the pressurised water through valves of the P.V.C (Polyvinyl Chloride) drip pipes in such a way that it systematically irrigate the whole field drop by drop directly to the root zone, and saves water up-to 70% as compare to flood irrigation method.

**(Drip Irrigation System)**

Drip irrigation is a modern concept of irrigation in which generally water and nutrients are allowed directly reached to the roots zone drop by drop in the right amount. As the name implies drip irrigation which means irrigation is done by drops of water. It is also known trickle irrigation or a micro-irrigation system.

In this modern era this modern facility of irrigation are generally adapted for irrigation because it is very effective and efficient method of irrigation, as it also have the potential to save enough amount of nutrients and water up-to 70%, by allowing water to deliver systematically directly to the root zone of the plants.

In drip irrigation system, specially designed P.V.C. or Polyvinyl hose pipes having a diameter 13-32 mm are generally used to install this modern irrigation system, through these pipes water are allowed to reach directly to the root zone drop by drop of the plants, and helps the plants to grow un-effectively and efficiently. The main objective of the drip irrigation is to place water directly into the root zone and minimize the evaporation rate.



**(Ancient drip irrigation system)**

## History

Simcha Blass is known as a father of Drip irrigation system, this great invention has changed the world of agriculture by minimizing the use of water for irrigation and nutrients for development of plants. The very first Drip irrigation experimental system was established in 1959 by Simcha Blass, after 5-10 years he partnered later with Kibbutz Hatzerim in 1964, successfully they both created an irrigation company called Netafim.

This modern concept of irrigation was first adopted by Israel for cultivation, as there is a scarcity of water available in Israel, which is not enough for cultivation, to overcome this problem they adopt Drip irrigation method as this method consume less amount of water and nutrients and give good yield.

**(Drip by Drip water reaches to the root zone)**

## How does Drip Irrigation work?

Drip irrigation works by controlling the pressure of the water, which flows from the main water supply lines, tanks or a tube-wells to the drip irrigated pipes. With the help of drip irrigation system the pressurised water that diverts from the main line to the drip irrigated lines are controlled in such a way that drop by drop it irrigate the root zone of each and every individual plant through P.V.C pipes and saves the water in enough quantity and helps the plant to grow efficiently. Drip irrigation system was compiled with modern technology. After the installation it automatically controls the pressure of the water with the help of valves. Suitable pressure is used to irrigate the root zone of the plant accordingly; once the whole field get irrigated through drip system it automatically switched off the system which helps to prevent further loss of water.

## Why Drip Irrigation?

### Drip irrigation system help

- To save optimum amount of water and nutrients.
- It need less labour requirement as compare to other irrigation method.
- It efficiently utilise the water and nutrient with least loss as compare to other system.
- Chances of crop failure reduce.
- Drip irrigation helps to give better output in yielding.
- Less chances of weeds competition with crops.

## Requirement to setup Drip Irrigation System

**Station Pump :** Takes water from the main source and deliver it into the Drip irrigated pipes with right pressure.

**Control valves :** These valves are specially designed to control the pressure and discharge of water in the entire drip irrigated system.

**Filtration system :** This system helps to clean the entire water which flow into the drip pipes.

**Fertilizer tank :** This tank help to add accordingly measured doze of fertilizer into the water during irrigation.

**Mainlines/ Sub-line :** These are specially designed P.V.C or polyvinyl hose lines having a diameter 13-32(mm) which is used to supply water from the control head into the fields.

**Emitter:** Emitter device are used to accurately control the discharge of water from the lateral lines to the plants.

**Pressure gauge:** In this irrigation system this device is used to measure the pressure of the water which was flow in the entire drip irrigation system.

**Crops Suitable for Drip Irrigation System**

- **Orchard**–Grapes, Banana, Pomegranate, Orange, Mango, Lemon, Citrus, Guava, Pineapple, Papaya.
- **Vegetable-** Tomato, Chilly, Capsicum, Cabbage, Cauliflower, Onion, Okra, Brinjal.
- **Cash crops-** Sugarcane, Cotton, Strawberry.
- **Flower-** Rose, Carnation, Gerbera, Orchids, Jasmine.
- **Plantation-** Tea, Rubber, Coffee, Coconut.
- **Oil-seeds-** Sunflower, Groundnut.

**Merits of Drip Irrigation System**

- Crop grows consistently, healthy with good yield.
- It saves water up-to 70% as compare to traditional method of irrigation.
- It also enhances the yield of crop plants.
- It also minimizes the use of fertilizer doze.
- Cost of labour requirement, intercultural operations, Nutrients application also gets reduced.
- It also helps to enhance the infiltration capacity of the soil.
- Less chance of crop failure.
- Weeds are grown in less percentage.
- Minimize the effect of soil erosion.
- We can use recycled water efficiently.

**Demerits of Drip Irrigation**

- Initial investment is comparatively high to install Drip irrigation system.
- Having a high maintenance cost.
- Might be a chance of drip pipes leakage.
- Sometime P.V.C pipes are chocked or blocked.
- Need regular investment for replacing the Drip irrigation system entirely.
- Need high skilled labour to use this irrigation system.
- Solar radiation affects the pipes used in drip irrigation and shortening their usable life.
- This method of irrigation is not suitable for closely planted crops such as Rice, Wheat etc.
- The establishment of this system is different for each and every crop, so it is also considered as expensive method of irrigation.

**Conclusion**

Drip irrigation system mainly used in dry-land areas, where there is a scarcity of rainfall and water, like arid and semi-arid region. To overcome this problem farmers have to adopt this modern irrigation technique in dry land areas and have to take a one step towards Drip irrigation system, as this system need limited amount of water to irrigate the whole field drop by drop and also have a potential to conserve 70% of water as compare to flood irrigation.

In my opinion this is the best method of irrigation for dry land areas, all arid and semi arid region farmers have to adopt this method of irrigation for the effective and sustainable production of crops and plants.

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# Production Technology of Banana

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Introduction

Banana (*Musa paradisiaca* L.) is the second most important fruit crop in India next to mango. Its year-round availability, affordability, varietals' range, tastes, nutritive and medicinal value makes it the favourite fruit among all classes of people. It has also good export potential. Hi-tech cultivation of the crop is an economically viable enterprise leading to increase in productivity, improvement in produce quality and early crop maturity with the produce commanding premium price.

A banana is an elongated, edible fruit – botanically a berry – produced by several kinds of large herbaceous flowering plants in the genus *Musa*. In some countries, bananas used for cooking may be called "plantains", distinguishing them from dessert bananas. The fruit is variable in size, colour and firmness, but is usually elongated and curved, with soft flesh rich in starch covered with a rind, which may be green, yellow, red, purple or brown when ripe. The fruits grow upward in clusters near the top of the plant.

**Overview of Field**

## Origin

Banana evolved in the humid tropical regions of Southeast Asia with India as one of its centres of origin. Modern edible varieties have evolved from the two species– *Musa acuminata* and *Musa balbisiana* and their natural hybrids, originally found in the rain forests of Southeast Asia. During the seventh century AD its cultivation spread to Egypt and Africa. At present banana is being cultivated throughout the warm tropical regions of the world between 30°N and 30°S of the equator.

## Area and Production

Banana and plantains are grown in about 120 countries. Total annual world production is estimated at 86 million tonnes of fruits. India leads the world in banana production with an annual output of about 14.2 million tonnes. Other leading producers are Brazil, Ecuador, China, Philippines, Indonesia, Costarica, Mexico, Thailand and Colombia.

In India banana ranks first in production and third in area among fruit crops. It accounts for 13% of the total area and 33% of the production of fruits. Production is highest in Maharashtra (3924.1 thousand tonnes) followed by Tamil Nadu (3543.8 thousand tonnes). Within India, Maharashtra has the highest productivity of 65.70 metric tones /ha. against national average of 30.5 tones/ha. The other major banana producing states are Karnataka, Gujarat, Andhra Pradesh and Assam.

## Economic Importance

Banana is a very popular fruit due to its low price and high nutritive value. It is consumed in fresh or cooked form both as ripe and raw fruit.

Banana is a rich source of carbohydrate and is rich in vitamins particularly vitamin B.

It is also a good source of potassium, phosphorus, calcium and magnesium. The fruit is easy to digest, free from fat and cholesterol. Banana powder is used as the first baby food. It helps in reducing risk of heart diseases when used regularly and is recommended for patients suffering from high blood pressure, arthritis, ulcer, gastroenteritis and kidney disorders.

Processed products, such as chips, banana puree, jam, jelly, juice, wine and halwa can be made from the fruit. The tender stem, which bears the inflorescence is extracted by removing the leaf sheaths of the harvested pseudostem and used as vegetable. Plantains or cooking bananas are rich in starch and have a chemical composition similar to that of potato.

Banana fibre is also used to make items like bags, pots and wall hangers. Rope and good quality paper can be prepared from banana waste. Banana leaves are used as healthy and hygienic eating plates.

**Agro-climatic requirements**

Banana, basically a tropical crop, grows well in a temperature range of 15ºC – 35ºC with relative humidity of 75-85%. It prefers tropical humid lowlands and is grown from the sea level to an elevation of 2000m above m.s.l. In India this crop is being cultivated in climate ranging from humid tropical to dry mild subtropics through selection of appropriate varieties. Chilling injury occurs at temperature below 12ºC. High velocity of wind which exceeds 80 km /hr. damages the crop. Four months of monsoon (June to September) with an average 650-750 mm. rainfall are most important for vigorous vegetative growth of banana. At higher altitudes, banana cultivation is restricted to a few varieties like 'Hill banana".

Deep, rich loamy soil with pH between 6.5 – 7.5 is most preferred for banana cultivation. Soil for banana should have good drainage, adequate fertility and moisture. Saline solid, calcareous soils are not suitable for banana cultivation. A soil which is neither too acidic nor too alkaline, rich in organic material with high nitrogen content, adequate phosphorus level and plenty of potash is good for banana.

**Growing and Potential Belts**

The state-wise growing belts are given in the following:

| State | Growing belts |
|---|---|
| Andhra Pradesh | East Godavari, West Godavari, Kurnool, Cuddapah |
| Assam | Goalpara, Nagaon, Sonitpur, foothills of Garo hills |
| Gujarat | Surat, Vadodara, Anand, Kheda, Junagadh, Narmada, Bharuch |
| Jharkhand | Ranchi, Sahebganj |
| Karnataka | Bangalore, Chitradurga, Shioroga, Hassan, Chikka Mangloor |
| Kerala | Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha, Kottayam, Idukki, Ernakulam, Thrissur, Palakkad, Malappuram, Kozhikode, Wynadu, Kannur, Kasargod |
| Madhya Pradesh | Khandwa, Badwani, Khargaon, Dhar |
| Maharashtra | Jalgaon, Ahmednagar, Buldhana, Pune, Wardha, Dhule, Nanded, Parbani, Nandurbar, Satara, Sangli, Osmanabad, Buldhana, Akola, Yeothmal, Amravati, Thane, Kulara, Alibag |
| Orissa | Ganjam, Puri, Khurda, Gajpati, Cuttack, Dhenkanal, Angul, Sundargarh, Sambalpur, |

| | |
|---|---|
| | Bargarh, Deogarh, Koraput, Keonjhar, Raygada, Mayurbhanj |
| Tamil Nadu | Thoothukudi, Tiruchirapalli, Coimbatore, Tirunelveli, Karur, Erode, Kanniyakumari |
| West Bengal | Hooghly, Nadia, North 24 Parganas |

**Varieties Cultivated**

Commercially, bananas are classified as dessert types and culinary types. The culinary types have starchy fruits and are used in the mature unripe form as vegetables. Important cultivars include Dwarf Cavendish, Robusta, Monthan, Poovan, Nendran, Red banana, Nyali, Safed Velchi, Basrai, Ardhapuri, Rasthali, Karpurvalli, Karthali and Grand Naine etc.

Grand Naine, an imported variety from Israel is gaining popularity and may soon become the most preferred variety due to its tolerance to abiotic stresses and good quality Stalkes. Fruit develops attractive uniform yellow colour with better shelf life & quality than other cultivars.

Important banana varieties cultivated in different states of India are given below:

| State | | Varieties grown |
|---|---|---|
| Andhra Pradesh | - | Dwarf Cavendish, Robusta, Rasthali, Amritpant, Thellachakrakeli, Karpoora Poovan, Chakrakeli, Monthan and Yenagu Bontha |
| Assam | - | Jahaji (Dwarf Cavendish), Chini Champa, Malbhog, Borjahaji (Robusta), Honda, Manjahaji, Chinia (Manohar), Kanchkol, Bhimkol, Jatikol, Digjowa, Kulpait, Bharat Moni. |
| Bihar | - | Dwarf Cavendish, Alpon, Chinia, Chini Champa, Malbhig, Muthia, Kothia, Gauria |
| Gujarat | - | Dwarf Cavendish, Lacatan, Harichal (Lokhandi), Gandevi Selection, Basrai, Robusta, G-9, Harichal, Shrimati |
| Jharkhand | - | Basrai, Singapuri |
| Karnataka | - | Dwarf Cavendish, Robusta, Rasthali, Poovan, Monthan, Elakkibale |
| Kerala | - | Nendran (Plantain), Palayankodan (Poovan), Rasthali, Monthan, Red Banana, Robusta |
| Madhya Pradesh | - | Basrai |
| Maharashtra | - | Dwarf Cavendish, Basrai, Robusta, Lal Velchi, Safed Velchi, Rajeli Nendran, Grand Naine, Shreemanti, Red Banana |
| Orissa | - | Dwarf Cavendish, Robusta, Champa, Patkapura(Rasthali) |
| Tamil Nadu | - | Virupakshi, Robusta, Rad Banana, Poovan, Rasthali, Nendran, Monthan,Karpuravalli, Sakkai, Peyan, Matti |
| West Bengal | - | Champa, Mortman, Dwarf Cavendish, Giant Governor, Kanthali, Singapuri |

**Land Preparation**

Prior to planting banana, green manuring crop like daincha, cowpea etc., may be grown. The land can be ploughed 2-4 times and leveled. Ratovator or harrow is used to break the clod and bring the soil to a fine tilt. During soil preparation basal dose of FYM (about 50 tones/ha., before last harrowing) is added and thoroughly mixed into the soil.

## Planting

### Planting Material

About 70% of the farmers are using suckers as planting material while the rest 30% of the farmers are using tissue culture seedlings. Sword suckers with well-developed rhizome, conical or spherical in shape having actively growing conical bud and weighing approximately 450-700 gm are commonly used as propagating material.

Suckers generally may be infected with some pathogens and nematodes. Similarly due to the variation in age and size of sucker, crop is not uniform, harvesting is prolonged and management becomes difficult. Therefore, in-vitro clonal propagation i.e., Tissue culture plants are recommended for planting. They are healthy, disease free, uniform in growth and early yielding.

### Treatment of planting material

The roots and base of the planting material may be removed. The suckers are dipped in a solution of 0.5 % monocrotophos and bavistin (0.1%) before planting.

### Planting season

Planting of tissue culture banana can be done throughout the year as per the market demand except when the temperature is too low or too high. The planting time may be adjusted so as to avoid high temperature and drought at the time of emergence of Stalkes (i.e., approx. 7-8 months after planting). The planting time for long duration cultivars is different from short duration ones.

Thus, the important seasons for planting followed in different states of India are:

| State | Planting time |
|---|---|
| Maharashtra | • Kharif - June – July<br>• Rabi - October – November |
| Tamil Nadu | • February – April<br>• November – December |
| Kerala | • Rainfed- April–May<br>• Irrigated crop- August–September |

### Spacing

Traditionally banana growers plant the crop at 1.5m x 1.5m with high density; however, plant growth and yields are poor because of competition for sunlight. The region like north India, coastal belt and where humidity is very high and temperature falls down upto 5-7ºC, the planting distance should not be less than 2.1m x 1.5m.

| Season | Spacing |
|---|---|
| Kharif | 1.5 x 1.5 m., 2 x 2 m. or 2.5 x 2.5 m. |
| Rabi | 1.5 x 1.2 m., 1.5 x 1.37 m. |

Banana planting is carried out on the basis of patta double line method. In this method, the distance between the two lines is 0.90 to 1.20 m while plant to plant distance is 1.2 to 2 m. Due to this spacing, intercultural operations can be carried out easily and cost of drip irrigation is decreased. Experiments carried out recently show that good quality banana and heavy Stalk can be achieved by keeping the planting distance at 1.8 X 1.8 m. However, to get maximum yield plantation is done at 1.2 X 1.5 m.

High Density Planting: High density planting is in practice to accommodate 4444 to 5555 plants per ha. and yield of plants is recorded to be in the order of 55-60 tonnes/ ha., or even more. In general square or rectangular system of planting is a common practice followed by the cultivators. Planting 3 suckers / pit at a spacing of 1.8 x 3.6 m. (4,600 plants per ha.) for Cavendish varieties and 2 x 3 m., for Nendran (5000 plants per ha.) varieties are also followed.

### Planting Method

Pit planting is commonly followed in garden system of cultivation. A pit size of 0.5 x 0.5 x 0.5 m., is normally required. Small pits are dug in case of ridges and furrows. The pits are to be refilled with topsoil mixed with 10 kg of FYM (well decomposed), 250 gm of

neem cake and 20 gm of carbofuran. Prepared pits are left open for 15-20 days for solar radiation to kill all the insects, soil borne diseases and for aeration before refilling. In saline alkali soil where pH is above 8, pit mixture is to be modified incorporating organic matter and gypsum.

The suckers are planted in the centre of the pit and soil around is compacted. Plants are planted in the pits keeping pseudo stem 2cm below the ground level. Soil around the plant is gently pressed. Deep planting should be avoided. The field is irrigated immediately after planting.

Furrow planting is practiced in annual planting system in the states of Gujarat and Maharashtra. Trench planting is practiced in wet land cultivation of Cauvery delta region of Tamil Nadu.

**Nutrition**

Banana requires high amount of nutrients, which are often supplied only in part by the soil. Nutrient requirement (worked out on all India basis) is 10 kg FYM, 200 - 250gm N; 60-70gm P; 300gm K/plant. Banana crop requires 7-8 Kg N, 0.7- 1.5 Kg P and 17-20 Kg K per metric ton yield. Traditionally farmers use more of urea and less of phosphorous and potash. Urea is applied in three to four split doses.

About 100 g. of N/plant as top dressing in three equal split doses 60, 90 and 120 days after planting. Further application of 100 g. potash and also 40 g of phosphorus are essential and applied at planting. Application of full dose of P and K at planting and N in three equal doses in shallow rings about 8-10 cm. deep are recommended.

Application of 150 g. N in vegetative phase and 50 g N in reproductive phase enhances the yield. Application of 25% N as farmyard manure and 1 kg neem cake is beneficial. The application of 25 % N in organic form, 75 % N in inorganic form along with growing green manure crops is found to be beneficial. The requirement of phosphorus is comparatively low. Superphosphate forms the major source of P followed by the application of rock phosphate 50-95 g./ plant at planting. In acidic soils, triple superphosphate or diammonium phosphate is recommended. Phosphorus is applied in single dose at the time of planting and quantity of $P_2O_5$ depends upon the soil type and varies from 20 to 40 g. /plant.

Potassium is indispensable in banana cultivation due to its role in vital functions. It is not stored and its availability is influenced by temperature. Thus, continuous supply is required at finger filling stage. Application of K (100 g.) in two splits during vegetative phase and 100 g. in two splits during reproductive phase is recommended. Application of 200-300 g. $K_2O$ is recommended depending upon the cultivar. Plantains need higher K than other group of cultivars. Muriate of potash is generally used as a source of K. But in soils with pH above 7.5, potassium sulphate is advantageous.

Calcium influences yield through its interaction with N, P and K. In acidic soils, use of dolomite ($Mg_2CO_3$) and limestone ($CaCO_3$) as soil amendments is common.

In case of acute Mg deficiencies, foliar application of Mg $SO_4$ is found to be effective. Although sulphur deficiency in soils has been reported in some cases but is not a serious problem in case of banana. Sulphur uptake is active during sucker to shooting stage but after shooting sulphur supply comes from leaves and pseudostem.

**Fertigation**

In order to avoid loss of nutrients from conventional fertilizers i.e., loss of N through leaching, volatilization, evaporation and loss of P and K by fixation in the soil, application of water soluble or liquid fertilizers through drip

irrigation (fertigation) is adopted. A 25-30% increase in yield is observed using fertigation. Moreover, it saves labour and time and the distribution of nutrients is uniform.

**Micronutrients**

Combined foliar application of $ZnSo_4$ (0.5%), $FeSo_4$ (0.2%), $CuSo_4$ (0.2%) and $H_3Bo_3$ (0.1%) applied at 3,5 and 7 months after planting helps to increase yield and quality of banana.

**Irrigation**

Banana being a succulent, evergreen and shallow rooted crop requires large quantity of water for increasing productivity. Water requirement of banana has been worked out to be 1,800 – 2,000 mm per annum. In winter, irrigation is provided at an interval of 7-8 days while in summer it should be given at an interval of 4-5 days. However, during rainy season irrigation is provided if required as excess irrigation will lead to root zone congestion due to removal of air from soil pores, thereby affecting plant establishment and growth. In all, about 70-75 irrigations are provided to the crop.

Banana production should be supported by an efficient irrigation system like drip irrigation. Normal furrows, basin and trench systems are followed. Application of drip irrigation and mulching technology has reported to improve water use efficiency. There is saving of 58% of water and increasing yield by 23-32% under drip. Besides, the system also enables efficient fertilizer application through the fertigation technique.

**Drip Irrigation**

Application of irrigation through drip system helps to maintain the proportion of soil air and soil water which results in early and vigorous growth of Stalkes. Raw Stalk gets matured earlier by 30-45 days and yield is increased by 15-30 % and 58-60 % of water is saved on irrigation, weed is less, cost on intercultural operations is saved and water-soluble fertilizers can be applied.

Drip irrigation may be given @ 15 l. /plant /day from planting to 4$^{th}$ month, 20l. /plant/day from 5$^{th}$ month till shooting stage and 25 l./ plant/day from shooting till 15 days prior to harvest.

**Two methods are followed in case of drip irrigation**

**i) Single line system :** The spacing between the plants is 1.5 X 1.5 m. One lateral line and one dripper per plant is used.

**ii) Double line system :** The distance between the lines is 1 m., between two plants is 1.5 m and between two double lines is 1.8m each. One lateral and one dripper for two plants are arranged. The distance between the two lines may also be 2.1 X 2.4 m.

**Intercultural Operations**

The following inter-cultural operations are recommended for optimum productivity of the crop

i) Spraying of Glyphosate before planting @ 2 lit/ha is carried out to keep the plantation weed free.

ii) Four to five weeding's to be done whenever necessary.

iii) Harrowing the field three to four times to keep the soil loose. Earthing up should be done at 3-4 months after planting raising the soil level around the base of the plant by 10-12". It is better to prepare a raised bed and keep the drip line on bed 2-3" away from the plant. It also helps to protect plants from wind damage and production losses to some extent.

**Desuckering**

Removal of unwanted suckers is a critical operation in banana for reducing internal competition with the main plant. Small suckers are removed on regular basis upto 7-8 months.

### Propping

Due to heavy weight of Stalk the plant goes out of balance and the bearing plant may lodge and production and quality are adversely affected. Therefore, they should be propped with the help of two bamboos forming a triangle by placing them against the stems on leaning side. This also helps in uniform development of Stalk.

### Stalk cover & spray

Covering Stalk using dried leaves of the plant is economical and prevents Stalk from direct exposure to sunlight and also enhances the quality of fruit. But in rainy season this practice should be avoided. Sleeving of Stalk is done to protect fruits against dust, spray residue, insect and birds. Transparent and perforated polythene sheets with 2% (during cool season) – 4% (during summer season) ventilation may be used to cover Stalkes. This may be combined with neem cake application (1 kg/ha.). It increases the temperature around developing Stalk and also helps in early maturity.

Spray of monocrotophos (0.2%) after emergence of all hands is effective in controlling the thrips. Thrips attack discolours the fruit skin and makes it unattractive.

### Dehandling of false hands of stalk

Some incomplete hands in a stalk which are not fit for quality produce should be removed soon after bloom. This helps in improving the weight of other hands, finger size and improved skin: pulp ratio to meet the export standards.

### Mulching

Use of wheat straw and banana straw as a mulch material (12.5 kg/plant) in banana orchards is useful in increasing the stalk weight and conservation of soil moisture. The mulch is applied at the beginning of summer (February).

### Inter-cropping

Root system of banana is superficial and gets easily damaged by cultivation. Therefore, use of intercrop is not desirable. However short duration crops (45-60 days) like mung, cowpea and daincha are to be considered as green manuring crops. Leguminous crops, beetroot, elephant foot yam, ginger, turmeric and sun hemp may be grown as an inter-crop during the first 3-4 months. However, growing of cucurbitaceous vegetables should be avoided as they are bearer of viruses. In coastal regions of Karnataka, Kerala and Andhra Pradesh, banana is grown in coconut and arecanut plantations with tall cultivars.

### Growth regulators

In order to improve the grade of stalkes 2,4 D @ 25 ppm. (25 mg/l) may be sprayed after the last hand has opened. This also helps to remove the seeds in certain varieties e.g., Poovan and CO-1. Spraying with CCC (1000 ppm.) at $4^{th}$, $6^{th}$ month after planting and plantozyme @ 2 ml/l at $6^{th}$ and $8^{th}$ month after planting helps to achieve higher yield.

After full development of Stalk, potassium dihydrogen phosphate (0.5%) and urea (1%) or 2, 4 D solution (10 ppm.) is to be sprayed on the stalk so that banana size and quality is improved.

### Other farm operations

Other farm operations include the following:

- Removal of dry leaves (green leaves should not be removed).
- During the winter months if temperature goes below $10^{o}C$, growth of the plant is affected. Under such circumstances, irrigation is to be provided at night orsmoking is to be done by inducing fire.
- If neem cake of 1 kg. per plant is applied during winter months, the formationof Stalk becomes easier.

- Plantation should be protected from strong winds by growing tall plants alongthe farm border.
- Bamboo poles or eucalyptus poles are used for giving support to the banana plant.

**Plant Protection Measures**

**Insect Pests**

The insect pests mostly observed are root stock/rhizome weevil (*Cosmopolites sordidus*), stem borer (*Odioporus longicollis*), thrips, banana beetle (*Nodostoma subcostatum*), banana aphid (*Pentalonia nigronervosa*) and nematodes. Selection of healthy planting material and suitable intercultural operations apart from application of 0.04% endosulfan, 0.1 % carbaryl or 0.05 % monocrotophos depending upon the type of pest infestation have been found to be effective in controlling the pests.

**Diseases**

The main diseases reported are panama wilt (*Fusarium oxysporum*), anthracnose (*Gleosporium musarum*), leaf spot (Sigatoka) [*Mycosphaarella musicola* & *Cercospora musae*], shoot rot (*Ceratostomella paradoxa*) and viral diseases. Disease free planting material should be used and the infected plant parts destroyed. Spraying with 1 % Bordeaux, copper oxychloride or carbendazim in case of fungal infections has been found to give positive results.

**Harvesting and Yield**

Banana is harvested when the fruit is slightly or fully mature depending on the market preferences. For long distance transportation, harvesting is done at 75-80 % maturity. The fruit is climacteric and can reach consumption stage after ripening operation.

The planted crop gets ready for harvest within 12-15 months of planting and the main harvesting season of banana is from September to April. Stalkes attain maturity from 90-150 days after flowering depending upon variety, soil, weather condition and elevation. Stalk should be harvested when fingers of second hand from top are 3/4 rounded with the help of sharp sickle 30cm above the first hand. Harvest may be delayed upto 100-110 days after opening of the first hand. Harvested Stalk should generally be collected in well-padded tray or basket and brought to collection site. Stalkes should be kept out of light after harvest, since this hastens ripening and softening. For local consumption, hands are often left on stalks and sold to retailers.

The dwarf varieties are ready for harvesting within 11 to 14 months after planting while the tall varieties take about 14 to 16 months. After harvest of Stalk, only leaves are to be cut and plant system is retained for ratoon crop development. This improves the food supply and about 15 % can be saved on irrigation. For getting good quality banana, only 7 to 8 berries are to be retained in a Stalk.

First ratoon crop would be ready by 8-10 month from the harvesting of the main crop and second ratoon by 8-9 months after the second crop. Thus, over a period of 28-30 months, it is possible to harvest three crops i.e., one main crop and two ratoon crops. The yield of banana depends on a number of factors such as variety, plant density, management practices etc.

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**Harvesting of Banana**

**Table - 1: Variety-wise average yield of banana (tones/ha)**

| Varieties | Average yield (tonnes/ha) |
|---|---|
| Basrai, Rasthali | 40-50 |
| Shrimanti | 70 |
| Grand Naine | 65 |
| Ardhapuri, Meanyham | 55 |
| Hirsal, Safed Velchi, Red banana, Lal Velchi | 45 |
| Poovan | 40-50 |
| Monthan | 30-40 |
| Dwarf Cavendish, Robusta | |
| Champa & Chini desi | 50-60 |
| Nendran | 30-35 |

## Post Harvest Management

### Grading

Grading is mainly based on size, colour and maturity of the fruits. While grading, smaller fruits are separated from the larger ones in order to achieve uniform ripening. Immature, overripe, damaged and diseased fruits are discarded in the process of grading.

The fruits are generally harvested early in the season at a pre-mature stage to capture early market. Ethylene application is the best method to hasten ripening without loss in fruit quality and flavour. Mature fruits are ripened with lower doses of ethrel for uniform colour development (slow ripening under controlled condition at 15°-18°C).

### Storage

Mature green bananas can be stored for upto 3 weeks in ethylene free air or upto 6 weeks in a controlled atmosphere at 14°C.

### Packing

Wooden or cardboard boxes, rectangular in shape and bamboo baskets are used for packaging and transportation of fruits. In some cases, banana Stalkes are packed in old gunny bags wrapped with banana leaves. Due to poor packing quality the bananas deteriorate and fetch low price.

Packing of hands or dehanded fruits in polythene (about 100-gauge polythene bags with 0.2% holes) enhance the shelf life under room temperature as well as in cold storage, while polythene bags without perforations develop fungal infections due to high humidity.

High quality bananas are generally exported. Firstly, fingers are removed from the Stalk and washed in water. Then they are washed in dilute sodium hypochloride solution to remove the latex, dipped in 0.1 % of carbendazime solution and finally air dried. These fingers are graded on the basis of their length & girth and packed in plastic Corrugated Fibre Board (CFB) cartons having capacity of about 13 to 14.5 Kg. A suitable packing material like foam etc, may be used. These boxes are kept at 13-15$^0$ C temperature and 80-90% humidity having cold storage. Bananas can be stored in such controlled atmosphere in a cooling chamber for a period of 20-25 days. The bananas are to be exported via cold chain of shipment at 13$^o$C and refrigerated vans in the country.

**Transportation**

Road transport by trucks/lorries is the most popular mode of transport due to easy approach from orchards to the market. For distant markets rail wagons are used.

**Marketing**

Several intermediaries like wholesalers and commission agents, are involved in marketing of the fruit. Private traders carry out nearly 95% of the trade and even provide credit to farmers for cultivation, but at high rate of interest. Cooperatives account for the balance 5% of the volume of trade.

**Conclusion**

Banana should be planted in the same area for which it is suitable for better yield and quality. If it is not done, then, extra care should be given for managing optimum number of suckers, timely fertilization including micronutrient application and irrigation for better yield and quality of banana.

**The major sources for technology, as well as quality planting material are :**

- Assam Agricultural University, Borbheta, Jorhat-781013, Tel: (0376)-2340044.
- Indian Institute of Horticultural Research, Hessarghatta, Bangalore-560089, Karnataka, Tel (080)-28466471/6353.
- Horticulture Research Station, Assam Agriculture University, P.O. Kahikuchi, Guwahati-781017, Tel: (0361)-2840232.
- Regional Research Station, Mahatma Phule Krishi Vidyapeeth, Neemkheda Road, Jalgaon, Maharashtra, Tel : (0257)-2250986.
- Tissue Culture & Agricultural Services, Jain Irrigation Systems Ltc. Jain Plastic Park, N.H.No.6, Bansbari, P.O. Box-72, Jalgaon-425001, Maharashtra, Tel: (0257)-2258011/22.
- Mahabana, Krishi Utpanna Bazar Samittee, Jalgaon-425003, Maharashtra, Tel: (0257)2271150
- National Centre for Research on Banana (ICAR), Thogamalai road, Thayanur P.O., Trichi-620102, Tamil Nadu, Tel: (0431)-2618104/106.
- Department of Horticulture, Birsa Agriculture University, kanke, Tel: (0651)-2230691.
- Department of Horticulture, Horticulture & Agro-Forestry Research Programme (ICAR), Plandu, Ranchi, Jharkhand, Tel: (0651)-2260141, 2260207.
- Department of Horticulture, JNKUV, Jabalpur (Adhartal), Madhya Pradesh, Tel: 2480771 (PBX-345). 2481773(PBX-345).
- State Horticulture Farm, Adhuthurai, Thiruvidaimarudur TK, Thanjuvar district, Tamil Nadu.
- Directorate of Horticulture, Shivajinagar, Pune, Maharashtra-560003
- Directorate of Horticulture, Khanpara, Guwahati-781022, Assam.
- Directorate of Horticulture, Lalbagh, Bangalore, Karnataka.
- Assam Horticulture Society, Directorate of Agriculture Campus, Khanapara, Guwahati-22, Tel: (0361)-2333175.

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# Value Addition in Banana Pseudostem: Present Status and Future Prospects

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## Introduction

Banana (*Order: Zingiberales*; Family: Musaceae; Genus: Musa) is an important tropical and sub-tropical fruit crop grown all over the world. India is the largest producer and consumer of banana globally, producing about 30.46 million tons in the year of 2019 (FAOSTAT, 2021), contributing about 23% of world production. India is the largest producer of banana and the major producing states are Maharashtra, Kerala, Tamil Nadu, Gujarat, Bihar, West Bengal, Assam, Andhra Pradesh and Karnataka. Banana is commonly known as Kela in Indian sub-continent and regionally as Vazhappazham in Kerala, Vazhakkai in Tamil Nadu, Aratipandu in Andhra Pradesh, Kola in Bengali and Kol in Assam. Banana is a large perennial monocotyledonous herbaceous plant having height up to 9 m with a long pseudostem that arises from the underground rhizomes (Ghag & Ganapathi, 2018). The leaves are oval, elongated and dark green in colour with each plant producing a single inflorescence. The fruits are oblong and fleshy with very small black seeds (Imam & Akter, 2011). All parts of plantain plants namely fruits, leaves, pseudostem, rhizomes and inflorescence are useful. Thus, it is known as a 'Kalpatharu' in India, which is a Sanskrit term meaning 'wish granting tree'(Ghag & Ganapathi, 2018). The plant is traditionally used as a medicinal herb. The leaves serve as a wrap for cooking, wrapping and serving food in certain traditions. Pseudostem and inflorescence are ingredients in many traditional cuisines. Rhizomes and the outer layer of pseudostem are utilized as animal feed. The fruit part is most commonly used either as raw fruit or in desserts, breakfast dishes when it is ripened. Unripe fruits are used commonly in curries, fried chips etc. The banana fruit, peel and banana pseudo-stem from various species of banana have been reported to be rich in total carbohydrates, fibre and minerals especially potassium. The cultivation of plantain is mainly carried out for fruits and the other parts such as leaves, inflorescence, pseudostem, peels and rhizomes are practically wasted. However, currently they have gained the status of valuable by-products generated from banana cultivation (Padam *et al.,* 2014). It is estimated that, for each tonne of banana fruit harvested, approximately 4 tons of biomass wastes including rotten fruit, leaves, pseudostem, rhizome and fruit bunch stem are produced (Subagyo & Chafidz, 2018).That is, in a hectare, on an average about 60 to 80 tons of pseudo-stem alone. Conventionally, there are a few constraints in utilising them, for instance pseudostem and inflorescence are considered as a vegetable in certain cultures, but the acceptance is very limited when compared to other leafy vegetables due to discolouration and taste. The surface of the banana pseudo-stem is easily subjected to browning after harvest, which will affect the sensory evaluation and economic value of the banana

pseudostem made products. Other than the medicinal and culinary uses of banana, recent research identified plantain and its parts as a great source of phytochemical (Reddy & Hemachandran, 2014). Several applications of the banana pseudostem in functional food and nutraceutical industries have been explored.

**Banana Pseudostem**

Banana Pseudostem (BPS) constitutes a major part of plant biomass, which are wasted usually left in the plantation or incinerated. BPS is a rich source of fibre, total carbohydrate and cellulose (Saravanan *et al.,* 2011). Pseudostem is the part of plantain plant, which is formed by tight overlapping of leaf stalk one over another with a centre having tender core in a cylindrical shape. Plantain stem is a low-cost agricultural waste, which can be altered into certain value-added products in the current scenario.

**Banana Pseudostem applications**

At present, the banana pseudostem is dumped on road side or burnt which causes environmental pollution. The usage of agricultural wastes contributes to the concept of green technology and hence paves the way towards sustainable development. Moreover, it is an additional income for both small scale farmers and processing industries (Padam *et al.,* 2014).

**a. Natural fibre**

Some researchers have successfully demonstrated the use of banana pseudostem and leaves for extraction of fibres on a small scale. The pseudostem fibre is used for making several value-added products namely rope, cordage, fishing net, mat, packaging material, paper sheets, textile fabrics, bag, table cloth, handicrafts, absorbent, polymer/fibre composites etc. (Subagyo & Chafidz, 2018). The fibre is extracted by using a decorticator machine then retting and degumming process are done.

**b. Fuel**

Bioethanol can be produced from banana pseudostem by fermentation process. Similarly, through banana waste methane can also be produced using anaerobic fermentation.

**c. Substrate for edible**

Banana pseudostem can be utilised as a good substrate for edible mushrooms because of its high cellulose content.

**d. Heavy metal and dye**

Studies reported that banana pseudostem can be powerful absorbers of mercury and lead. Similarly, it is also reported that banana pseudostem adsorbed methyl red in aqueous solution.

**e. Organic manure**

Banana pseudostem outer peels are used as organic manure for banana plantations itself.

**f. Organic farming**

Since banana pseudostem is having a good water retention capacity it can be used in organic farming. It can be done through digging small holes in the banana stem with the help of a sharp object like a knife. Add a little soil and feel free to plant as required.

**g. Others**

Pseudostem can be used in pulp and paper industries due to its cellulosic content. The banana pseudostem fibre can also be used for ropes such as marine rope since this fibre has good resistance to sea water and has buoyancy properties.

**Banana Pseudostem: Food applications**

The banana central core finds use in South Indian cuisine. The tender core in the centre of the banana pseudostem is edible. In southern part of India, pseudostem is cooked both as gravy and stir fry seasoned with ginger, garlic, chillies, shallots with curry leaves and grated coconut. In Assam, a dish called kolposola is

prepared from young banana pseudostem. Some commonly prepared dishes using banana pseudostem and their recipes are stir fry, curry, soup, stew, thorgh onto and stem bajji. Recently, value added innovative products from banana pseudostem are developed from Central Food Technological Research Institute, Karnataka. Apart from this, the high value products viz. mordant from sap, microcrystalline cellulose powder from fibre and edible products like candy from central core can also be obtained (Desai *et al.,* 2016). Stem juice can be prepared with or without addition of other juices like lemon or grape and sugar or jaggery (Kumar & Reddy, 2015; Ravi *et al.,* 2011). Extensive studies are undergone to explore various possibilities of value addition of banana pseudostem. Banana pseudostem can be dried into powder and can be utilized for carbohydrate and mineral fortification in different bakery products like bread, biscuits, cookies and dairy products like Shrikhand, Paneer and cheese (Thorat & Bobade, 2018).

**Health benefits of Banana Pseudostem**

- Banana stem is a rich source of fibre and helps in weight loss (Chandrasekaran, 2012).
- Rich in potassium and vitamin B6.
- It helps to control obesity.
- It is said to be a diuretic and helps detoxify the body.
- It can be used as a source of starch, pectin, cellulose, natural dye, bio generation of flavours and nutrients like dietary fibre, carbohydrates and minerals (Padam *et al.,* 2014).
- It has less glycemic index and high dietary fibre and antioxidant content which is good for diabetes (Bhaskar *et al.,* 2011).
- In southern India, it is consumed as fresh juice to prevent kidney stones (Dawn *et al.,* 2016).
- Banana pseudostem powder is a well-known remedy for urinary disorders, stomach troubles like diarrhoea, dysentery and flatulence.
- The food products which are fortified by banana pseudo-stem powder served as nutraceutical food and these show nutritional improvement as well as prove as medicine.
- It is known to be nutritionally superior and associated with several health benefits.

Recently researchers are more focused on identification, quantification and isolation of different bioactive components present in the pseudostem which have potential nutraceutical applications. Few are listed in Table 1.

**Table 1: Studies showing potential nutraceutical activities of banana pseudostem**

| Variety/Species | Study/ Bioactivity | References |
|---|---|---|
| Musa spp. (8 cultivars) | In vitro Anti-oxidant activity | Saravanan & Aradhya, 2011 |
| Musa sapientum Linn. | In vivo Anti-diabetic and Anti-lipidemic activity | Dikshit *et al.,* 2012 |
| Musa parasidiaca Linn. | In vitro Anti-oxidant activity | Joyetal., 2016 |
| Musa acuminata | In vitro Anticancer activity | Nindia *et al.,* 2019 |
| Musa spp. (10 cultivars) | Antimicrobial activity | Jouneghani *et al.,* 2020 |

**Banana stem extracts**

Banana stem extracts having potential hypoglycaemic properties are traditionally used as anti-diabetic agents. A comparative study

among various plant parts of plantain plant for hypoglycaemic effect showed that the banana stem juice extract exhibited highest antidiabetic activity than other plant parts as fruit, rhizome and peels (Reddy & Hemachandran, 2014).

## Conclusion

Banana pseudostem is a by-product of banana plant which has a potential for providing profitable products. Banana pseudostem is an agro waste in plantain cultivation. So, there is a great possibility of utilising banana pseudostem in the food processing and other industries thereby providing an additional income for both small and marginal to largescale growers. In India, the fibres are being used for preparing handicrafts, ropes etc., which otherwise can be used for making fabrics, home furnishings and good quality papers. The presence of various bioactive components in the pseudostem enhances the nutritional quality as well as therapeutic values of the food products. Therefore, it will create a great opportunity for food science researchers to work on it. The current problem of agro waste management can also be solved through efficient utilization of banana pseudostem which will directly benefit the growers as well as have a significant contribution towards increasing the share of horticulture in overall agricultural GDP of India.

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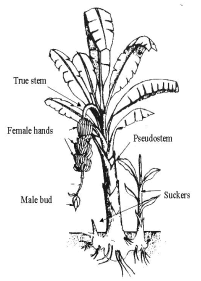
## Pictures




**Pic. 1. Banana Pseudostem (Source: FAO,2021)**

**Pic.2 Natural Fibre extracted from banana pseudostem**


**Pic.3 Banana stem green tea**

**Pic.4 Banana pseudostem sabji**

Pic.5 Different handicraft from banana pseudostem

Pic.6 Banana Pseudostem for growing veggies.

Pic.7 Banana pseudostem kept for drying

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# Common Storage Grain Pests and Their Management

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Introduction

In India, Agriculture is a way of life for nearly seventy percent of the population. The impressive growth registered in agricultural production made the country self sufficient with a record of food grain production of 315.72 million tonnes in 2021-22. Seed is the critical determinant of the agricultural production. Post harvest seed management is one of the vital components as there is a tremendous loss of the produce after harvesting and storing. Post harvest losses are huge at the farm and trade level, where nearly 70 percent of the farm produce is stored either for food, feed or seed. On an average, losses due to insects at storage are reported to be in the range of 10-20 percent but at times may be as high as 30 percent. In fact, insects cause the highest loss of grain. The damage created by insects on the grain can affect the farmers because their grain may lose value for marketing, consumption or planting. This article gives an overview of damage symptoms and management strategies of common storage grain pests.

**Classification of Pests:** The stored grain pests can be categorized as major or minor pests based on the severity of damage. On the basis of their feeding behavior, these can be grouped as internal and external feeders (Table no. 1 & 2).

**Internal feeders:** These insects mostly lay eggs inside or on the surface of grains, spend a part or entire larval and pupal life inside the grains and only emerge as adults. These contribute significant loss of germination which is not detectable outside e.g. rice weevil, maize weevil, granary weevil, pulses beetle, lesser grain borer etc.

**External feeders:** This group of insects feed on germ and endosperm from outside. These may attack whole seed and damage the germinal portion or feed on the seeds, which have already been damaged/infested by other insects or broken mechanically. These insects' pests or their stages are generally visible among the seeds e.g. Red flour beetle, Rice moth and khapra beetle etc.

**Table number 1**

| Common name | Scientific name | Family | Order |
|---|---|---|---|
| **Internal feeders** | | | |
| Rice Weevil | *Sitophilus oryzae* (L.) | Curculionidae | Coleoptera |
| Wheat Weevil | *Sitophilus granarius* (L.) | Curculionidae | Coleoptera |
| Maize Weevil | *Sitophilus zeamais* (Motsch) | Curculionidae | Coleoptera |
| Lesser grain borer | *Rhizopertha dominica* Fab. | Bostrichidae | Coleoptera |
| Mungbean beetle | *Callosobruchus maculates* | Bruchidae | Coleoptera |
| Cowpea beetle | *Callosobruchus chinensis* L. | Bruchidae | Coleoptera |
| Gram beetle | *Callosobruchus analis* | Bruchidae | Coleoptera |
| **External feeders** | | | |
| Red flour beetle | *Tribolium castaneum* (Herbst) | Tenebrionidae | Coleoptera |
| Confused flour beetle | *Tribolium confusum* | Tenebrionidae | Coleoptera |

| | | | |
|---|---|---|---|
| Rice moth<br>Khapra beetle<br>Indian meal moth | *Corcyra celphalonica* (Staint)<br>*Trogoderma granarium* (Everts)<br>*Plodia interpunctella* (Hubner) | Galleriidae<br>Dermestidae<br>Phycitidae | Lepidoptera<br>Coleoptera<br>Lepidoptera |

**Table number : 2**

| Hosts | Insects | Nature of damage | Illustration |
|---|---|---|---|
| Rice, Wheat, maize and other cereals in storage | Rice weevil: *Sitophilus* Spp., *oryzae*, *granaries* & *zeamais* | The developing larva lives and feeds inside the grain hollowing it out in the process. In rice (the preferred host) the entire grain is usually destroyed by the time the adult emerges. |  |
| Stored cereals and other stored foodstuffs | Lesser grain borer *Rhyizopertha dominica* Fab. | Both larvae and adults feed on the grains, usually from the outside, and in a rather haphazard manner. The adults are quite long-lived. They are both primary pests and can attack rice grains (paddy rice) more readily than *Sitophilus* spp. |  |
| Mungbean cow-pea, gram and other pulses | *Callosobruchus* spp., *maculates, chinensis & analis* | The larvae bore into the mungbean, cowpea or gram. Infestations usually originate from farm stores but the adult beetles can fly for up to about half a mile. The infested pods are then harvested and taken into the farm stores where further develo-pment takes place. |  |
| Maize, wheat and other stored grains. Many types of stored foodstuffs (alter-native). | Red flour beetle *Tribolium castaneum* (Herbst) | Infestation is apparent by the appearance of adults on the surface of the grain; there is extensive damage to previously holed or broken grains, or grain |  |

| Hosts | Insects | Nature of damage | Illustration |
|---|---|---|---|
| | | damaged by other pests. Damage is done by both larvae and adults. | |
| Flour, animal feed and other ground material | Confused flour beetle: *Tribolium confusum* | The adult resembles that of the red flour beetle and is difficult to distinguish without a microscope or magnifying glass. Larvae and adults feed on flour, animal feed and other ground material. |  |
| Rice, jowar, other millets, whole cereals, cereal products, dals, processed products of cereals, pulses, oilseeds, nuts, dry fruits and milled spices | Rice moth *Corcyra cephalonica* (Staint) | Larva is only responsible for damage. It pollutes food grains with frass, moults and dense webbing. In case of whole grains, kernels are bound into lumps up to 2 kg. It is more common in dark stores. Infestation is normally limited, to upper 45 cm only, in bulk grains. |  |
| Cereals and groundnut (main). pulses, spices and various cereal and pulse cakes (alternative). | Khapra beetle Trogoderma granarium | The larvae bore in the stored cereal grains and pulses, usually hollowing out the grain. Development is rapid in the hot humid tropics and very large populations may build up quickly. The pest is fairly polyphagous and can survive in facultative diapause for a year or longer in the absence of food. |  |
| Stored grains (main). Other plant and animal stored products (alternative) | Indian meal moth *Plodia interpunctella* | The adult moth is distinctive, with the outer half of the forewings a coppery-red separated from the creamy inner half by dark grey bands; body length is 6-7 mm and wingspan is 14-16 mm. |  |

**Losses caused by insects**

**a. Weight loss:** Estimates of the weight loss as a result of insect feeding vary widely with the commodity, locality and the storage practices involved. For grain legumes in the tropics, stored under traditional conditions, a loss in the range of 10-30 percent might be expected over a full storage season. Loss in quality/market

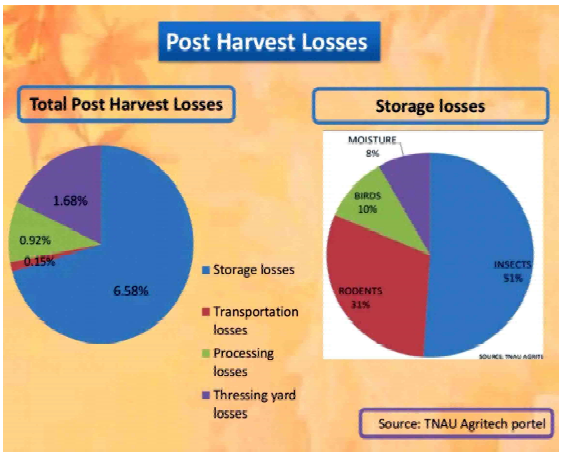
**b. Value:** Infested produce contaminated with insect debris has increased dust content. Grains are holed and often discolored. Food prepared from infested produce may have an unpleasant odour or taste.

**c. Promotion of mould development:** Insects, moulds and the grains themselves produce water in respiration, i.e., a breakdown of carbohydrate substrate. In humid conditions, without adequate ventilation, mould development and "caking" can spread rapidly, causing severe losses.

**d. Reduced germination in seed material:** Damage to the embryo of the seed will usually prevent germination.

**e. Reduced nutritional value:** Removal of the embryo by storage pests will tend to reduce the protein content of the grain. Thumb rules in management of storage pests:

- One percent reduction in seed moisture doubles the
- Reduction of 10 F temperatures nearly doubles the storage life.
- Good seed storage is achieved when the per cent relative humidity in storage environment and temperature in F add to hundred Eg. 50 percent and 50 F.




**Post harvest Losses**

**Management of Common Storage grain pests**

Management of insect pests of stored seed: Among the present methods of insect control, following are the important methods which can help in safe storage of food grains particularly at farmer's level (Gahukar, 1994).

- Preventive measure
- Curative measures

## Preventive measures

"Prevention is better than cure". Hence, the following preventive measures are recommended.

**I. Sanitation and handling of grains**

- Remove dirt, debris, mud balls, foreign particles, insects and infested grains from
- Healthy grains that will reduce insect infestation.
- Proper handling of grains and avoiding hooks on storage bags help minimize exposure to insects
- Bags should be stacked on wooden dunnage 0.5 metre away from the wall
- Bags should be stacked in rows having space of nearly 2 to 3 metre in-between height of a row should not be more than

15 bags leaving about 1/5th space of total storage from the roof.

- Likewise bulk storage structures should also be kept away from the ventilators or doors.
- Drying of grains. Grains are harvested at a moisture content ranging from 20-28%
- Moisture content should be brought to 12-13 percent
- Staggered sun drying with short exposure to sun spread over large number of days (9-11 am for 8 days) reduces insect infestation.
- Use of improved storage structures Gunny bags or jute bags with close weaves can reduce insect infestation.
- Polyester- polythene 400 gauge lined canvas was found to be resistant to all types if insect attack.
- Improved storage structures namely aluminum bin, Pusa bin, Pusa cubicle PAU bin, IGSI domestic bin

**II. Dis-infestation of stores/receptacles**

- Treatment of bulk and bag storage structures with insecticides is an important practice to avoid latent infestation in reused bags and bulk storage structure.
- The insecticides commonly recommended are malathion and dichlorvos.
- Legal method In India, the Destructive insects and Pests Act started in 1914.
- Plant Quarantine Order 2003; govern the regulation or restriction of movement of insects through commodities into the country and among different areas within the country.
- Grains or other commodities are thoroughly checked and treated at ports to avoid entry of insects.

## Curative measures

The infestation of stored grain insect pests can be controlled by the following methods :

**Non-chemical control measures**

**Chemical control measures.**

**I. Non-chemical control measures**

- Optimal temperature for most of the storage insects is between 25 and 33°C.
- High temperatures of 35°C and above will stop development.
- Maintain store house hygiene brushing the cracks, crevices and corners, removing all debris and cleaning the entire godown before storing the grains.
- Reduce moisture content below 10 %.
- Dry all the bags, bins etc in the sun.
- Neem leaf powder, Nochi leaf powder, turmeric powder, Sweet Flag (Vasambu) Rhizome powder all at 10g /kg have been found to be effective against storage pests.
- Kernels infested with primary feeders such as *Sitophilus* sp. *R. dominica* break apart and are separated from intact kernels.
- Other traps: Probe trap, Pulse Beetle Trap, Light traps, Sticky traps, Bait traps, Pheromone traps and TNAU Automatic Insect Removal Bin.
- Garlic extract is yet another plant product which is nontoxic and was found to be grain protectant.

**II. Chemical control measures (Fumigation)**

- Decide the need for shed fumigation (entire store house or godown) or cover fumigation (only selected blocks of bags).
- Atmospheric fumigation of seeds with ethylene dichloride-carbon tetrachloride against stored grain insect- pests:

- Preparation of the fumigant e.g., Ethylene Dichloride-Carbon Tetrachloride (EDCT) which is mixture of two in the ratio of 3:1 (by volume). For the preparation of one litre of the mixture, 250 ml of ethylene dichloride is put in the bottle. To this, 750 ml of carbon tetrachloride is added. It is mixed thoroughly and stored in a brown bottle.
- Atmospheric fumigation is generally done for 48 hrs to facilitate proper penetration of the fumigant and it also saves the fumigant as the dose depends upon the concentration x time product, i.e., 320mg/ liter for 48 h and 640mg/ lit. For 24 hours.
- Aeration or ventilation of fumigant after treatment is essential so as to remove the fumigant from the space and the material for the safety of the commodity as well as the environment.

**NOTE:** Never mix synthetic insecticides with grains meant for consumption.

## Conclusion

The present work on "Common storage grain pests and their management" was undertaken to study different storage grain pests causing both internal and external damage and the management using preventive and curative measures technique was verified. The objectives of the study were to detect the pests associated with the seed material and to study methods for their management.

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# Way of Farm to Fridge : Role of Value Addition in Agrarian Farming System

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## Introduction

India we all know is being recognized for its rich heritages and as a Agriculture dependent economy. Where agriculture shares 18.8% of country's GDP. India plays a key role in providing food and nutrition to its own as well as world's increasing population. India we all know is the largest producer of fruits and 2nd largest producer of vegetable in the world, also has a rich story of processing which is evident in many past narratives, where the use of techniques likes drying, fermentation, use of salt, sugar, spices etc., have been mentioned and are so commonly integrated in our daily life. With the advancement of time people have started preferring more packaged products/foods. There are many factors behind this trend like increasing per capita income, urbanization, increasing population etc. Also a clear trend exists towards diets that include more animal products such as fish, meat and dairy products, which in turn increases the demand for feed grains (FAO, 2007).

So, these are the favourable and most suitable factors to support the value addition trends. Value addition emphasizes on the consumers preferences of what they have to like from a given agricultural produce. It is also said that "Value addition is more about the consumer pull than the suppliers push." Combining all these factors like increasing the demands of the consumer, large population, high per-capita income etc., we can fetch more money to the pocket of the primary producer i.e., farmers.

## Value Addition and its role in diversified farming system

The term diversified farming system does not only include the growing different crops but also including different enterprises at the same time. This includes cultivation of fruits, flowers and vegetables, animal husbandry, sericulture, apiculture and so on. Besides giving a good return on the investment, these are best suited even for smaller farmers with limited resources. This diversification in the farming system reduces the loss of the farmers as well as guaranteed their income. The indulgement of value addition here at every steps, from harvesting of the produce to reaching in the hands of consumers satisfying their needs will ultimately benefits the farmer's income.

## Value Addition and its role in terms of food processing industry

The demand of packaged foods, juices, squashes etc., in the Indian market is increasing day by day. As we see many big players are coming in this market of food processing. This shows that how this industry is going to flourish in recent years. The area and the markets need to be identified, with proper market study. On the similar note, today, food processing industry plays a key role in providing an employment to number of people. The Indian domestic food market is expected to grow $344 billion by 2025 (Annapoorna, 2011 & Merchant, 2008). This increasing trend would certainly open the employment opportunities among the farmers and promises as an income enhancing potential.

**Food processing sectors and its products**

| Sectors | Products |
|---|---|
| Dairy<br>Fruits and Vegetable | Whole milk powder, skimmed milk, butter and ghee, cheese Beverages, juices, concentrates, pulps, slices, frozen & dehydrated products, potato wafers/ chips, etc. |
| Grains & Cereals | Flour, bakeries, starch glucose, cornflakes, malted foods, vermicelli, beer and malt extracts, grain based alcoho. |
| Fisheries | Frozen canned products mainly in fresh form. |
| Meat & Poultry | Frozen and packed –mainly in fresh from egg powder. |
| Consumer Foods Snack food | Namkeens, biscuits, ready to eat food, alcoholic and non alcoholic beverages. |

## Challenges

As any other sector this value addition sector also faces many challenges. The most important is the inadequate supply and chain system. India is still a developing country, it does not have adequate organization to ensure this supply – chain mechanism. Marwaha *et al.,* (2009) highlighted the challenges faced by potato processing industries as they have to make strategies to ensure round the year supply, specific breeding programme for the processing varieties, finding of low-cost alternative storage technology for the potatoes. In Fruit industry there is lack of storing facilities, post harvest handling and skilled labors. Mushroom industry with a high demand is facing lack of mushroom spawns, high costs of inputs like sawdusts, labors resources etc. like wise in the flower industry we still don't have refrigerated transporting system for long distance transportation. Like wise in any industry this industry is also facing the challenges, these challenges will itself diminishes as the demand start increasing and with the entry of big well establishes enterprises.

## Opportunities and scope

We are still lagging in term of processing of the food products when compared to other countries as it has been marked that only 6 percent of the food produced in India is properly processed which is much lower than in China (40 percent) and Malaysia (80%). According to the Ministry of Food Processing Industries, the processing levels are at mere 2 percent in fruits and vegetables, 15 percent in milk, 4 percent in fish and 2 percent in meat and poultry. The unorganized sector and small players dominate the sector and process more than 70 percent of the industry output in volume terms and 50 percent in value terms. This shows there is huge lack in the demand and the supply. The market is still waiting for huge investments in this sector to meet the demand of such a large population. The unorganized sector is playing a big role to meet demand in present scenario, but this sector has its own limitations like capital, ecosystem, infrastructure etc. One of the report suggest that Indian farming community incur the losses equal to 92,600 crore Rs. /year. The main reason for losses has been assigned to the low level of processing of the agricultural commodities. Emphasis should be given on the small and marginal enterprises in the village areas and to establish the micro-enterprise by promoting them and giving subsidies. These way farmers will have a very easy and efficient way to sell their produce at their own levels. We need to integrate the technologies such as electronics, material science, computer,

biotechnology etc., to further strengthen the knowledge base and for the advancement in the area. Opening of global markets leaded to export of our products as well as developed technologies and facilitate generation of additional income and employment opportunities. (Singh *et al*., 2012) One of the most efficient ways to increase the farmers income in this whole process is that only when they themselves would participate in the whole process and this will eliminate the unnecessary middle man in the whole value chain of the processed food. Given the opportunity in the sector, this would also reduce the over dependence over the farming as a single source of income

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# Scope of Fruit and Vegetable Carving: An Innovative Pathway towards Generating Employment in Urban Horticulture Sector

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## Introduction

Fruit carving is the art of sculpting fruit, a very common technique in Europe and Asian countries particularly popular in Thailand, China and Japan. Carving art on the fruits and vegetables has become the sign of attraction for the guests attending the parties. There are many fruits that can be used in this process; the most popular one that artists use are watermelons, papayas, muskmelons, pineapples etc. Regardless of its origins, fruit and vegetable carving is flaunted in many different Asian restaurants, cruises, hotels and other various places. In the mid-20$^{th}$ century, this art of vegetable carving began to grow outside Asia. Since then, other cultures have slowly come to appreciate the beauty and culture associated with the practice. Today, one can marvel at vegetable carving throughout the world. Irrespective of the occasion and place, fruit and vegetable carvings find a prominence. They are not easy to make and are a testimony to the skills and talents of the artisans carving it. In most cases, these specialized artisans have taken formal training from culinary institutes and this gives them a hold on the basic techniques. The rest is up to their imagination and practice. Artisans carve fruits and vegetables about three hours before the event starts and they leave it in cold water for the carvings to set. The tools they need to carve include cutting board, small and medium sized knives with sharp edges, a sharp peeler with preferably an oval edge, bells pins, tooth picks and dry sticks used to represent the stem of flowers. With these tools, the artisan is all set to run his or her imagination wild and come up with a variety of flowers, baskets, insects, birds, animals, toys and just about anything that is appropriate for the occasion. Other than restaurants, one can see carvings done by artisans in all major food festivals today. In some cultures, fruit and vegetable carvings are displayed in formal gatherings and in private parties. In India, for example, one can see fruit and vegetable carvings displayed in many wedding halls just before guests enter the dining area. The idea behind such display is not only to show the skills of the artisans, but also to entice guests to enter the dining hall. Some chefs believe that a visual display of food triggers taste buds and helps guests to better relish their food. For these reasons, it is common to find different carvings on the entrance of dining halls in Indian weddings.

## Present Scope

The demand for fruit and vegetable carving is increasing day by day as the people are looking towards alternatives that are livelier and more attractive to decorate in the functions. The abundance of fruits and vegetables throughout the year even in the off-season has been achieved due to advanced

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All the pictures are original work done by Mr. K. Sai Teja (first author)





caterers, hotels and resorts. On a smaller scale, fruit carvers can present a dish with decorative garnishing to add an aesthetically pleasing experience to their viewers.

**Future Prospects**

Rural women, self-help groups, FPO (Farmer Producer Organizations) can be trained with the art of fruit and vegetable carvings to propagate the skill in this field which helps them to generate income as an association. Several food carving competitions are being held across the world which brings the artists great reputation and opportunities to work with some of the biggest events, restaurants and ceremonies. The art of carving fruits and vegetables is eternal and has a never-ending horticultural techniques which overcome the problem of non-availability of raw materials for carving. There are very less artisans who are experienced in this art and there is lot of scope in training through workshops and symposiums. Once fruit carvers have mastered the techniques past the intermediate stage and become professionals, they can price their services to restaurants, professional

demand. In short, when you see a carved fruit or vegetables the next time, spend a few minutes to admire its beauty and intricacy. It will not only give you a glimpse into the culture, but will also make the artisan happy.

## Limitations

The major obstacles of fruits and vegetable carvings include the lack of quality raw materials, pattern designers, transmission of knowledge and creating added value. Quality fresh fruits and vegetables are needed so that the finished carvings can be kept and displayed longer which also depends on the atmosphere and time period where the carvings will be displayed. Fruits and vegetable engravers lack experience and consistency in their art forms where there must be a consistent balance in the lines, patterns, shapes, weight, colour and texture. The lack of understanding these factors result in underdeveloped carvings and development of patterns. The limited time available to prepare the carvings has limited the designs and patterns for each venue. The transmission of knowledge between artisans is still limited due to the closure and unwilling transfer of knowledge from senior artisans. The limited transfer of knowledge and skills due to competing attitudes of modern society has led to inefficient development of fruit and vegetable carvings and lack of apprentices.

## Conclusion

Although there are many limitations to the art of fruit and vegetable carving, their lies an immense potential in this sector towards employment generation for Indian youth in urban well as peri urban horticulture sector. For a developing country like India by adoption of this unique art will help us towards building our entrepreneurship and contribute towards the national GDP in horticulture sector.

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# Bio-Chemical Changes during Growth and Development of Punjab Nectarine Fruits

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Introduction

Fruit development involves many physical changes such as change in fruit size, fruit weight, fruit skin colour, stone size, firmness and bio-chemical changes including texture softening, production of flavour volatiles, wax development on skin and change in carbohydrate composition, organic acids, sugars and proteins. During development the composition of fruit is altered either due to formation of new compounds or degradation of others. Out of the various bio-chemical and physical changes, changes in flavour, colour and texture are of utmost importance, for the acceptability of the fruit. During fruit development there is development of the enzymes to catalyse the formation of pigments. The main pigments formed and accumulated are β-carotene, xanthophyll, anthocyanins and lycopene. The green colour loss is due to the degradation of chlorophyll. The main factors responsible for chlorophyll degradation are pH changes (mainly due to leakage of organic acids), oxidative systems and enzyme chlorophyllase. The increase in flavour and aroma during fruit development is attributed to the production of a complex mixture of volatile compounds and degradation of bitter flavanoids, tannins and other related compounds. The alcohols and aldehydes are generated after metabolism of their corresponding amino acid of sugar.

The tannins (secondary metabolite) and other phenolic compounds, present in fruits impart astringency (slight acidity or bitterness of taste). Small amount of astringency is essential to the taste of many fruits but the high levels found in unripe fruits make them unacceptable. During fruit development, the tannins are either partially broken down or polymerized into products which are not astringent. The maturity induces the breakdown of carbohydrate by carbohydrates and leads to conversion of starch to sugars. The increase in sugar makes the fruit much sweeter and therefore more acceptable. The acidity decreases as organic acid are utilized in respiration of fruits. The breakdown of polysaccharides by enzymes not only gives the typical sweetness, but also provides precursors for many aromatic flavour compounds. Textural change is the integral part of ripening, which is the result of enzymatic degradation of structural as well as storage polysaccharides. Fruit texture is influenced by various factors like structural integrity of the primary cell wall and the middle lamella, accumulation of storage polysaccharides and the turgor pressure generated within cells by osmosis. Change in turgor pressure, and degradation of cell wall polysaccharides (pectin, cellulose and hemicelluloses) and starch determine the extent of fruit softening.

**Changes in Total Soluble Solids (TSS) content (º Brix)**

There were little changes that took place in the soluble solids content during maturation of non-melting flesh cultivars were observed by Brovelli *et al.,* (1998). The result concluded that in Oro 'A', TSS had slightly increased from 10.12 to 11.47 in harvest 2, while in (FL 86-20 C) TSS slightly changed from 10.8 to 11.9 in

harvest 2. Kader (1999) considered mean values of SSC over 10º brix as a minimum value for consumer acceptance for yellow- flesh nectarine. Bhatnagar and Kaul (2002) investigated that the total soluble solids varied from 13.40º B in Shan-e-Punjab to 13.80º B in Flordasun mature peaches.

Park and Kim (2002) observed that soluble solids contents increases with the fruit maturity in peach fruits. According to Farina *et al.,* (2006), the soluble solids contents decreased exponentially at commercial harvest date in Fairtime peach. Crisosto *et al.,* (2003) reported that in nectarine cv. Spring Bright fruit soluble solids concentrations varied from 8.0 to 16.0 % with a mean of value of 11.0 % whereas, in Elegant Lady cultivar of peach, soluble solids concentrations varied from 9.0 to 15.0 % with a mean value of 12.4 % and considered 12 % SSC as a threshold value that assess a high acceptability of nectarines and peaches. Cascales *et al.,* (2005) revealed that total soluble solids content increased significantly during maturation from 11.5º brix in the green/unripe state to 13.1º brix in the ripe state.

The fruits of nectarine cultivars 'Venus' and 'Maria Dolce' were harvested and separated in two ripening stages by ground colour *i.e*, green ($M_1$) and yellow ($M_2$) by Infante *et al.,* (2008). They found that in 'Venus', SSC content at harvest did not exceed 10.3 %. On the other hand, fruits of 'Maria Dolce' showed a quite high score (14.0 %) for SSC even on $M_1$ and it further increased to 16.4 % at $M_2$. The significant differences were observed by Cantin *et al.,* (2010) among peach and nectarine progenies for Soluble Solids Content (SSC). The SSC values ranged from 7.6 to 24.6º Brix among these progenies. The highest value (24.60º Brix) was recorded by a seedling derived from the cross between 'Venus' (an acid nectarine) and 'Big Top' (non-acid nectarine). Abidi *et al.,* (2011) reported that the F1 progeny of 'Venus' x 'Big top' showed values of SSC from 11.2 to 17.5º brix with a mean of 13.9º brix, which is greater than the minimum (8º brix) established by the EU to market peaches and nectarines.


***TSS of immature Punjab Nectarine fruits***


***TSS of mature Punjab Nectarine fruits***

Abrol *et al., (*2015) observed that the Total Soluble Solid (TSS) content of nectarine fruits increased with a progressive increase in harvesting dates. The lowest TSS values were recorded on the first harvesting dates and these values increased gradually with each successive harvest and became maximum by the last harvesting dates. During the 7 day ripening period the maximum TSS content was observed in fruits that were sampled on the 5th harvesting dates in all the cultivars viz., May Fire (12.5° B), Snow Queen (12.2° B), Silver

King (12.1° B) and Red Gold (12.3° B). The Total Soluble Solids (TSS) of Punjab nectarine fruit showed a continuous increase throughout the growth and development. There was a rapid increase in TSS level with the advancement of harvest maturity stage due to conversion of polysaccharides (cellulose, starch) into monosaccharides (glucose, fructose) and disaccharides (sucrose, lactose, maltose) sugars were reported by Mishra *et al.,* (2018). This has been related to accumulation of glucose, sucrose and high levels of fructose. Chander *et al.,* (2004) reported that increased level of TSS during development was a result of translocation of photosynthates from leaves to fruits because leaves are the manufacturing sites of carbohydrates.

**Changes in Titratable acidity (TA) content (Percent)**

Robertson *et al.,* (1991) demonstrated that titratable acidity, quinic and citric acids decreased with increased degree of maturity of peach cv. Majestic. However, malic acid increased with maturity throughout grade 1 to grade 5 and then decreased to 0.59 %. While studying the changes in metabolites during the fruit development of two greenhouse grown peach cultivars, Moing *et al.,* (1998) noticed that the two major organic acids in both cultivars were malic and citric acid. The fruits of Ferjalou-Jalousia did not accumulate malic and citric acids during their development. The acidity of 'Jalousia' increased sharply up to 410 meq $L^{-1}$ at 110 DAB and then decreased to 220 meq $L^{-1}$ at 125 DAB. Thus the fruits of Fantasia had normal acidity, while Ferjalou-Jalousia had fruits with low acidity at maturity. Babu and Yadav (2002) observed that fruits harvested at 82-96 days after fruit set had the lowest titratable acidity (0.67 %) in peach cv. Shan-e-Punjab. They also observed that there was no significant increase in fruit quality after 82 days after full bloom in Shan-e-Punjab cultivar of peach grown under Meghalaya conditions. The titratable acidity of 0.58 % and 0.61 % were recorded in Flordasun and Pratap cvs. of peach at ripening stage by Bhatnagar and Kaul (2002).

Crisosto *et al.,* (2003) reported that in nectarine cv. Spring Bright fruit titratable acidity ranged from 0.60 to 1.20 % with a mean of 0.92 % whereas, in Elegant Lady cultivar of peach, titratable acidity ranged from 0.45 to 0.90 % with a mean of 0.74 %. Ma *et al.,* (2003) showed that flat peach (*Prunus persica* var., Compressa) had a sweet taste and low titratable acidity (less than 0.4 %). Cascales *et al.,* (2005) reported that acidity decreased when the fruits passed from the unripe to the semi-unripe stage, after which it remained constant. Citric acid content decreased pronouncedly with maturation from 0.32 g in the unripe state to 0.19 g when semi-unripe and to 0.12 g/100g in the ripe state. Malic acid content which is present significantly in higher concentrations than that of citric acid decreased with maturation but not so sharply, going from 0.68 % in the unripe fruit to 0.58 % in the ripe fruit. In fante *et al.,* (2008) reported that fruits of 'Venus' variety of nectarine showed almost similar amount of titratable acidity at two different ripening stages $M_1$ and $M_2$. However, Maria Dolce variety harvested at $M_1$ stage had 0.50 % and at $M_2$ had 0.41 % Titratable acidity. Abidi *et al.,* (2011) reported that 'Venus' is an acid nectarine (TA = 0.7 %) on the other hand, 'Big top' is a non-acid nectarine (TA= 0.4 %). Thus the progeny of these parent trees showed variability of titratable acidity with the a mean value of 0.7 g malic acid per 100 g fresh weight (FW) , which is lower than the maximum limit (0.9 %) for normal acidic peaches.

***Determination of Titratable acidity (%) of Punjab Nectarine fruit***

Aubert and Chalot (2020) noticed that the level of titratable acidity and total organic acids were about two fold significantly higher in the blood-flesh cultivars. During the growth and development period of Punjab Nectarine fruits, the acidity content initially increased which was followed by a steep decline. These results agree with the findings of Abrol *et al.,* (2015) who reported decrease in acidity during last stages of maturation of nectarines. Increase in acidity might be due to higher synthesis of organic acids in the initial stages (Mishra *et al.,* 2018). During the later stages, decrease in acid content may be due to rapid utilization of organic acids and conversion of organic acids into their salts and sugars either by the enzyme invertase during the period of ripening or by the reaction involving the reversal of glycolytic pathway (conversion of glucose into pyruvic acid) as suggested by Bakshi *et al.,* (2018). A sharp decline in acidity at the over-maturity stage might be partly due to enhanced respiration and partly due to intracellular fermentation which starts at a very late stage and converts malic acid to ethanol (Etienne *et al.,* 2013).

**Changes in TSS : TA ratio**

It had been suggested by Robertson and Meredith (1989) that the TSS : TA ratio indicates the ripeness of fresh fruit. The fruit with a greater than 15:1 will ripen to high-quality fruit. Robertson *et al.,* (1991) reported that TSS/ TA ratio increased significantly from 13.6 (maturity grade 1) to 19.3 (tree ripe stage) during the maturity of peach cv. Majestic. Badiyala and Lakhanpal (1994) reported that fruits of Shan-e-Punjab had higher TSS/acid ratio (16.89) than Early Amber, Flordared and Flordasun. Kher and Dorjay (2001) found that the TSS/acid ratio was maximum (19.18) in Flordared and minimum (17.14) in Flordasun. Babu and Yadav (2002) reported that the fruits of Shan-e-Punjab harvested 82 days after the fruit set had TSS/acid ratio (18.37) under the edaphic and environmental conditions of Meghalaya. TSS : acid varied from 21.26 in Shan-e-Punjab to 23.44 in Flordasun was reported by Bhatnagar and Kaul (2002). Ferrer *et al.,* (2005) noticed that during the ripening of fruits of peach cv. Calanda, the SSC/ acid ratio increased from 10.5% in ripeness degree 1 to 35.1% in ripeness degree 2.

According to research findings of Babu *et al.,* 2011, the maximum TSS: acid ratio (16.96) was recorded in TA-170 during the 11$^{th}$ week after fruit set. On the other hand, the maximum TSS: acid ratio (17.28) in Flordasun and (17.05) in Shan- e-Punjab was recorded during the 12$^{th}$ week after fruit set. The TSS/ TA followed a continuous increasing trend throughout the growth and development of Punjab Nectarine fruits. Fruit taste mainly consists of TSS and acid contents that are stored in the developing fruits. A specific TSS/ TA ratio in the fruit gives it a characteristic taste and flavour. Chander *et al.,* (2004) reported that sharp increase in TSS content and corresponding decrease in the acidity content during the fruit development, both were simultaneously responsible for the increase in TSS/ acid ratio. Similar trends of change in TSS/ acid ratio were observed by Babu *et al.,* (2011) in peach cvs, TA- 170, Flordasun and Shan-e-Punjab.

**Changes in Sugars content (%)**

**a. Changes in total sugars (%) level**

Kobashi *et al.,* (1999) reported that as the fruit mature on the tree, glucose and fructose are converted into sucrose, the predominant sugar in the ripe fruit. The total sugars and the proportion of sucrose were higher, while the proportions of glucose and fructose were lower in the mature fruits. This confirms that the total amount of sugars increased and that glucose and fructose were converted into sucrose while the peach fruit matured on the tree. Colaric *et al*., (2005) reported that sorbitol was the attribute most related to peach aroma and taste among carbohydrates and organic acids. While studying the 205 genotypes from different progenies, Cantin *et al*., (2007) reported that the average content of total sugars in the peeled fruit was 72.1 g per kg FW in peaches and 77.1 g per kg FW in nectarines.

***Determination of sugars content (%) in Punjab Nectarine fruits***

Abidi *et al.,* (2011) reported that sorbitol content varied greatly among genotypes ranging from 1.7 to 19.5 g per kg FW. Abrol *et al.,* (2015) recorded the maximum total sugars content after ripening with values of 4.32, 4.71, 5.47 and 3.95 % for the cvs. May Fire, Snow Queen Silver King and Red Gold, respectively. The changes in total sugars level in the pulp of developing fruit of Punjab nectarine showed a continuous increase till the fruits were mature. There was a marked increase in total sugars content during the stage II, which is followed by steady increase during phase III. According to Guizani *et al.,* (2019), the rapid increase in the content during the third stage of fruit growth may be due to hydrolysis of starch into simpler hexose sugars and also due to conversion of acids into sugars. According to research findings of Dhuria *et al.,* (1978), the total sugars increased with the advancement of maturity and then declined sharply at post-maturity stage in peach fruit.

**b. Changes in reducing sugars (%) level**

According to Byrne *et al,*. (1991), the level of fructose for all peach genotypes was twice that of glucose. According to Abrol *et al.,* (2015) there was a significant increase in reducing sugar content of all the nectarine cultivars with a delay in harvesting from the 1$^{st}$ to the 5$^{th}$ sampling date. On the first sampling date the reducing sugar contents were lowest in the cv. Red Gold (1.48 %) and highest in Silver King (1.85 %).

During the period of fruit development in Punjab Nectarine, the reducing sugars concentration continued to increase rapidly upto phase II and then remained almost constant during phase III. The increase in the content of reducing sugars can be ascribed to the process of conversion of photosynthates into sugars with the progress of maturity period. Bakshi and Massodi (2009) reported that with the onset of maturity, starch gets hydrolyzed into monosaccharides and disaccharides which leads to an increase in reducing sugar contents. However, after complete hydrolysis of starch, no further increase in sugar content takes place but subsequently their concentration declines because they are primary substrates for respiration. Mijacika (1976) reported that invert sugar content (glucose and fructose) rose in the beginning to its maximum in one-third (1/3) developed fruits and then declined to a minimum in ripe fruits.

**c. Changes in non-reducing sugars (%) level**

Mijacika (1976) stated that sucrose content increased throughout fruit growth in peach fruit. Byrne *et al.,* (1991) found that sucrose was the major soluble sugar. The sucrose content of the peach genotypes ranged from 45 % to 65 % of the total soluble sugars. The sucrose content showed a sharp increase from 50 days to 120 days after full bloom and then decreased slightly while, after stone hardening ended, other solids showed a gradual decreasing tendency from 80 days after full bloom was investigated by Cho *et al.,* (2000). It was noticed by Abidi *et al.,* (2011) that sucrose was the major sugar present in the evaluated genotypes with 58.4 g per kg FW, followed by fructose, glucose and sorbitol.

The increase in non-reducing sugars was slow during the earlier stages of fruit development of Punjab Nectarine. However, a rapid increase in non-reducing sugars took place during the stage III of fruit development. Desnoues *et al.,* 2014 reported that with the advancement of maturity period, there was a regular and continuous increase in sucrose concentration in peach fruit. Wu *et al.,* (2005) reported that sucrose in peaches is dominant at maturity, followed by the reducing sugars (glucose and fructose) and then sorbitol (type of carbohydrate called sugar alcohol). According to research findings of Abrol *et al.,* (2015), as the fruit matures, the glucose and fructose are converted into sucrose, which is predominant sugar and thus the proportions of sucrose were higher than other sugars.

**Changes in Ascorbic acid (mg/100g FW) content**

Dhuria *et al.,* (1978) observed that ascorbic acid content in peach fruit increased with increasing maturity on tree, while it declined sharply at post-maturity stage. Gil *et al.,* (2002) reported the maximum ascorbic acid (5-14 mg/100g FW) in white-flesh nectarines followed by (6-9 mg/100 g FW) in yellow-flesh nectarines, while the minimum ascorbic acid (4-13 mg/100g FW) in yellow-flesh peaches. Kumar *et al.,* (2003) observed the maximum ascorbic acid (6.42 mg /100 g) in the peach cv. July Elberta. Aubert and Chalot (2020) reported that vitamin C content was 40 % significantly higher in blood -flesh peach cultivars than that of white flesh peach cultivars at maturity. Serra *et al.,* (2020) demonstrated that flesh colour and textural typology significantly impacted ascorbic acid values during fruit development of peach. The red flesh had three to four fold higher levels of ascorbic acid, when compared to the white and yellow flesh genotypes. However, the white-flesh had roughly 34 % higher ascorbic acid values than the yellow flesh genotypes. They also found that non- melting genotype had maximum (20 mg /100g FW) ascorbic acid, while slow softening had minimum (5.88 mg / 100g FW) ascorbic acid.

***Determination of ascorbic acid of Punjab Nectarine fruits***

The ascorbic acid followed a continuous decreasing trend throughout the growth and development period of Punjab Nectarine fruit. Abrol *et al.,* (2015) showed decreased ascorbic acid content with the progress of maturation period of peaches. Kumar and Chitkara (1988) reported that ascorbic acid content of unripe peach fruits was always higher than that of ripe fruit, the higher ascorbic acid content during the initial stage may be attributed to the adequate supply of hexoses *i.e*, glucose, galactose, mannose and fructose (the first three are aldoses, whereas

fructose is ketose) through photosynthetic activity. Muhammad *et al.,* (2014) also reported that citric and malic acids stabilize the ascorbic acid content, however, decline in vitamin C content with an advancement of fruit growth stage which also associated with decrease in the acidity levels, which may be attributed to an oxidation or breakdown of ascorbic acid.

**Changes in Juice pH content**

***Changes in juice pH during development of Punjab Nectarine fruits***

Moing *et al.,* (1998) studied the compositional changes during the fruit development of two peach cultivars 'Jalousia' and 'Fantasia'. They found that in Jalousia juice pH was 3.94 at 34 Days After Bloom (DAB) and it decreased to 3.78 at 86 DAB and then juice pH increased to 4.66 until maturity, while the juice pH of 'fantasia' decreased from 3.85 at 34 DAB to 3.48 in mature fruit. Cantin *et al.,* (2010) found the significant difference among progenies of 'Venus' (an acid nectarine) and 'Big Top' (non-acid nectarine) regarding the juice pH. The fruit juice pH ranged from 2.80 to 5.50 and the mean pH of different progenies ranged from 3.32 to 3.36. Abidi *et al.,* (2011) observed that the F1 population of 'Venus ' x 'Big top' had pH values varied from 3.2 to 4.0 with a mean value of 3.6, which are values of normal acidic fruits.

During growth and development, the juice pH of Punjab Nectarine fruit initially decreased and then showed an ascending trend. An accumulation of malate and citrate was markedly reduced during the fruit development, which resulted in fruits with lower acidity and higher juice pH. An increase in pH showed the formation of organic acids during maturation of fruits. Rooban *et al.,* (2016) also reported that the acidity was inversely correlated to juice pH. Thus the mature fruits which had a low acid content had a correspondingly high juice pH.

**Conclusion**

It can be concluded that there was a progressive and rapid increase in total soluble solid content of the fruit, with the advancement of maturity period. The level of acidity of Punjab Nectarine fruits initially increased during stage I and II, thus reaching to its maximum value at the end of stage II. Then the acidity content decreased during the stage III. The TSS/ acid ratio increased continuously throughout the growth and development of Punjab Nectarine fruits. As the dates after full bloom ascends, there was a rapid increase in TSS/ acid ratio during the phase III. The fruits had exhibited maximum TSS/ acid ratio on maturity, which obsessed the highly acceptable eating quality. However, the taste of fruits becomes deteriorated due to over maturation stage of fruit.

The reducing sugars content increased markedly during stage II. Then, the reducing sugars level remained almost constant during phase III. However, there was a rapid and

continuous increase in total sugars and non-reducing sugars throughout the development of fruit. The young fruits contained highest ascorbic acid content than mature fruits. The level of ascorbic acid decreased with the progress of fruit growth and development. The juice pH content followed an erratic pattern during the entire period of fruit growth and development.

The variations in ascorbic acid content and pH of fruit juice did not show any relationship with the maturity stage. So, ascorbic acid and juice pH cannot be used as an index for determining the harvest maturity of Punjab Nectarine fruits. The TSS and acidity level can be considered as a maturity indices for harvesting of fruits. The total sugars content and TSS/ acid ratio can also be taken as a criteria for depicting the harvest maturity of Punjab Nectarine fruit.

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# Mushrooms: A Hidden Treasure of Nature

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## Introduction

Mushrooms are the fleshy fungus which belongs to class *Basidiomycota* and family Agaricomycetes. It is fleshy spores bearing fungus which is having a cap, stem and gills underside the cap. Some of the mushrooms are edible and some are wild which is sometimes very poisonous. Mushrooms can be known for its good taste and for its nutritional benefits. It contains fiber, proteins, Vitamin B, selenium, copper with more than 90% of water and naturally a good source of Vitamin D because in many food products Vitamin D can be fortified by direct addition or by irradiation. Many products can be prepared with mushrooms like biscuits, pickles, soups, consume fresh etc. Mushroom cultivation is a very good technique of growing mushrooms by using animals, plants and industrial waste. It has gained importance due to its medicinal and nutritional value.

## History of Mushroom

As per ancient Indian literature mushrooms are used as a food since 3000 B.C. Greeks and Roman considered it as "Food for the God". Aucularia auricular was the first mushroom cultivated in China on wooden logs. Mushroom cultivation started in France in 18$^{th}$ century. In the year 1961 mushroom cultivation was initiated at Solan (HP) in India.

## Varieties

About 75,000 types of mushrooms are identified worldwide. Out of these 2,000 are edible and about 1,000 types of mushrooms are non edible. Only 20 species of mushroom are grown worldwide on commercial basis. There are still many species of mushroom which are undiscovered. Some of the edible and medicinal mushrooms which are grown in India are:

**Button Mushroom (*Agaricus bisporus*) :** Native to Europe and North America. Growing season for button mushroom is November-February Rabi / winter.

**Shiitake Mushroom (*Lentinula edodes*) :** Native to East Asia and are highly consumed in Asian countries.

**Oyster Mushroom (*Pleurotus ostreatus*)** known as "Dhingri" in India. Growing season for oyster mushroom is November –February Rabi / winter.

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**Milky Mushroom (*Calocybe* spp.):** Growing season for milky mushroom is March – October.

**Paddy straw Mushroom (*Volvariella volvacea*):** It is usually grown on Rice straw bed and is used extensively in Asian Cuisines. Growing season for paddy straw mushroom is April –October Kharif and Zaid.

**Ganoderma lucidum: King of herbs / Mushroom of Immortality.** It is also known as Reishi mushroom or lingzhi mushroom. It is the most important medicinal mushroom in the world. During 1980 reishi mushrooms was developed in China. These are mainly grown in hot and humid locations. It is used for the prevention of tumor, hypertension, used as anticancer, as an antibiotic, helps to boost immunity, as anti cholesterol, fight against fatigue, for the treatment of diabetes.

**Nutritional value**

Mushrooms are rich source of protein, dietary fiber, vitamins and minerals. In different mushrooms the carbohydrate content on dry weight basis varies from 26-82% the digestible carbohydrate profile of mushroom includes starches, pentoses, hexoses, disaccharides, amino sugars, sugar alcohols and sugar acids. Mushrooms contain zero cholesterol. It has ergo sterol which acts as a precursor for Vitamin D which synthesis in human body. Some edible mushrooms contains high amount of protein. Mushrooms contain 12-35% of crude protein by different species. Mushrooms are also rich in theronine and valine but these are deficient in sulphur containing amino acids (methionine and cysteine).

**Medicinal value**

- Mushrooms are good for heart patients.
- It comes under low calorie food.
- It prevents cancer and tumor growth also.
- It has anti-aging property.
- It can regulate digestive system.
- It works as immunity booster.
- Prevent constipation problem
- It can help in Improving – IQ level
- Take it as good protein source for diabetic & TB patient.
- It helps to cure anemia.

**Advantages**

a. Mushrooms are famous due to its good taste and unique flavour.

b. It is a short duration crop with easy production practices.

c. Production cost is low with high net return.

d. It gives employment to many unemployed people.

e. Mushroom cultivation is a labor intensive farming with less time consumption.

f. Good way of recycling agricultural waste.

g. High nutritional and medicinal value.

h. Mushroom cultivation is a very good option for small and landless farmers.

i. Recently market demand is high.

j. As less effort is required for cultivation it is suitable for woman.

k. Mushroom substrate can be reused for vermin-compost production.

## Conclusion

Mushroom plays a very important role in contributing livelihoods of people through income generation and food security. India has diverse climatic conditions in different regions and possible to cultivate many varieties of mushrooms (Sharma, *et al.,* 2017). Successful mushroom cultivation for trade requires to working in joint natures or partnership with regional agro-industries, universities or wholesalers can help reduce vulnerability (Thakur, 2014). For the good marketing of mushrooms, the development of R & D helps to provide good infrastructure and supply chain. Good marketing facilities determine the future of mushrooms industry in India. The production and consumption of mushrooms is also increased by proper awareness about its medicinal and nutritional values. Production also depends of sufficient availability of well equipped labs, good quality of spawns, cold storage etc. Mushroom production favours sustainability by recycling of organic waste. As it is labor consuming and skill oriented task, it generates employment in both rural and urban areas in production as well as in processing and storage units. Mushroom cultivation not only provides a gainful employment to Indian rural youths, but the cost of mushroom production per unit area will be greatly reduced (Karthick and Hamsalakshmi, 2017).Government of India also takes initiatives to motivate rural & urban youth to become entrepreneur and also motivate many farms to establish mushroom units at different locations.

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