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Effective Use of Photoperiod in Domestic Animals for Better Production

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ABSTRACT

Several managemental practices are used by farmers or producers to get better production from domestic animals. Photoperiodic manipulation is an easy and economical method to enhance the productivity of the animals. The light perceived by the eyes affects the secretion of melatonin and simultaneously other hormones also. Thus photoperiod can affect many productive and reproductive traits of the animal. It can influence the growth rate, the onset of puberty, milk production, the incidence of disease etc. So effective photoperiodic management can help the farmers to obtain a better production and better economy.

Keywords: Cattle, photoperiod, melatonin, milk production

1. INTRODUCTION

With the rapid increase in human population food security has become a major issue nowadays. In this case, we have to depend upon the domestic animals largely for milk, meat and other animal products. So, the demand for animal products is increasing day by day. The producers and farmers are also trying to increase the production from domestic animals. Several managemental practices and techniques have been used to enhance the production. Among these, the photoperiodic management has established itself as a great tool to uplift the animal productivity. Photoperiod can be defined as the duration in 24 hour period in which the animals are exposed to light. Several types of research have established a clear relationship between photoperiod and animal production. It directly affects the physiology and behavior of the animals. In this article, we will discuss briefly how the photoperiodic management can help in increasing production and thus helping the farmers economically.

2. PHOTOPERIOD AND MELATONIN

The length of the day gives the animal a clear environmental signal so that they can accurately determine the time of the year. It initiates several physiological changes in the animal. Based on the duration, photoperiods can be of two types i.e. long day photoperiod (LDPP) and short day photoperiod (SDPP). In case of long day photoperiod, the light exposure is 16 to 18 hours whereas in short day photoperiod the light exposure is only 8 hours and darkness is 16 hours.
When light is perceived by the eyes, a signal goes to the pineal gland of the animal through neuronal pathways. The pineal gland is an endocrine gland which is situated in the brain between the cerebral hemispheres. This gland secretes a hormone named melatonin. Melatonin has a role in sleep and other physiological actions in mammals. Peak melatonin secretion occurs at night in the absence of light and a basal level is maintained during the daytime.

3. EFFECTS OF PHOTOPERIOD

Photoperiod affects several productive and reproductive traits of the animal. It influences the growth rate, age at puberty, milk production and many other characters. How photoperiod affects these traits and their proper management are described below.

3.1 GROWTH AND PUBERTY

Photoperiod has a clear effect on the growth of domestic animals. It has been observed that growing lambs kept for 3 to 4 months under artificial long photoperiod (16L: 8D) grow significantly faster than those under short photoperiods (8L:16D). In the case of cattle, long days increase the lean tissue and growth; both of which are associated with elevated concentration of insulin like growth factor. Studies have shown that calves reared under LDPP had more starter intake and average daily gain before weaning. These calves also generated more volatile fatty acids (VFAs) compared to calves reared under SDPP. These data clearly indicate that LDPP enhances overall body growth possibly through accelerated ruminal development. As the growth rate increases, it helps in the early onset of puberty in cattle.

3.2 REPRODUCTION

There are certain animal species which mate at a certain time of the year. These animals are called seasonal breeders. Depending upon seasons these are classified into two types i.e. long day breeder and short day breeder. The animals that breed during spring and summer are called long day breeders while the animals which breed in winter are called short day breeders. Examples of short day breeders are sheep, goat, fox, deer etc. The horse is an example of long day breeder. During the spring or summer, the short day breeder animals show anestrus. In this time there is more light signal from the environment. This results in decreased melatonin secretion. Consequently, this causes decreased GnRH and gonadotropin secretion. So the animal cannot come into stress due to insufficient reproductive hormones. The reverse occurs during the winter and animals come into estrus.

Though cattle is not a long day breeder photoperiod has an effect on its reproduction. It has been already discussed earlier that long day photoperiod exposure to the heifer can hasten the onset of puberty. In the case of buffaloes, cases of summer anestrus have been reported. In summer when there are increased day length and increased environmental temperature, there is decreased secretion of melatonin and gonadotropin resulting summer anestrus.

3.3 LACTATION

Photo periodic management has a great effect on the lactation yield of the animals. If the cattle are kept under a long day photoperiod the milk production increases 3 to 4 kg per day at any stage of lactation compared with cattle kept under short day photoperiod. Photoperiod has a galactopoietic effect during the lactation. This effect is mediated by increased growth hormone and insulin like growth factor. Many times bST is injected to the animal for more milk yield. It has been observed that injection of bST and LDPP have an additive effect and can be practiced together.

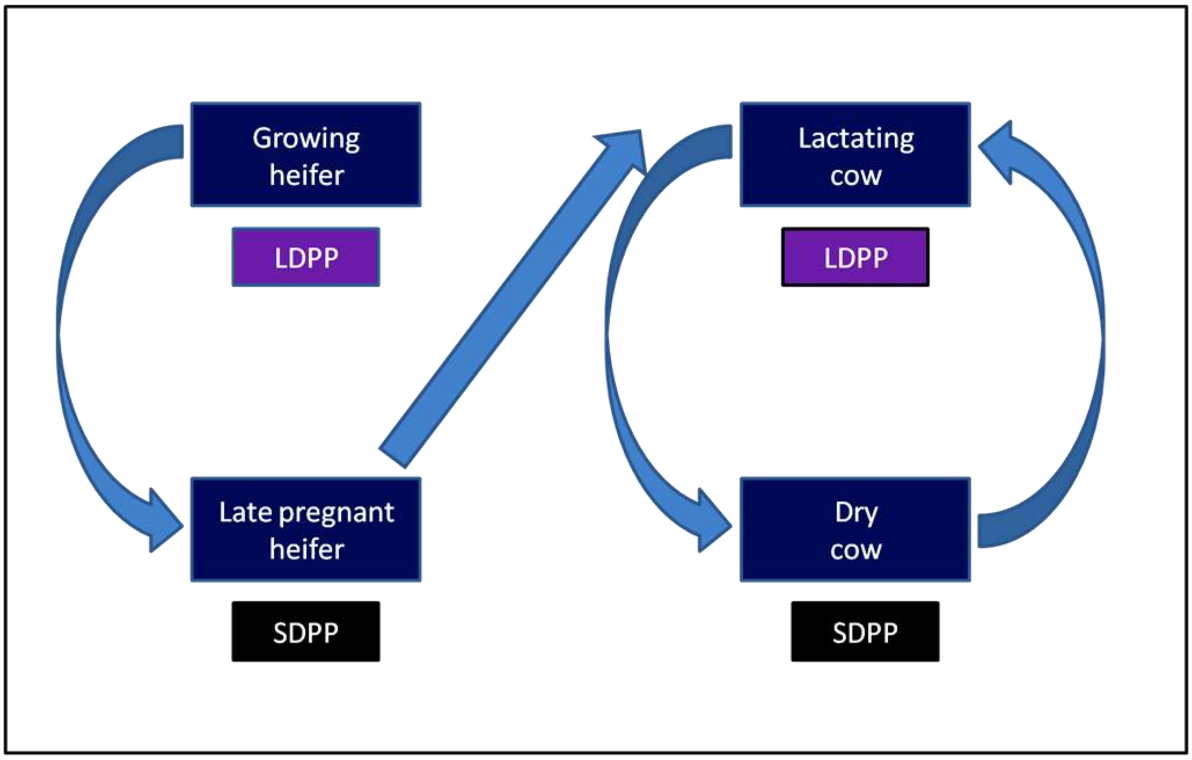

Fig 1: Photoperiodic management of cattle in different stages (LDPP- Long day photoperiod, SDPP- Short day photoperiod)

The effect of photoperiod during the dry period of the animal is dramatically different from that in lactation. If the animals are kept under SDPP rather than LDPP it will have better production in the subsequent lactation. This effect can be fully obtained if the animals are kept 35 to 60 days in a dry period under SDPP. Actually in this time the level of prolactin decreases but the receptor for prolactin increases. It helps in the action of prolactin in the next lactation and enhances milk production. Similarly, the late pregnant heifers should also be kept in short day photoperiod; though the growing heifers should be kept in long day photoperiod.

3.4 IMMUNE FUNCTION

Photoperiod also affects the immune system of the animal through shifts in prolactin secretion. Calves under SDPP shows increased neutrophil chemotaxis. Similarly, peripheral blood mononuclear cells (PBMC) are higher when cows are exposed to SDPP. So in dry period cows kept under SDPP shows better immune response than the cows under LDPP. In the dry period, the animals are always at higher risk for intramammary infection. But this photoperiodic manipulation can offer a better managemental practice for improving the health condition of the animals in a dry period.

4. IMPLEMENTATION OF PHOTOPERIODIC MANAGEMENT

Light is measured in footcandles (FC) or lux (lx), with 1 FC = 10.8 lx. For a good response, 15 footcandles at 3 feet from the floor is generally recommended. The light intensity of fewer than 5 footcandles is considered as darkness. The intensity of the light can be measured by a light meter. The light sources include fluorescent, incandescent, metal halide and high-pressure sodium lighting. The selection of light should be according to efficiency and other conditions.

Table 1: Intensity and duration of light in different stages

<table>
<tr><th rowspan="2">Different stages</th><th colspan="2">Light</th><th colspan="2">Dark</th></tr>
<tr><th>Time (hrs)</th><th>Intensity (footcandles)</th><th>Time (hrs)</th><th>Intensity (footcandles)</th></tr>
<tr><td>Calf</td><td rowspan="3">16</td><td rowspan="3">15-20</td><td rowspan="3">8</td><td rowspan="3"><5</td></tr>
<tr><td>Growing heifer</td></tr>
<tr><td>Milking cow</td></tr>
<tr><td>Late pregnant heifer</td><td rowspan="2">8</td><td rowspan="2">15-20</td><td rowspan="2">16</td><td rowspan="2"><5</td></tr>
<tr><td>Dry period</td></tr>
</table>

CONCLUSION

It is clear from the above discussion that photoperiod has a significant role in the productive and reproductive performances of the animals. It affects the physiology of the animal through alteration of melatonin and other hormones. Photo periodic manipulation can be an easy and economical management tool for the farmers and producers for better production and more benefit.

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Seed Quality: A multiple Factor Affecting Attribute

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The seed is a fragile living organism which is considered as a miracle of life. In working with seeds especially in harvesting, thrashing, cleaning, handling, storage and transportation, it is essential to keep in mind that at all times inside the seed is a dormant miniature plant.

Orthodox and Recalcitrant Seeds

Seeds can be divided into two major groups based on their viability characteristics.
Orthodox Seeds: A decrease in seed moisture increases the period for which seeds will remain viable. Seeds of pulses, cereals and oilseeds belong to this group and can be kept viable for one to many years depending upon storage conditions. Species vary considerably with respect to storability and can be divided into good storers. e.g. okra and gram gram; intermediate storers, e.g. cotton, sorghum, wheat and maize and poor storers. e.g. soybean and onion.
Recalcitrant Seeds: Some seed species must retain a relatively high moisture content in order to maintain maximum viability. Even when these recalcitrant seeds are stored under moist conditions, their longevity is often quite short and only occasionally exceeds more than a few months. Seeds of coffee, rubber, cocoa and oil palm belong to this group.

Reasons for Seed Storage

Seeds are stored for two reasons: first, since there is usually an interval of time (1 to 10 months) depending on the crop and cropping system in-between seed harvesting and sowing of the succeeding crop. Second, the more fundamental reason for seed storage is of course to preserve or maintain their physiological quality throughout the storage period by minimizing the rate of seed deterioration.
Stages of Seed Storage: The seeds are considered to be in storage from the moment they reach physiological maturity until they germinate. The entire storage period can be divided into the following stages:
1. Bulk Storage: The period from harvest through packaging, including aeration, drying and holding

operations.

2. Packaged Storage: The period between packaging and distribution.

3. Distribution Storage: The period from distribution through sale to the farmers including time in
transit, at assembly points (wholesalers) and at retail outlets.

4. Farm Storage: The period between delivery of seeds to farm and planting.

Types of Storage: There are three types of storage.

i) **Short Duration**: (6-8 months). Storage of seeds from harvest to next planting.
ii) **Medium Term**: (12-14 months). Storage of carryover seeds.
iii) **Long Term**: (5-20 years). Storage of germplasm and breeder seed.

FACTORS AFFECTING SEED LONGEVITY DURING STORAGE:

Seeds are viable, therefore, they lose viability during storage. Various external factors like seed moisture or relative humidity of the atmosphere, storage temperature, inheritance, initial level of seed quality, mechanical damage during harvesting/ threshing, gases during storage, microflora and insects, fungicides and insecticides etc. affect the seed longevity during storage. The details of these factors are given below:

1. Genetic Factors

Seed longevity is an inherited characteristic at both the species level and at the cultivar level. Some kinds are naturally short-lived e.g. onion, soybean, peanuts etc. Some similar kinds e.g. tall fescue and annual rye grass though they look very alike, differ considerably in storabililiy. Some kinds of seeds are inherently long lived, others are short lived, while others have an intermediate life span. Differences in storability extend even down to the variety level. Among the vegetables, onion seeds are short lived, radish seeds are intermediate in longevity and watermelon seeds are relatively long lived. Soybean and peanut seeds do not store well as compared to seeds of wheat, corn, cotton, sorghum and rice.

2. Initial Seed Quality

The storage potential of seeds is greatly affected by their quality at the time they enter storage or their pre-storage history. The pre-storage history of a seed lot encompasses all the events in the life of the seeds from the time physiological maturity is reached until' they are placed in storage. Seeds are highest in quality at the time of physiological maturity. Since most kinds of seeds reach maturity at moisture contents too high for mechanical harvest, they are subjected to the field environment from maturation to harvest. Adverse climatic conditions, especially ram, high humidity, warm and freezing temperatures can delay harvest and result in rapid and severe deterioration of seeds. Mechanical abuse to seeds associated with harvesting, handling and processing operations, and damage caused by inadequate or improper aeration and damage caused by inadequate or improper aeration or drying can have both immediate and residual effects. Seeds lots with a "good" pre-storage history (minimal field deterioration, mechanical damage, etc.)

store well, while those with a "bad" pre-storage history store poorly. "**Carry over only high quality seed**"

Table: Storability classes for different crop species

Good	Moderate	Poor
Wheat	Paddy	Sunflower
Bajra	Maize	Groundnut
Mung	Sorghum	Soybean
Urd	Cowpea	
Lentil		
Chickpea		
Pigeonpea		
Jute		

Good = Two planting seasons or more
Moderate = One planting season
Poor = One or less than one planting season

3. Seed Structures

The presence of glumes (lemma and palea) in grasses has a positive influence on life span. Husk and Chaff have an inhibitory effect on mold, suggesting that the increased life span of cereal seeds during storage is due to suppression of mold growth by the glumes. Oat and timothy seeds have a longer life span when stored with the glumes intact than they do when stored as machine hubbed caryopsis. Generally, small seeds escape injury, whereas large seeds are more likely to be extensivelydamaged. Size, arrangement of essential seed structures and composition are factors contributing to seed damage. Bean, limabean and soybean are examples of seeds highly susceptible to damage. Spherical seeds usually give more protection than flat or irregularly shaped seeds. In case of onion, a high incidence of abnormal seedlings are observed. This may be because embryonic root tips of onion extend beyond the seed, a condition conducive to mechanical injury.

4. Hard Seeds

Hard seeds are found in the families leguminasae and malvaceae. Varying percentages of hard seeds of most species become permeable during storage. Softening depends on temperature and relative humidity. Hard seeds are considered viable and have good storability.

5. Provenance

The seed samples obtained from different sources may show differences in viability behaviour. The pearlmillet seed produced in Andhra Pradesh had good luster and germination whereas the luster of seeds produced in Haryana was not good. However, the storability of seed produced in Haryana was better than that produced in Andhra Pradesh.

IN ENVIRONMENTAL FACTORS THAT AFFECT VIABILITY DURING STORAGE

6. Seed Moisture and Relative Humidity

Seeds are hygroscopic. They lose or gain moisture depending upon the RH of the atmosphere in which they are stored. The amount of moisture absorbed by seeds depends upon relative humidity (RH).

Relative humidity is a measure of the water vapor in the air relative to the amount that the air can hold at saturation at a given temperature.

Equilibrium Moisture Content (EMC): Each kind of seed attains a characteristics moisture content at a given RH at a particular temperature. This is called equilibrium moisture content. The EMC also depends upon the chemical composition of seeds, of the various compounds present in seeds. Protein absorbs the most water, and carbohydrates slightly less and lipids do not absorb water at all. This phenomenon can be accounted for by the fact that fats and oils do not mix with water. Establishment of EMC in seeds is a tune dependent process, that is, it does not occur instantaneously. A period of time is required, the length of which varies with seed kind, initial moisture content, the percent relative humidity and temperature.

The EMC of seeds is also affected by the temperature and the degree of deterioration. As temperature increases, the moisture content of seeds in equilibrium with a specific level of relative humidity decreases on the order of about 1% moisture (decrease) for each 11°C rise in temperature. Deteriorated seeds have a slightly higher EMC than high quality seeds.

The amount of moisture in the seeds is probably the most important factor influencing seed viability during storage. The rate of deterioration increases as the seed moisture content increases. The following activities take place at various levels of moisture content in the seeds.

Moisture content (%)	Activity
> 30 Seed Germination	
18-30	Rapid deterioration by micro-organism
18-20	Respiration
10-18	Fungi can grow and destroy the seed
8-9	little or no insect activity
4-5	Free from insects and fungi

7. Temperature

Temperature also plays an important role in the life and death of seeds. Within the normal range, biological activity of seeds, insects, and molds increases as temperature increases. Therefore, higher the temperature, more rapid the seed deterioration at a given moisture level. Althoughlow temperatures are more effective than higher temperatures for storing seed, maintenance of low temperature is expensive, and temperatures above freezing, especially between 5°C and freezing are adequate.

The higher the moisture content of seeds, the more they are adversely affected by temperature. High moisture content seeds can be damaged by below freezing temperatures. High drying temperatures will damage high moisture content seeds. As the seeds dry, however, their thermal death point increases up the temperature scale.

Cryogenic Storage:

In cryogenic storage seeds are placed into liquid nitrogen at - 196°C. At this temperature there is little detrimental physiological activity, prolonging the storage life of seeds. This method is safe and cheaper than conditioned storage. but limited in capacity to the amount of storage space available in the cryogenic tanks. Hence it is not practicable for most commercial seed but is useful to maintain a valuable germplasm over prolonged period of time.

8. Interaction between Seed Moisture and Storage Temperature

Seed moisture content and temperature are the most important factors influencing seed longevity. Of these two, moisture content has the greater influence on seed longevity. Well-dried seeds will store quite well at temperature upto 40°C. This fact had led to the development of sealed storage of seeds. On the other hand relatively high moisture content seeds will keep well only if the temperature is reduced to 10°C or less.

Harrington's Rules of Thumbs: Harrington proposed rules of thumb to measure the effects of moisture and temperature on seed longevity. These rules are as follows:

1. Seed life is doubled by every decrease of 5°C in storage temperature when temperatures are between 0°C to 50°C.
2. Seed life is doubled with every decrease of 1% in seed moisture content when seed moisture content is between 5 and 14%.
3. Good seed storage is achieved when the percentage of relative humidity in storage environment and the storage temperature in degrees Fahrenheit add up to one hundred. The rules of thumb may be considered as a rough guide and are not as exact as the nomograph of Roberts (1972). Roberts developed formulae to describe relationship between temperature, seed moisture content, and period of viability. From this relationship he constructed a seed viability nomograph for crops like wheat, barley, rice, broad bean, onion and lettuce. Dry, cool conditions are best for seed storage. The general prescription for seed storage is a dry and cool environment. How dry and how cool depends upon kinds of seeds to be stored, desired period of storage, and physiological quality of the seeds.

9. Gas during storage:

Seeds can be stored in moisture-resistant or hermetically sealed conditions. Metal cans are completely effective in maintaining seed moisture at the initial 5% level. Using this method seed can be stored up to 10 years or longer. Increase in pressure of oxygen tends to decrease the period of viability. The ambient air from seed can be removed and replaced with specific gases like CO, and N„ decreasing 02. Pea seeds were stored at 18.4% moisture at 25°C for 11 weeks where 02 was decreased from 21 to 1.4% and CO2 was increased from 0.03 to 12%. In hermetic storage of seeds the seeds are stored in vacuums at low moisture content. The ambient air can be replaced with pure gas in sealed containers such as carbon dioxide and inert gases like nitrogen, organ and helium.

10. Microflora, Insects and Mites etc.

There are six main types of organisms associated with seeds in storage.
a) Fungi and Bacteria
b) Insects and Mites
c) Rodents and Birds

a) Fungi and Bacteria: Seed microflora is dependent upon the relative humidity of the storage environment. The storage fungi are inactive below 62% RH, little activity at 75% RH. Activity increases rapidly when RH is more than 75%. The storage bacteria require more than 90% RH. Certain organisms can grow at temperatures from -8°C to 80°C.

b) Insects and Mites: There is no insect activity at seed moisture contents below 8% but if seed is infected, increased activity may generally be expected up to about 15% moisture content. The optimum temperatures for insect activity of more important storage insects range from 28 to 38°C. The temperature below 17 to 22°C are considered unsafe for insect activity.

The following insects/pests are important during seed storage.

- ❖ Rice 'Weevil (Sitophilus oryzae L.). This is very common pest of stored seed throughout the world. Affects the seeds of cereals (rice, wheat, maize, oat, barley), linseed, cottonseed, cocoa and other cereals.
- ❖ Khapra Beetle (Trogograina granarium E.). It is native of India, also reported from Europe, Australia, North American and other countries of Indian sub continent. Attacks the seeds of cereals, pulses and dried fruits.
- ❖ Lesser Grain Borer (Rhizopertha dorninica F.). It is a native of India and now reported from rest of the world. Attacks the seeds of wheat, sorghum, millets and rice.
- ❖ Pulse Beetle (Callosobruchus sp.). Common in Asia, North America and Europe. All Pulses and beans are attacked by it.
- ❖ Rust Red Flour Beetle (Tribolium castaneurn H.). Distributed worldwide, primary pest of milled products, animal feed and processed foods. Attacks the already damaged seeds.
- ❖ Angoumois Grain Moth (Sitotroga cereolae O.).

Distributed worldwide. Attacks the seeds of cereals (rice, wheat, maize, sorghum, barley, oats, millets).

Insects can completely destroy the seed, but can be controlled by adequate packaging and storage. Insect multiplication can be reduced or eliminated by proper drying and by storage of seed at low temperatures. Insects can be controlled by creating good storage facilities and by using insecticides and fumigants to prevent infestation. Fumigate the stores with aluminum phosphate @ 7 tablets (3 g each) or EDCT mixture (3:1) per 1000 cubic feet space with exposure period of at least 7 days.

c) Rodents and Birds: Birds can also cause loss to seed during storage if small openings exist. Therefore, all openings and holes should be properly sealed or screened. Rats and other rodents are a more serious problem. The rodents can be controlled by building the store so that the floor is 90 cm. above the ground level at the entrance and having a lips 15 cm. lip around the building at the 90 cm. level of the floor.

11. Fungicides and Insecticides:

The storage fungi and insects are controlled by certain chemicals and fumigants. Improper dose at improper time may lead to the damage to seed quality. Therefore, precautions must be taken when using such chemicals/fumigants.

12.Storage in Transit:

The seeds also lose their viability during improper storage in transit or at retail store or at the user's farm. Adequate storage precautions at all these points should be taken.

Trucks, rail, roads and ships are the major modes of seed transportation all over the world. A major cause of loss and damage to seed shipments is torn sacks or bags causing loss of both seed and container. Protruding nails and bolds and loose or splintered boards are conunon causes of torn bags during transit. Water may cause the containers to split apart damaging seeds' germination capacity. Leafy roofs. loose fittings doors and worntarpaulins may lead to such damage. Industrial chemicals and oil residues not removed from the railcar or truck before loading may cause the seed bags to disintegrate. The containers may soak up some of the residues or take up an odor from them.

CONCLUSIONS

Seeds can be divided into two major groups based on their viability characteristics viz. Orthodox and recalcitrant. The seeds are considered to be in storage from physiological maturity to sowing in the field. Several biotic and abiotic factors like seed moisture or relative humidity, storage temperature. inheritance, initial level of seed quality, mechanical damage during harvesting/ threshing, gases during storage, microflora etc. influence the seed storability. The following conclusions can be drawn.

- ✓ The seed longevity is a characteristic of the species and/or cultivar.
- ✓ High quality seeds store better than low quality seeds.
- ✓ Seed moisture content and temperature are the most important factors influencing seed storability.
- ✓ Moisture content of seeds is a function of relative humidity and to a lesser extent of temperature.
- ✓ Moisture content is more important than temperature.
- ✓ A one per cent decrease in moisture content or 5.5°C decrease in temperature nearly doubles the storage life of seed.

- ✓ For good seed storage the sum of temperature (°F) and RH (%) should be one hundred.
- ✓ The effective sealed storage of seeds requires that moisture content be substantially lower than for non-sealed storage.
- ✓ Periodic inspection and fumigation of stores is essential to control the insects/pests.
- ✓ Good sanitation should be a continuous practices.

Nano-fertilizers: A smart way for Crop Nutrition

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The current population of the world is 7.6 billion and it is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100 (United Nations, 2017). This implies that new systems for food, water and energy will be required to ensure food security. Producing more food requires natural resources, consumption of land, supply of water and energy. For that, scientific research will be requested to provide new practices and technologies to solve highly complex problems in near future. The practice of intensive cropping with hybrid varieties for boosting food production in India has caused nutrient depletion in soil. Consequently macro- and micro-nutrient deficiencies are reported in soils of India. However, the agricultural production was increased, but availability and accessibility of food (i.e. food security) to the population is still the major problem. Also, not only the food security but nutritional security is the most important. Nutritional security is an essential element of food security. Human needs can only be satisfied through a diversity of macro- and micro-nutrients to ensure good health. Nutrition to agriculture is one of the most important factors to improve food as well as nutritional security.

The nutrient use efficiency/fertilizer use efficiency of the micronutrients is very low. So it must be improved by modifications in the fertilizers like nano-fertilizer. Nano-fertilizer is required in less quantity, so it reduces the cost of fertilizers and also reduces the chemical load of fertilizers on the soil. Nano-structured fertilizer exhibits novel physico-chemical properties, which determines their interaction with biological substances and processes. The application of nano-technological formulation to agricultural crop inputs is one of the proposed tools for sustainable intensifications. Nano-fertilizer facilitates slow and steady release of nutrients, hence enhances nutrient use efficiency by reducing loss of nutrients. These fertilizers have higher surface area and particle size less than the pore size of roots and leaves of the plant which can increase penetration into the plant and improve uptake and nutrient use efficiency of the fertilizer (Liscano *et al.*, 2000).

NEW OPPORTUNITIES

There are at least two to three fundamental aspects in using nano-fertilizers as a means of supplying plant-nutrients to meet the future needs: (i) Increased yield and production rate, (ii) increased efficiency of nutrients applied by means of nano-fertilizers and (iii) reduction in the use of costly chemicals and their effects on soil health. Among them, increasing efficiency of nutrients applied is most important as it affects all the other factors in one or other way.

Plant nutrition and Fertilization

Nutrient use efficiency (NUE) is a measure of how well plants use the available mineral nutrients. Nutrient use efficiency of crop plants is lower than 50% due to physical and chemical soil properties, leaching losses, gaseous losses of applied nutrients and fertilizer characteristics in all agroecosystems. For example, Urea, which is one of the most common and important N- fertilizers, but plants are not able to take up the molecules of urea. Plants are able to take nitrogen from urea only after its decomposition via hydrolysis, volatilization and urease soil enzyme (Eriksen and Kjeldby, 1987). The fertilizer use increased 20 times and 7 times for N and P, respectively, between 1950 and 2000. On the other hand, to maintain high production using fertilizers of lower efficiency, the production costs are increasing. Also, it leads to environmental pollution.

As for micronutrients, though they are present in plant parts in very low concentration generally below 100 ppm, they play a vital role in various physiological activities which are essential for plant growth and development. Micronutrients are activators of specific enzymes or enzyme classes. Micronutrients are responsible for plant defense against diseases or abiotic stress (Welch and Shuman, 1995). Furthermore, plants are the sources of micronutrients for humans and animals. Deficiency of micronutrients in soil limits the crop productivity and nutritional value of food. The most widely used method of micronutrient application is soil application. Under unfavorable soil conditions (pH of soil), micronutrients frequently precipitate and become less available to plants (Mortved, 1985). It has been reported that fertilizer-micronutrient use efficiency by crops is lower than 5% (Monreal *et al.,* 2016). To overcome the soil limiting factors, a new approach widely used to provide micronutrients to crops is via leaf treatments (seed treatment and foliar application). However, plants primarily absorb plant-nutrients through their roots. The amount of micronutrients that can be absorbed by leaves is limited and they are not transported to roots via phloem (Page and Feller, 2015).

Smart delivery of nutrients to crop plants

The main objectives of sustainable agriculture are productivity, profitability and environmental health. The best management practices of fertilization must support these objectives. The improvement in nutrient use efficiency in crop production is one of the main pillars of this vision (Manjunatha *et al.,* 2016).

Nanotechnology can play an important role in strengthening of sustainability of agriculture, also providing the feasibility of smart way of crop nutrition. Nano-particles act as a carriers of nutrients and they allowed their controlled release in the environment. These nano-particles are called as a "*nano-fertilizers*".

The design and structure of the nano-fertilizers strongly influences the release of nutrients and minimizes the losses of nutrients. In field conditions or in standing crop conditions, nano-fertilizers are provided to crops via irrigation or spraying on canopies of crop. Also, these fertilizers can be applied via seed treatment before sowing. Through the application of nanotechnology in crop nutrition, fertilization to crops will be carried out in many different ways. In particular, the nutrient elements will be possibly delivered as follows:

- As particles or emulsions of nanoscale dimensions: the main aim is to clarify whether nanoparticles e.g., fullerenes, carbon nanotubes and $nTiO_2$ in different crop growth stages may or may not partially replace the traditional fertilizer practices (Millan *et al.*, 2008; Perrin *et al.*, 1998).
- Encapsulated nanostructures: they are designed to allow the controlled release of nutrients (**Fig. 1**). As to do this, the outer shell of nanocapsules is engineered and programmed to open when stimulated by environmental factors or man-induced pulses. Following are some examples of possible controlling mechanisms of encapsulated nanomaterials (Aouada and de Moura, 2015):

i. Slow-release: The capsules release their payload slowly over a longer period of time so as to synchronize the assimilation of plants and limit leaching.

ii. Quick-release: The capsule shell may break when it comes to contact with the leaf surface.

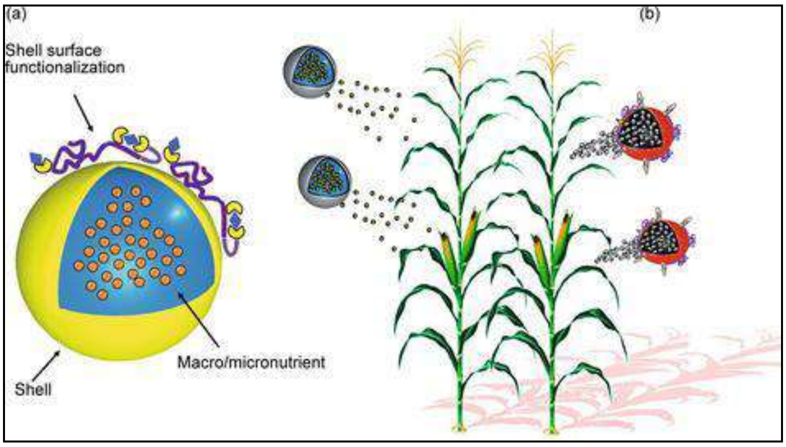

Figure 1 (a) Model of nanocapsule containing nutrient elements (b) Example of opening strategies of nanocapsule

iii. Specific-release: The release of nutrient occurs through a mechanism between a receptor (molecular or functional group) which is bound to the shell and a target molecule.

iv. Moisture-release: In presence of water, the shells get break down and release the nutrients.

v. pH release: in specific acidic or alkali conditions/environment, the shell breaks up and releases nutrients. (e.g., within the plant tissues or inside the shell).

vi. Ultrasonic or magnetic pulses: the shell of nanocapsule opens in response to an ultrasonic or magnetic pulse which is emitted by a man-controlled system (in case of precision agriculture).

- Delivered in a complex formed by nanocapsules incorporated in a matrix of organic polymers of biological or chemical origin which act as a carrier (**Fig. 2**): These provide the expected traits to nano-fertilizers. In contrast to, natural substances should be preferred as they are available easily, biodegradable and cheaper than the synthetic substances (Corradini et al., 2010). The properties of this nanostructure allow a controlled release of nutrients as a function of time or after interaction with the environment. Currently, the studies on zeolites (Servin *et al.,* 2015), polycrylic acid and chitosan (Robert *et al.,* 1995) are being conducted to test the potential of them.

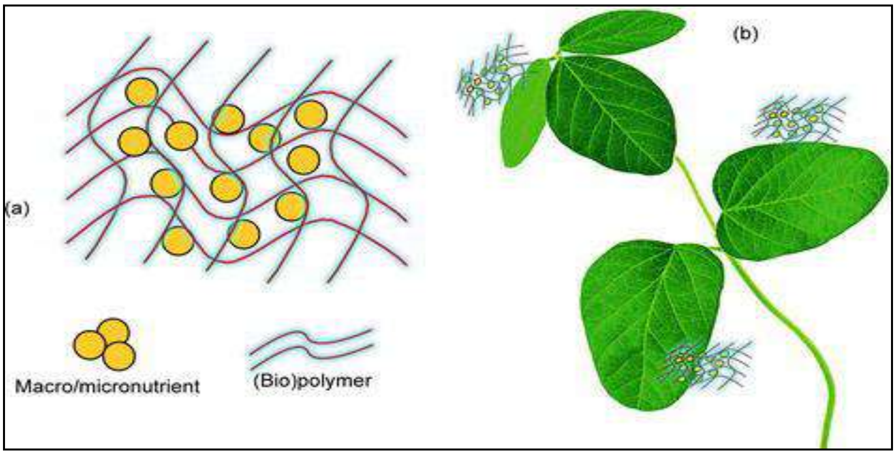

Figure 2 (a) Model of biopolymeric structure containing nutrient elements (b) Deposition of engineered nanomaterials onto the crop leaf after spraying treatment

There has not been extensively studied yet about the effectiveness of nano-fertilizers. However, there are some successful examples which demonstrate that such new formulations have significantly improves the efficiency of fertilization. Now, the challenge for research is to develop the nano-fertilizers and test their carriers that allow their controlled release, following a schedule possibly synchronized with the physiological needs of crop plants. The researchers are still at the stage where they getting conflicting results of the studies on interactions between nanomaterials and biota. This also occurs in studies of nano-fertilizers.

CONCLUSION

It can be concluded that the utilization of nano-fertilizers is the smart way of nourishing the crops with nutrients, but it still needs deep basic knowledge about their fate in the agro-ecosystem.

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Use of Probiotics in Aquaculture

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ABSTRACT

Probiotics are the beneficial microorganisms that when consumed, cause several positive impacts on host. The use of probiotics in animal husbandry is not a new practice. Nowadays, the role of probiotics in aquaculture has also become evident. It acts as a growth promoter, inhibits pathogens, and improves nutrient digestion, stress tolerance and reproductive ability in aquatic organisms. It has a role on several species including shellfish, finfish, microalgae etc. The effective use of probiotics can be advantageous in fish production and improve the economic condition of farmers.

Keywords- Aquaculture, fish, probiotics

1. INTRODUCTION

The term "Probiotics" was first introduced by Lilly and Stillwell in 1965. This term originally comes from two Greek words "Pro" and "bios" which mean "for life". In 1905 Dr. Elie Metchnikoff first described the positive role played by probiotics and reported that we can replace harmful microbes by beneficial microbes and change the flora of our body as food greatly relies upon gut microbes. Grossly we can define Probiotics as one or more microorganisms having advantageous roles for the host. They have the ability to survive in the digestive tract of the host because of their capacity to tolerate acid and bile salts. Day by day, the knowledge of probiotics increased and the concept of the probiotics and its characteristics features have been clarified intensively. Probiotics exhibit an antimicrobial effect through the modification of intestinal microflora, secretion of antibacterial substances, and competition with pathogens to eliminate them from the intestine. Probiotics can improve the host health in a positive manner by limiting the nutrients which are essential for pathogen survival and production of antitoxic effects. For all these beneficial effects, probiotics are largely used in animal production. Comparatively, the use of probiotics in aquaculture is recent. But, it has opened a new door in aquaculture practices. It is being used in diversified areas with increasing order. In this article, we have briefly described the role of probiotics in aquaculture, so that farmers can effectively use it in fish farming.

2. CONCEPT OF PROBIOTICS IN CASE OF AQUATIC ANIMALS

Unlike terrestrial animals, gastrointestinal flora of the aquatic animal largely depends upon the external environment. The main reason for that is the flow of water is constantly passing through the digestive tract. As a result of that, most of the microbiota is very temporary and fluctuates greatly in the intestine because of continuous intake of food and water. The gastrointestinal tract of aquatic animals consists of potentially pathogenic bacteria such as *Salmonella*, *Listeria* and *Escherichia coli*. Probiotic bacteria and other microorganisms include gram-positive bacteria such as *Bacillus*, *Carmobacterium*, *Enterococcus* and few species of *Lactobacillus*. Few gram-negative facultative anaerobes such as *Vibrio* and *Pseudomonas* as well as yeasts, fungi and algae are also included. With consideration of aquatic animals, the definition of probiotics has modified as living microbial additives that have a beneficial effect on the health of hydrobionts and help them to increase their productivity positively.

3. ROLE OF PROBIOTICS IN AQUACULTURE

To achieve sustainability in aquaculture, the application of probiotics in the culture of aquatic animals is one of the major weapons of our 21st century's civilized industry. Initially, probiotics were mainly used as a growth promoter to enhance the growth of aquatic animal and also for the purpose of improvement of the health condition of aquatic animals. Later, new areas of applications of probiotics have been invented to improve the health and productivity of aquatic environments. The effects of probiotics on reproduction or stress tolerance have been positively implemented for the development of the aquatic system. But this requires more and more scientific improvement and development. The versatile roles of probiotics are described below.

A. GROWTH PROMOTER

Probiotics have been successfully utilized in the aquacultural sector for the purpose of promoting the growth of the aquatic animals. But the actual mechanisms through which it can promote growth is unknown. The cause may be that it can increase the appetite or through the improvement of digestibility or maybe because of both the factors. Probiotics microorganisms have the capability to colonize in the GI tract when administered over a longer period. Probiotics have a higher rate of multiplication than the rate of expulsion. As a result of that, they are able to adhere to the mucosa of the GI tract, when continuously added to fish culture. The efficiency of probiotics as growth promoter depends upon many factors such as hydrobionts species, body temperature, enzyme level, genetic resistance and water quality.

i. **Effects on microalgae:** The effects of probiotics have been implemented on microalgae, which as known as the base of aquatic food chains because of its photosynthetic mechanisms which are absent in higher organisms. Impact of probiotics on microalgae or phytoplankton as growth-promoting substances has been demonstrated intensively. But due to its complicated nutritional requirement, production limitations for this species is there. Higher growth of microalgae *Chaetoceros muelleri* can be achieved in the presence of *Vibrio alginolyticus* probiotic.
ii. **Effects on live feed:** Rotifers were first used as live feed for most cultured aquatic species larvae because of their small size. The growth of the rotifer can be enhanced with the addition of lactic acid bacteria and best results are obtained in case of *Brachionus plicatilis* with the addition of *Pediococcus acidilactici* and *Lactobacillus lactis spp.lactis*.
iii. **Effects upon edible fishes:** The growth of edible fishes can be enhanced by using probiotics. For example, the diet of Nile tilapia was fortified with a probiotic strain, like streptococcus which increases the weight and body mass of the fish by significantly increasing the crude protein and lipid content of the fish. By supplementing the diet with probiotics, production can be enhanced 115.3% of this commercially important species with simultaneous application of commercial formulation at a concentration of 2%.
iv. **Effects upon ornamental fishes:** Impact of using probiotics can be noticed upon growth improvement of the ornamental fishes including swordtail (*Xiphophorus helleri, X. maculatus*) and guppy (*P.reticulata, P. spenops*). Significant increases in growth and survival of these species were achieved when their feed was supplemented with *Bacillus subtilis*.
v. **Effects upon shellfish culture:**
   a. Application of probiotics can significantly enhance the survival rate of shellfishes by improving the growth rate of the same.
   b. The growth rate of small and large abalone was improved by 8% and 34% respectively in the 8th month of culture.
   c. Abalones supplemented with probiotics has increased the survival rate of the 62% compared to 25% survival of the untreated animals.

B. INHIBITION OF PATHOGENS

Probiotic microorganism constitutes a barrier against the proliferation of pathogens because of their capacity to release bacteriostatic chemical substances, which exhibit a bactericidal effect on pathogenic bacteria that inhabit in the intestine of the host. Antibacterial effect of probiotic microbes depends upon several important factors, like their bacteriocins, siderophores, enzyme or hydrogen peroxides and their ability to alter intestinal pH due to the generation of organic acids.

C. IMPROVEMENT IN NUTRIENT DIGESTION

Probiotics can create a beneficial impact on the digestive process of aquatic animals. Probiotic strains have the capability to synthesize extracellular enzyme-like proteases, amylases and lipases as well as to provide growth factors like vitamins, fatty acids and amino acids. Nutrient absorption efficiency was greatly enhanced when the feed was supplemented with probiotics.

D. IMPROVEMENT OF WATER QUALITY

Water quality of the aquatic system can greatly be improved when they are enriched with gram-positive strains of probiotics like *Bacillus*. As the gram-positive bacterial group is much more efficient in transforming organic matter to carbon-di-oxide than the gram-negative group. The accumulation of dissolved and particulate organic carbon can be minimized by the application of high levels of probiotics in production ponds. Furthermore, balance in the production of phytoplankton can be achieved by the application of probiotics.

E. ENHANCEMENT OF STRESS TOLERANCE

In most cases, conventional agricultural practices create stress in aquatic animals such as some of the transport mechanisms can cause a change in water temperature. If we prepare the fish species in advance with the periodic treatment we can raise stress-tolerant species of aquatic animals by enhancement of stress-tolerance of aquatic animals. Sometimes urge for excessive productions in shorter times can cause stress in species of the crop which can induce a general depression on the muscle protein synthesis causing chronic stress in Zebrafish, Danio rerio. In such cases, we can increase stress tolerance by using probiotics.

F. EFFECT ON REPRODUCTIVE CAPACITY

Reproductive capacity or efficiency depends upon appropriate proportional concentrations of lipids, proteins, fatty-acids, Vit-C, Vit-E and carotenoids. Interactions between these components influence reproductive capacity in various ways, such as in fertilization, birth and development of larvae. Commercially available broodstock diets can intensively enhance the reproductive capacity of brood fish. Probiotics can be added to this type of commercially available broodstock diet in order to prevent infections and enhance the reproductive capacity of aquatic animals efficiently.

4. SAFETY CONSIDERATION OF PROBIOTICS

Probiotics may cause four types of side effects in susceptible individuals. They are the systemic infection, deleterious metabolic activities, excessive immune stimulation and gene transfer. But traditionally probiotics used in the food industry are safe for human consumption. No detrimental effects on human health been ever determined which is the best proof of safety.

CONCLUSION

The increasing production cost of food is the main reason for the present global food crisis. So, aquaculture is recognized as a path to fulfill the increasing demand for freshwater food and seafood. But, it is facing several challenges due to high production pressure. In this situation, the use of probiotics can show a new path. It is already established that it has a clear role in fish and other aquatic organisms. The effective use of probiotics in aquaculture can help in increasing production and assisting the farmers economically.

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Prevention of monetary losses through insect pest management in seed stores

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The growth of agriculture based economies of the world depends upon the sustained supply of quality seeds. The productivity led growth in agriculture is based on application of advanced technology, which in turn is dependent on cultivar's access to the seed of desired genetic composition and adequate purity. Quality seed also offer the highest economic and social return among all the agricultural inputs. It also ensures the optimum utilization of the other production inputs *viz.,* pesticides, fertilizers etc. In India, ecological conditions are diverse in different regions and consequently a number of crops are cultivated. A large insect fauna is associated with each of these crops from production to storage because of the congenial conditions for the survival and multiplication of insect pests. The extent of losses caused by these arthropods in total seed yield and quality depends upon their feeding behavior/life cycle. Besides these pests also lower the seed recovery which has a significant impact on the success of seed industry in the region.

Seeds are required to be stored since seeds harvested in the preceding season are usually used for sowing in the next season after an interval of six months or more. Also buffer seed stock needs to be maintained which may extend from 2 to 3 years. In tropical and subtropical world, the losses in typical village stores as well as warehouses are more due to seed damage by biotic (insects, rodents, micro-organisms etc.) and abiotic (temperature, humidity) factors. Among these factors, largest proportion of preventable (post harvest) wastage is due to moisture insects and rodents in storage.

DAMAGE

Insect pest infestation during storage leads to poor health status of seeds. It is well known that insect pests infesting stored products are tropical in origin. The seed quality is affected on the basis of insect damage to endosperm or embryo. If embryo portion is damaged, seed fails to germinate and if endosperm is damaged, seed may germinate and develop into a seedling but the vigour of the seedling will depend upon the extent and intensity of the damage. The degree and type of insect infestation and insect species involved depend upon the crop seed and prevailing ecological conditions. Other factors *viz.,* sanitation, bulk for bag storage etc. generally influence the seed safety. In bulk storage seeds continuously release heat and moisture by respiration, slowing down the air movement through the bulk of the seeds, which tends to develop hotspots and caked seeds. Insects also damage indirectly by contaminating the seed with their waste, casteskins, webbing and body parts. Heating also takes place due to feeding by some insect pests which leads to development of moulds. The "Weevilized" seeds are not accepted either seeds may fail to meet the certification standards or they may lead to contamination of new stores.

LOSSES

In India, post-harvest losses accounts for about 10 per cent of total food grains due to unscientific storage, insects, rodents, micro-organisms etc. The annual storage losses have been estimated 14 -million tonnes worth of Rs. 7,000 crores in which insects alone account for nearly Rs. 1,300 crores (2015). The major economic loss caused by storage insect pests is not always by consumption but also by the amount of contamination. About 600 species of insects have been associated with stored grain products and nearly 100 species of among them cause economic losses. Through weight loss, viability loss, commercial value loss, consumer preference loss, nutritional values loss, fungal growth and storability loss.

In Haryana, both primary and secondary seed feeders in wheat seed. Lesser grain borer *Rhyzopertha dominica* was most popular followed by *Sitophilus oryzae* in farmer's saved wheat seed samples. *Trogoderma granarium*- essentially a germ feeder was recorded, from dry zones. On an average, 67.6 per cent samples could not meet the minimum certification standards; maximum damage in a sample was by *Trogoderma granarium* in which 43 per cent seed embryo was eaten by the beetle.

TEMPERATURE AND SEED MOISTURE

Most insect pest of stores have a short period from egg to adult and their reproduction rate is high. The two abiotic factors which influence these characteristics are temperature and moisture. Since cool and dry conditions are safe for seed storage, it is considered that side with moisture less than 10 per cent and temperature below 20°C remains free from pests. The optimum range of temperature for most insect species lies between 28-32°C. Temperatures less than optimum and decrease their feeding activity, prolong developmental period may cause mortality in many individuals due to starvation. At Higher temperature (25 to 35°C) and humidity, seed deterioration is accelerated since the conditions favour insect multiplication and formation of hot spots besides biochemical and nutritional changes in seeds.

High seed moisture content is the greatest single factor for the loss of seed viability. With high moisture content, the spoilage increases due to seeds' on metabolic activity and also increased pest incidence. The moisture requirement differs from one insect species to another. However, all of them need more than 10 per cent seed moisture. Therefore, seeds having less than 10 per cent moisture are safe for storage. Storage above 16 per cent seed moisture content not only deteriorates the seed quality but also occupies more space as its bulk increases. The seed moisture content of 12-14 per cent is congenial for insert development and moulds, at 18 to 20 per cent heating starts and at 45 per cent seed moisture, germination starts. The process initiates chain reactions resulting in the loss of seed viability. Insect-pests of stores obtain water primarily from the seed itself. If the moisture content of seed is low, generally less than 10 per cent, the insects must obtain water by breaking down the seed components or by using their own energy reserves. Under such situations, fewer insect survive. It is important to note that fluctuations of moisture as small as 0.5 to 1 per cent can significantly affect the rate and extent of insect infestation.

HARVESTING CONDITIONS

The harvesters and threshers available in the market are designed for grain and not for seed crops. Threshing efficiency is the main criteria for grain crops whereas seed breakage is the concern of seed grower. Grain crops are harvested at low grain moisture content through at such a moisture content, the seed damage would be more, which in turn would affect the storability of the seed. However, harvesting and storing seed at high moisture content would not only lead to quick multiplication of insects but also invasion and development of various fungi. The development of insects is, however, aided if broken seeds and dockage are present in a seed lot. For the store insects infesting the crops in the field after harvesting, threshing must be done quickly so that control measures could be applied in stores before damage occurs in serious proportions. Regions where *Sitotroga* occurs, prompt harvesting and threshing is best since it helps to prevent infestation in field and in bin.

Seed residues in processing plant especially conveyors, seed treater, transport vehicles *viz.*, trolley, trucks etc., harvesters and threshers etc., are particularly susceptible to store seed insects and storage fungi. The favourable temperature and moisture conditions provide the suitable environment for the build-up of large pest populations. Therefore, inspecting, removing and treating these seeds residues is advisable to prevent contaminating newly harvested seed crop.

CERTIFICATION REQUIREMENTS

In Indian Minimum Seed Certification Standards, seed standards for "insect damage" have been provided in chapter 1 (General seed certification standards) and subsection 25th. The rule states that "A seed lot under certification said not have apparent or visible evidence of damage by insects for both foundation and certified seeds classes in excess of one per cent for seeds of maize and legumes and 0.5 per cent for the seeds other than maize and legumes unless otherwise prescribed".

Thus, it is essential to determine the insect infestation of a seed sample/ lot submitted to Seed Testing Laboratory. The information obtained is reported to be useful in several ways.

- Insects cause poor germination and weak seedlings.
- Latent / hidden infestation can lead to increase infestation of a seed lot during transit/storage.
- Spread of insect-pests to newer areas and
- It helps in adoption of proper remedial measures.

For assaying the seed sample from "ID" point view, it is essential to test the sample immediately at the time of its lifting or preserve it in a way so that insects do not multiply.

SEED STORAGE

A. Requirements of Store

In India, farmers store the seed by various methods to prevent losses, but they succeed only partially owing primarily due to use of traditional receptacles (pit type / underground structures, paddy straw structures, *kacha kothi*, earthen ports, oil drums, *parchhatii* and *theka* storage structure) where maximum loss occurs. Safe storage is aided by absence of cracked seeds and other inert material which not only provide food to insects and fill up the spaces between seeds but also interfere with the natural movement of air through the seeds if stored over long periods and seed quality could not be maintained in a survey of Haryana State, it is observed that most farmers do not distinguish between seed and grain. In fact, the produce is consumed as grain from threshing onwards and the same lot is used as seed for planting in the next season.

Though on commercial scale "Silos" are being used, yet "Pusa metallic bins" are commonly used by the farmers for on-farm storage. Seeds kept in dark, damp stores and improper receptacles absorb moisture from either ground or atmosphere particularly during monsoon. The warm season and high seed moisture content are highly conducive to the development, survival and rapid multiplication of insect-pests. Thus, to save the seed from insect damage/infestation the storage structure should have following characteristics.

- It should be moisture proof.
- It should allow controlled aeration to cool the seeds and thus limit insect development.
- It should be capable of being made sufficiently air tight, for distribution of fumigants.
- It should be easy to clean and inspect and also allow smooth in and out movement of seed.

- Besides, it should protect the seed from rodents, birds, objectionable odors, theft etc.

B. Sources of Insect Infestation:

The harvested seeds most likely have optimum temperature and moisture conditions for insect development. Before strategies are adopted for the control of these insects, the sources of insect-pest infestation in stores should be looked into to prevent the multiplication of insects. The sources of insect infestation are:

- Leftover seed from bins/stores or spilled seeds under the stacks
- Cleanings of the processing plant
- Old infested stores
- Old gunny bags
- Insect infested trolleys, wagons, trucks etc.

Storing insect infested seeds with fresh stock or vice-versa. Entry of insects from neighbouring stores and carryover of field infestation

C. Seed Inspection during Storage:

Frequent inspections and constant vigilance are the most important steps of pest management in seed stores. Foul odour, flour spots on gunny bags or dockage generally indicate foci of infestation. Small plastic traps, with or without pheromone bait have been successfully used in the bulk seed to scout for insects.

Appropriate inspections of a seed store including outside areas are essential to check the insect population build-up. The behavior of the insect must be kept in mind when looking for signs of their probable presence. The inspections must be made by well equipped and trained staff who should look for the raw seed, equipment used during transportation, processing, cleaning etc. and maintain a complete record of the insect control. Regular periodic inspections throughout seed storage must be made to detect initial insect infestation or heating. Such inspections are particularly important during monsoon or in coastal regions where seed moisture and ecological conditions are congenial for rapid insect multiplication.

Inspections of possible insect infestation in stored seeds have become pivotal with shift towards integrated pest management. In fact, inspections have become a routine schedule/part of any efficient and effective pest management programme. Inspections should be pre planned to the extent possible and basic tools and equipment prepared prior to the inspection. During the inspection, checking should be made everywhere including all static areas and equipment. Clear and concise reports should be provided. For inspection we need a seed probe and seed physical purity boards to separate the insect(s) and damaged seeds.

The build-up of the pest population changes according to ambient temperature and moisture levels during the storage. It is, therefore, advisable to inspect the stores/bins at 3 or 4 week intervals. During monsoon period and in coastal areas inspection should be made at fortnightly interval. Seed samples should be drawn systematically and inspected for insect population, seed damage and dockage.

During the inspection, be alert to the presence of odours, caking and crushing as these are clear indicators of insect and moisture problems.

INSECT PESTS OF SEED STORES:

A large number of insect species are associated with seeds during storage. These insects mostly belong to orders Coleoptera (beetles/ weevils) and Lepidoptera (moths). These insects, depending upon their ability to damage sound seeds, can be divided into Primary and Secondary seed feeders. The primary consumers breach the pericarp or testa making feeding possible by a much wider range of insects, mites and fungi. The primary consumer obtains water metabolically from seeds and releases it into their immediate environment along with waste heat. At the same time the accumulating frass, seed dust and carcasses restrict air movement, contributing to the formation of hot spots. Amongst primary pests, adults and larvae of *Trogoderma granarium, Sitophilus oryzae* and *Rhizopertha dominica* are most important pests. Grain moth, *Sitotroga cerealella* is not a serious problem in North India but is a major pest in coastal as well as South India. In legumes, *Callosobruchus* spp. is very serious. The generation time is often short and in a few months, the population can explode. The weevils complete their life-cycle inside individual seeds and may develop into substantial population before their presence is even noticed.

Primary feeder insects: *Callosobruchus maculates; Sitophilus oryzae* ; *Sitotroga cerealella* and *Rhizopertha dominica*

Secondary seed feeders attack the already damaged seed where testa is cracked, holed or broken either due to mechanical damage during harvesting, threshing and processing or by too rapid seed drying or by prior feeding damage by primary seed feeders. Such insects are primary pests of flour/processed products. Most common secondary pests on seeds include the larvae of *Ephestia, Plodia* and the beetles of *Oryzaephilus, Cryptolests, Tribolium* and the other Tenebrionidae. As per the climatic requirements, *Trogoderma* is a serious pest of warm and dry regions while *Sitophilus* and *Rhizopertha* of humid and moderately warm regions.

Secondary feeder insects: *Tribolium castaneum; Oryzaephilus surinamensis* ; *Cryptolests* spp and Trogoderma granarium

In seed stores, insects can be categorized into two groups:

Group-1: Insects that infest the seed in the field and do not multiply in transit/ store e.g. pink boll worm in cotton, midges in millets etc. The number of seeds damaged in field remains constant. Pests are transmitted through these infested seeds from place to place and year to year. They resume their life activity in field or other media under favourable conditions.

Group-II: Insects that infest the seed in field/ store or any other place where seed is handled. These arthropod pests continue life-cycle in ambient conditions. Number of damaged seeds as well as insects continue to increase with the passage of time e.g. weevils, beetles, moths etc. Thus, after lifting a seed sample containing such insects, it should immediately be tested.

Proper pest control is predicated on knowing what we are trying to control. Thus, identification of insect pest species is important. Knowing the insect species in a potential problem can help us decide what the risks are, what actions are indicated and how prompt these actions need to be adopted.

MANAGEMENT:

For the management of the insect pests in a seed store, the management strategy should be well defined, since not only insect pests are to be controlled but the viability of the seeds is also to be preserved. Five key steps in dealing with insects in a seed store or processing plant, as reported earlier, in chronological order are:

1. Have an inspection or surveillance system for the storage which would yield prompt awareness of a possible problem;
2. Determine the extent and nature of the possible problem - what species, how many and when;
3. Device a plan for the control of the problem. Make use of your own basic knowledge and information. Consult experts, literature etc. or whatever combination is required;
4. Implement the device plan being willing to modify it as indicated and ;
5. Monitor the results of the effort.

The strategy of insect pest management must keep into consideration the following key aspects of insect control:

A. Prevention:

1. Keep facility clean (sanitation)
2. Do not bring the insects into the processing plant
    - check conveyances
    - check raw seed including packaging supplies
    - maintain building tightness
3. Have clearly defined inspection programme for early detection
    - use check list(s) of where to look
    - use traps as monitoring devices

B. Presence noted — Assessment of Problem:

1. Species definitely identified
2. Determine behaviour/habits
   – think like an insect
3. Determine source(s) or origin(s) of infestation

C. Plan of Management:

1. Define magnitude of "problem" species, number/locations etc.
2. Select control treatment(s) based on:

- seed damage in bulk or bag
- potential for contamination
- physical facilities
- risk to operator & others
- Cost (control measures, possible loss of seed or seed quality etc.)

Insects in seed stores are controlled by avoidance, physical manipulations of the store and fin toxic chemicals. Right type of storage structure play a pivotal role in keeping the seed insect free in on-farm storage in tropical and sub-insect regions of the world. Generally the control measures are grouped into (i) preventive and (ii) curative measures. The curative methods are categorized into chemical and non-chemical methods. The chemical methods include fumigation of stores as well as spraying the store surfaces/bags and also mixing of insecticidal dusts with seeds. Nonchemical methods include biological control, host resistance to pest, modified atmosphere system, temperature manipulations, radiation, physical barrier etc.

Preventive:

- Prompt harvest, drying and thorough cleaning of the seed help prevent entry of insects into the seed stores.
- Good sanitation in the processing plant and harvest machinery is crucial, since seed pests often breed in small remnant deposits of old seeds in inaccessible places *viz*., conveyer belts, screens, lift, hoppers etc.
- Hard to reach spots should be disinfested by fumigation.
- Destroy (burn or burry deep) the sweepings, clear trash, litter from outside the store/ processing hall and remove the spilled seeds from under the stacks.

- Remove all the leftover seeds from store/bin; sweep down the walls, ceilings, sills, ledges and floor etc.
- Make necessary repairs of crack and crevices.
- Use new gunny bags for fresh harvest. However, if old bags are to be used dip them in
  0.1% malathion 50 EC (l part malathion 50 EC + 500 parts of water).
- Drying followed by cooling and ventilation of bulk stored seed, as well as temperature monitoring is important for long term storage.
- Bagged seeds must be kept at distance from walls to allow inspections, fumigation and
  avoiding the seed to absorb moisture from moist surfaces.
- To disinfest the stores, spray 0.5% malathion 50EC (1:100) on floor, wall and ceiling or fumigate with aluminium phosphide tablets (3 g each) @ 7-10 tablets or 10 L EDCT per 1000 cubic feet.
- To avoid insect damage to store seed, mixing of malathion 5D @ 250 g/qtl or deltamathrin 2.8 EC @ 4 rnl/qtl seed is recommended. This treatment besides checking the insect infestation in seeds do not have any deleterious effect on its quality.
- Spray inside and outside surfaces of the store after cleaning with the following insecticides to kill any insect that has remained in the store or insects that may crawl across these areas to damage the stored seed:

1. 0.1% malathion 50EC (1 part of insecticide +500 parts water) or
2. 0.1% fenvelrate 20EC (1 part of insecticide + 200 parts water) or
3. 0.1% cypermathrin 25EC (1 part of insecticide + 2500 parts water).

Care must be taken to treat all the cracks, crevices and areas around doorways and other places where insects could enter from outside.

Note:

- Always look for the expiry date on the label of the insecticide container; use as directed on the label; do not use spray material that have sat overnight after being mixed with water.
- To keep pulses free from the bruchid infestation, keep a 7.0 cm layer of sand at the top of seed stored in bulk.

FUMIGATION

Under tropical and sub-tropical climatic conditions, inadequate methods of seed storage as well as high risk factors of insect infestation warrants the use of fumigants in seed stores or application of insecticides to save the seed from insect ravages. Fumigation with fumigants is widely practiced, for curative or preventive action, as they are cost effective, efficient and easy to use against target pests besides can penetrate into places when other control methods become impossible or impractical.

Fumigant is a chemical substance, which at specified temperature and pressure can exist in gaseous form in sufficient concentration to be lethal to the pest organisms. Apart from other characteristics a fumigant should not affect the viability of seeds, should be non-persistant, non-corrosive and highly diffusible. Fumigation with fumigants *viz*., aluminium phosphide, methyl bromide, ethyl dibromide and EDCT are most common world over. EDB has been found to reduce the seed germination of many cereals and legume crops. Though no adverse effects of fumigation with aluminium phosphide have been observed yet varietal differences have been observed in wheat, rice, green gram and broad beans for germination and other quality parameters. At higher seed moisture content and phosphine doses, complete loss of viability, mutagenic effects and chromosomal aberrations have been reported in wheat and onion seeds. In rice, high phosphine dose resulted in increased dihydrogenase activity, seed leachate electrolytes along with decreased respiratory enzymes. In most of the crops, the germination and vigour is affected with excessive fumigation doses and prolonged exposure period if the seed moisture content is high. Hence, even fumigation has implications during revalidation of seed lots.

Aluminium phosphide should thus be used with care in seed stores as phosphine gas react differently with seed of crops having different moisture contents. The storage facilities should be sound to avoid movement of moisture in the store, as seed quality is reported to be affected if phosphine fumigation is done at more than 12 per cent seed moisture content.

CURATIVE

- Fumigate with aluminium phosphate @ 7 tablets (3 g each) or EDCT mixture (3:1) per 1000 cubic feet space with exposure period of at least 7 days.
- Never keep the fumigant at the bottom of the floor/bin as the gas is heavier than air and travel downwards. Since the gas can penetrate downwards up to 8 feet the fumigant should be placed accordingly.
- Spray the stores with DDVP @ 0.25% (1:300). For 100 m^2 area, 3litres of spray material is required. Spray on all the walls, ceiling and floor of the store. Spray other surfaces/ structures (see check list) where presence of insect is suspected.
- Surface of the bags should be sprayed with malathion 50 EC (1 ml malathion in 100 ml water) after 3 or 4 weeks.

PRECAUTION:

- Fumigations are to be done cautiously by trained persons/under technical guidance.
- It should be ensured that the fumigated structures are air tight.
- Never use EDB in seed stores as it would affect seed quality.

- Never mix BHC or DDT with seeds.

NON CHEMICAL METHODS

Biological Control:

Stored product insects are attacked by an array of parasites and predators that exert some degree of natural control. Augmentation or manipulation of these natural enemies offers new means of controlling storage pests in situations where the use of other means of control is objectionable. A parasitic wasp, *Bracon hebetor* attacks late stage larvae of *Cadra cautella* and *Plodia interpunctella* to suppress their populations. The potential of this method is still rudementry in stores.

Fig. *Bracon hebetor; Cadra cautella* and *Plodia interpunctella*

PHEROMONES:

Synthetic pheromones have been produced for the almond moth, red and confused flour beetles. lesser grain borer, khapra and few other insects species. The studies have shown that pheromone traps are effective in detecting hidden infestation.

HOST RESISTANCE TO INSECT-PEST:

Though much effort by plant breeders has been made to develop insect resistant lines in various crops, yet little research has been performed to develop lines whose grains/seeds resist attack by stored product insects.

TEMPERATURE MANIPULATION:

The application of high or low temperatures offers a non-chemical means of disinfesting stored commodities. Sub lethal temperatures can affect reproduction, growth, development, feeding and movement. However, temperature adverse to survival of storage insect population must not affect the seed viability.

CONTROLLED OR MODIFIED ATMOSPHERES :

Killing of insects with modified atmosphere of oxygen, carbon dioxide and nitrogen has long been recognized. Laboratory studies have shown that atmospheres deficient in oxygen are effective in controlling all life stages of principal insect species that infest stores. For instance, air with only 2 per cent oxygen will asphyxiate *Sitophilus* weevils. Further, continuous storage in these atmospheres for period upto 1 year did not adversely affect germination of wheat, rice, barley, malt and almonds. Further tests to compare the economic feasibility of modified atmospheres and chemical control methods are needed. In addition, basic information on population growth and development of surviving insects subjected to these conditions are needed.

RADIATION:

Effect of Gamma-Radiation has been studied extensively for disinfestations of insects in stores. However, its affect on seed viability has not been studied in detail.

PHYSICAL BARRIERS:

One of the demonstrated non-chemical methods for the control of stored pests is the use of physical barriers placed around the commodity. For example, a multi-wall paper bag has been developed to protect the seeds. Another physical barrier is the packaging material which prevents the insects from infesting the seeds in bags. The packaging materials identified to be resistant to insects are: ethylene tetrafluoroethylene, polyester, polyvinylchloride, polypropylene and polycarbonate. Insecticides have also been inserted into packaging material to make them insect resistant. Plastic sheet with high tensile strength is also being tried as barrier for the insect infiltration. Also, physical disturbance or turning of seeds, vacuum conveyance and Entoleters have been reported to reduce the population of external feeding insects only. Inert dusts derived from the shells of diatoms are being used to mix with seeds. However, seed moisture must be kept in mind while using these dusts.

INTEGRATED PEST MANAGEMENT

Nowadays, IPM can be applied for the management of insect pests in stores. Computer models are being used to predict when the control strategy is to be adopted and recommended which control method(s) to be used. These models use the knowledge of insect ecology and previous store history in the best management programmes. IPM requires a complete understanding of insect pests species, their monitoring, biology, behavior and reaction towards various management strategies. In IPM reduced use of pesticides encourage biological and physical methods of pest control besides decreasing the chances of insecticide resistance. Frequent sampling is most important component in such management programmes.

Empowerment of farm women through poultry value chain

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ABSTRACT

Women compose majority of poor poultry birds keepers, prefer easily manageable birds and depend on access to common-property resources, and that poultry practices is begin to become feminized, we can safely determine that women are the main users and caretakers of locally adapted poultry activities. Poultry are probably the most important livestock species for many poor, rural families world-wide. Poultry keeping is largely the responsibility of women, but despite this, research into rural poultry development is usually narrowly focused on technical aspects with very little attention being paid to the wider socio-economic issues. Interventions to improve poultry production are often seen as a way to reach poor rural women to improve their livelihood.

Keywords: Poultry, Livelihood, Women, Livestock and Rural

INTRODUCTION

***"Empowerment of women leads to development of a good family, good society and, ultimately, a good nation."*- A.P.J. Abdul Kalam**

As honourable late A.P.J. Abdul Kalam says, that empowerment of women leads to development of a good family, good society and, ultimately, a good nation. It clearly states that women are the nuclei of the socio-economic development of country. When women move forward, the family moves, the society moves and the nation moves. Considering the role that women, as a home and hearth bound segment of society, may have played in taming, nursing and raising the first livestock, it is logical to assume that they were also the world's first livestock owners (Kohler-Rollefson and Rollefson, 2002). Women compose not only around 70 percent of the poor, they also make up the majority of poor livestock keepers. According to an extensive study by ILRI of the 600 million poor livestock keepers in the world, around two-thirds are women and most live in rural areas (FAO, 2009a; Thornton *et al.*, 2002).

Poultry is one of the fastest growing segments of the agricultural sector in India today. While the production of agricultural crops has been rising at a rate of 1.5 to 2% per annum, while total chicken population has registered an annual growth of 7.3% in the last decade.(GOI report, 2012-17)

Women as a class, play a pivotal role in the process of economic development. According to census 2011, women constitute 48.43 percent of the total population of India and 25.56 per cent of the female population are designated as workers. Amongst the female workers, 24.03 per cent are identified as cultivators, 41.07 per cent as agricultural labourers and 02.99 per cent are involved in plantation, livestock, fisheries and other allied sectors. Traditionally in rural communities, women had been playing vital role not in agriculture alone but also in related activities e.g.; poultry, livestock and domestic activities. Women are an integral part of the human Society. Women contribute one third labour force required for farming operations and allied enterprises. They have been playing significant role in home, farm and allied activities.

POULTRY FARMING AND ITS BENEFIT

Poultry farming is generally considered a key asset for rural livelihoods. Requirement of small space, low capital investment, quick return from outlay and well distributed turn over throughout the year make poultry farming remunerative in both rural and urban areas. The rearing of poultry provides an excellent opportunity for gainful employment to idle or unemployed members of rural communities (Gazi *et al.,* 2014). It offers advantages over other agricultural and allied sectors and is an entry point for promoting gender balance in rural areas. In particular, because in most societies, all household members have access to livestock and are involved in production, poultry activities are a daily occupation. Poultry also plays an important role in contributing to women as livelihood option and food security by enabling direct access to animal source protein, providing income from sale of eggs and poultry birds that can in turn be used to purchase food especially during times of food deficit, contributing to increased aggregate cereal supply as a result of improved productivity from use of manure. It is also a source of cash and can open up access to credit by the sale of birds provides an emergency source of cash for medical treatment or school fees, while eggs provides a regular flow of cash income often used to purchase food and household items. It represents a very familiar skill to most of the poor women and it can help them in moving into a positive spiral of events that may lead them for elevation of their socio economic status.

BACKYARD POULTRY FARMING

In India, despite a huge industrial poultry sector, backyard poultry keeping is still common among tribal and rural households, although the percentage has dropped from 50 percent to 10 percent within 30 years. Backyard poultry production is traditional in most rural and peri-urban areas of India, particularly in some communities (Gazi *et al.,* 2014). Rural farm women keep backyard poultry in scavenging systems to supplement and enhance their livelihoods. In Thane district, farm women generally rear poultry birds in their backyard. Overall backyard poultry farming is practised here. Some advantages of rearing backyard poultry birds are:

- Well adapted to local conditions – no disease problems once they are adult;
- Low external input – thrive on waste, insects, weeds, etc.
- Can protect themselves from predators;
- Good market demand for their produce, which sells at a premium;
- Replacements are easily available. (Rangnekar D.V. and S. Rangnerkar, 2002)

ROLE OF WOMEN IN POULTRY

Women play an important role in poultry management, processing and marketing, acting as care providers, feed gatherers, and birth attendants. They are also involved in egg production, control the sale of eggs and poultry birds. Identifying and supporting women's roles as poultry owners, processors and users of poultry products strengthens their decision-making power and capabilities, are key aspects in promoting women's economic and social empowerment and consequently provides a way to enable rural women to break the cycle of poverty. Poultry ownership also increases the women's decision-making and economic power within both the household and the community. Ownership of poultry by women can influence the decisions they make on how to use that poultry or poultry products, as well as how to use other streams of benefits, for example, income emanating from that poultry farming. Poultry ownership increases the likelihood of gaining access to credit. The outstanding demand for poultry products gives considerable opportunities for the rural women to escape poverty by diversifying livestock production.

WOMEN EMPOWERMENT via POULTRY FARMING

Women empowerment states the ability of women in which she enjoys the right to take her own decision, she has freedom of thoughts and views, she has independence in society. It ultimately strengths her economically, socially and emotionally. Enhancing the position of women in the power structure of the society is called women empowerment. In general sense, it refers to empower women to be self dependent by providing them access to all the freedom of opportunity (Bhuyan, 2006). It is an active, multidimensional process which should enable women to realise their full identity and power in all spheres of life. Empowerment of women is important to take into account some aspects of female empowerment like economic participation, political participation and power over economic resources. (Prem Chand *et al.*, 2011)

Poultry keeping is one of the factor used to empower women economically because women perceiving poultry keeping has a source of small cash, source of nutritious food to the family at very low cost, useful during celebration of important events, festivals and entertaining of important guests and relations. Increasing women's control over land, physical assets and financial assets can improve child health and nutrition, and increase expenditures on education, contributing to overall poverty reduction. Moreover, there is hardly any household in the rural areas of the country where poultry is not kept and mostly households keep desi and/or local fowls. Their involvement in poultry keeping stems from the fact that they and their household members derive a lot of benefits from poultry rearing. Poultry meat and egg provides essential protein requirement for the family. It also has better energy and protein conversion ratio per feed supplement fed than many other farm animal species.

FARM WOMEN AND POULTRY VALUE CHAIN

The women engaged in combination of raising field crops, orchards, poultry, or other livestock species is called as farm women. The poultry value chain can be defined as the full range of activities required to bring a product (e.g. live animals, meat, eggs, fibre, manure) to final consumers passing through the different phases of production, processing and delivery (IDRC, 2000). It can also be defined as a market-focused collaboration among different stakeholders who produce and market value-added products (IFAD). Value Chain analysis is essential to understand the production system, marketing channels and their relationships, the participation of different actors, and the critical constraints that limit the growth of poultry production and consequently the competitiveness of smallholder farmers. These farmers currently receive only a small fraction of the ultimate value of their output, even if, in theory, risk and rewards should be shared down the chain source (Rota, 2009). There are large commercial farms that use the formal market and small scale commercial farms that mostly market their product live in the informal market. (Thwala, 2011).

POULTRY FARMING SCHEMES

Swayam scheme is initiated by Department of Animal Husbandry, Government of Maharashtra. This scheme is mainly for schedule tribes including for both gender male and female. It mainly aims for self employment and nutrient intake of tribal rural people resulting in improving their present situation and better life. Here beneficiaries are distributed a flock of total 45 layer birds.

In addition to central sector schemes, a number of centrally sponsored schemes (CSS) have been in existence in the previous plans. These schemes have substantially contributed to the growth of poultry sector especially rural poultry.

Under CSS on Poultry Development with components viz. Assistance to State Poultry Farms, Rural Backyard Poultry Development and Poultry Estates, 218 state poultry farms have been benefitted covering most states. It is felt that some state poultry farms which were left out need to be further strengthened. Grants were provided to the State Government for promoting smallholder poultry rearing in rural/tribal areas of the country with refinance from NABARD. This scheme has benefitted a large number of poor families in enhancing their income and nutritional security.

CONCLUSION

Rural women traditionally play an important role in poultry sector and are often in control of the whole process from feeding to marketing, which is not the case in production systems for other livestock species. Women benefits from poultry value chains which includes local poultry production and marketing, or particular points of value chains such as informal trading, processing or as service providers. The management, processing and marketing of poultry products generates income that women tend to be involved in, and brings benefits for the whole family for instance by increasing food security at the household level. Owning, controlling and benefiting from poultry production increases women's self-esteem and strengthens their role as producers and income generators within the household and in the community.

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Hybrid Seed Production Technology of Rice and Guidelines for the Conduct of DUS test

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INTRODUCTION

- Rice is the seed of the grass species *Oryza sativa* or *Oryza glaberrima*
- It is the agricultural commodity with the highest worldwide production
- The majority of rice produced in Asia is in from India, China, Indonesia, Thailand, Myanmar and Bangladesh (IIRI-World Rice Statistics, 2010)
- Rice is one of the oldest cultivated crops with a basic chromosome number of 12 and total 24 species among them only 2 are cultivated species, i.e., *Oryza sativa* – Asian rice and *Oryza glaberrima* – African rice and rest are wild species which include both diploid and tetraploid forms
- Genome size is 430 Mb
- Genome sequencing by India – 11^{th} Chromosome (IRGP, University of Delhi)

Table 1: Genetic resources of *Oryza spp.*

Sr. No	Species	Genome	Sr. No	Species	Genome
1	*O. sativa**	AA	13	*O. punctate*	BB. BBCC
2	*O. nivara*	AA	14	*O. latifolia*	CCDD
3	*O. rufipogon*	AA	15	*O. alta*	CCDD
4	*O. gleberrima**	A^gA^g	16	*O. grandiglumis*	CCDD
5	*O. barthii*	A^gA^g	17	*O. australiensis*	EE
6	*O. longistaminata*	A^lA^l	18	*O. granulata*	-
7	*O. glumaepatula*	$A^{gl}A^{gl}$	19	*O. meyeriana*	-
8	*O. maridionalis*	A^mA^m	20	*O. longiglumis*	-
9	*O. officinalis*	CC	21	*O. ridleyi*	-

10	*O. minuta*	BBCC	22	*O. schlechteri*	-
11	*O. rhizomatis*	CC	23	*O. branchyantha*	FF
12	*O. eichingeri*	CC	24	*O. coarctata*	-

HISTORICAL BACKGROUND

- 1964 - Prof. Yuan Long Ping Anjiang Agricultural School, Hunan Province.
- 1970 - Mr. LiBiHu found plant with WA type cytoplasm from wild rice (*Oryza ruifipogon*) in Yacheng County, HanNan Island.
- 1972 - Yan Long (Jiangxi Province) and Yuan Long Ping (Hunan Province) developed Zhen Shan 97A.
- 1973 - Zhang Xian Cheng from Guangxi Province found that IR 24, IR 26 and other rice varieties had the restoring ability to WA type cytoplasm.
- 1976 - Commercial rice hybrids developed.

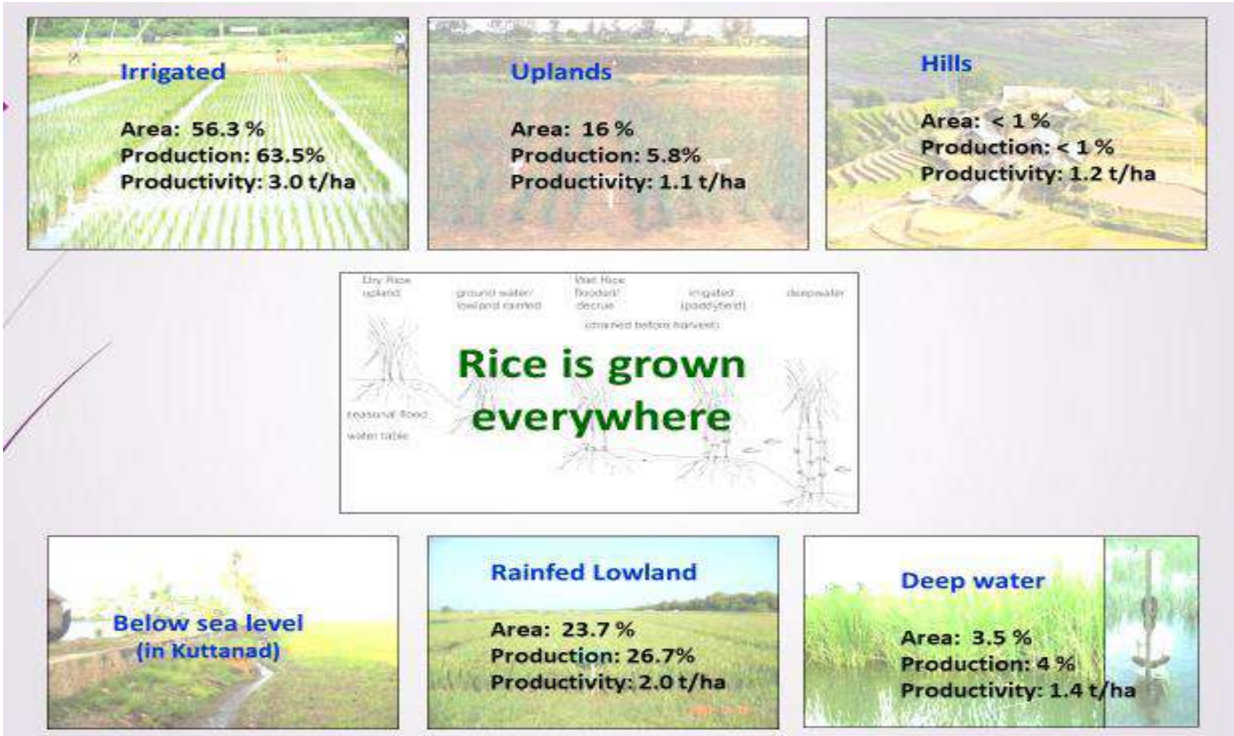


Table 2: Rice Production Worldwide in 2016-17

Sr. No	Country	Production (MT)
1	China	144.95
2	India	110.15
3	Indonesia	036.86
4	Bangladesh	034.58
5	Vietnam	027.40

6	Thailand	019.20
7	Myanmar	012.65
8	Phillipines	011.69
9	Brazil	008.38
10	Japan	007.78

Source : https://www.statista.com/statistics/255945/top-countries-of-destination-for-us-rice-exports-2011/

Table 3: Area, Production and Yield of Food Grains in India

Crop	Area (Lakh hectare)			Production (M Tonne)			Yield (kg/ha)		
	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17
Rice	441.1	434.99	431.94	105.48	104.41	110.15	2391	2400	2550
Wheat	314.65	304.18	305.97	86.53	92.29	98.38	2750	3034	3216
Other cereals	251.7	243.89	247.71	42.86	38.52	44.19	1703	1579	1779
Pulses	253.54	249.12	294.65	65	17.15	16.35	728	656	779
Food Grains	1243	1232.18	1280.26	252.02	251.57	275.68	2028	2042	2153

DEVELOPING RICE HYBRIDS

- Hybrid rice is commonly developed in the following genetic and non-genetic systems: Cytoplasmic genetic male sterility, environment-sensitive genic male sterility and chemically induced male sterility (Virmani *et al.*, 2003; Jiming *et al.*, 2009; Liyong and Xiaodeng, 2014).
- Due to self-pollination efficiency in rice, male sterility systems (MSS) is the most effective method in hybrids development, where unviable pollen grains are developed in female parents.
- Generally, male sterility classification methods and their exploitation in crop plants are on genotypic basis which includes: Cytoplasmic Male Sterility (CMS), cytoplasmic genetic male sterility (CGMS), genetic male sterility, genetically engineered male sterility, chemically induced male sterility and environmental sensitive genic male sterility (Jiming *et al.*, 2009).
- There is main two methods of hybrid seed production in Rice,
  - Three Line Method
  - Two Line Method

Cytoplasmic male sterility (CMS)

- Popular MSS is the cytoplasmic male sterility (CMS) or 3-line system, and utilize 3 different lines (varieties), firstly, male sterile line (A line).

- Where the cytoplasmic male sterility trait is controlled in both cytoplasm and nucleus; this line is used as female in hybrid seed production.
- Secondly, maintainer line (B line), is needed for use as a pollinator in maintaining the male sterility. The maintainer line has viable pollen grains and sets normal seed.
- Finallyhe restorer line (R line) is any rice cultivar that restores fertility in the F1when it is crossed to a CMS line.
- Multiplication of A line (female parent) must be carried out before the production of hybrid (F1) seeds (Virmani, 1992).
- This is an expensive method as it requires three varieties, moreover; CMS varieties have a limited spectrum because some lines cannot be used as restorers (Jiming *et al.,* 2009). Basmati rice also do not possess restorer genes hence it's difficult to cross them with CMS varieties (Lopez and Virmani, 2000).

ENVIRONMENTAL SENSITIVE GENIC MALE STERILITY (EGMS)

- The other breeding system, 2-line hybrid system, involves environmentally sensitive genic male sterile (EGMS) or S lines.
- The seed parents can be multiplied just like any conventional inbred when planted in the fertility-inducing environments.
- In sterility inducing environments, they become male sterile and may serve as a female parent in producing F1 hybrid seeds.
- At this time most fertile lines can be crossed with S-lines to produce hybrids with less risk of contamination with S- plus breed seeds (Liyong and Xiaodeng, 2014).
- Use of EGMS to produce hybrid seeds is called Two-line system (Virmani, 1996; IRRI, 2009) because it utilises the male sterile female parent and male fertile pollen donor.

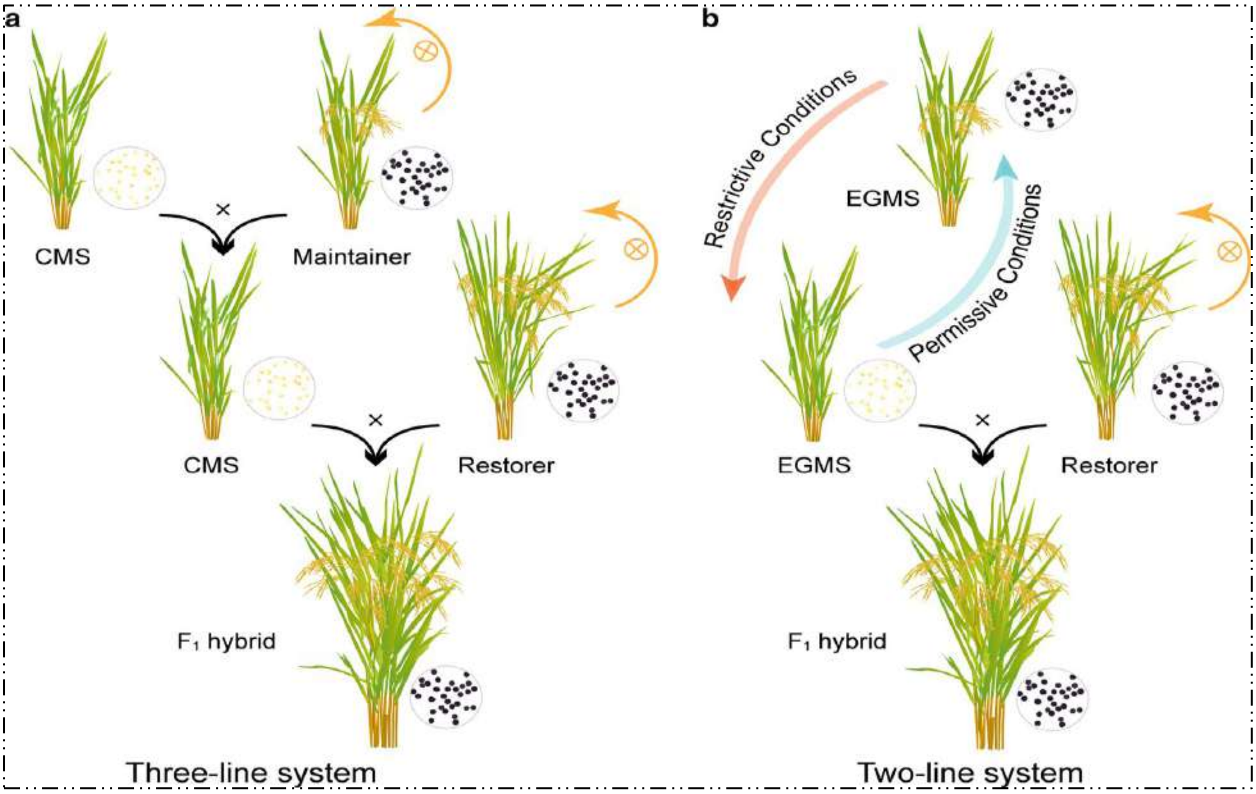
Ideotype of hybrid rice

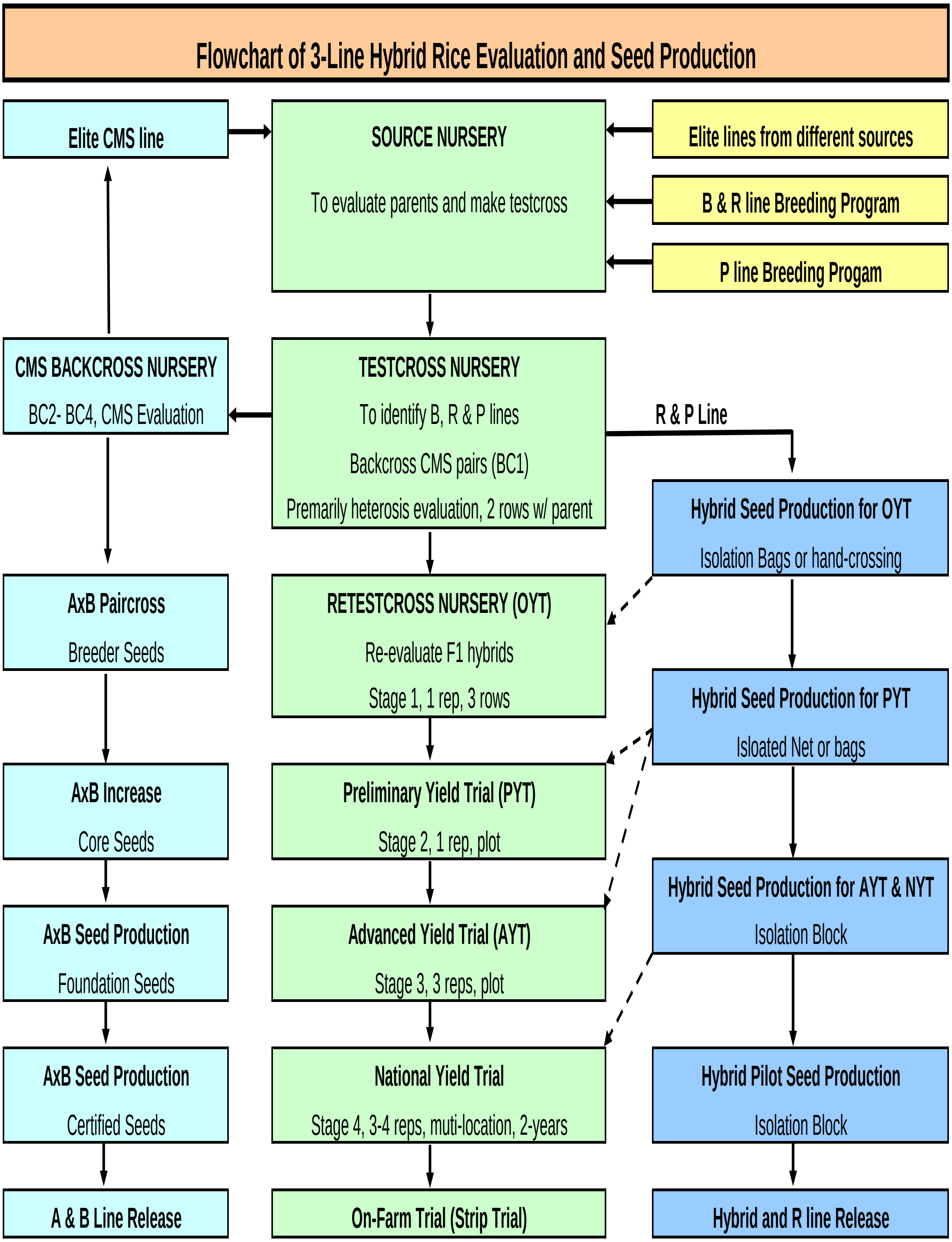
- Moderate tillering capacity
- Heavy and drooping panicles at maturity
- Plant height of at least 100 cm and long panicle height at maturity
- Flag-leaf length of 50 and 55 cm
- All leaves should remain erect until maturity
- Narrow and V-shape leaves
- Harvest index of about 0.5

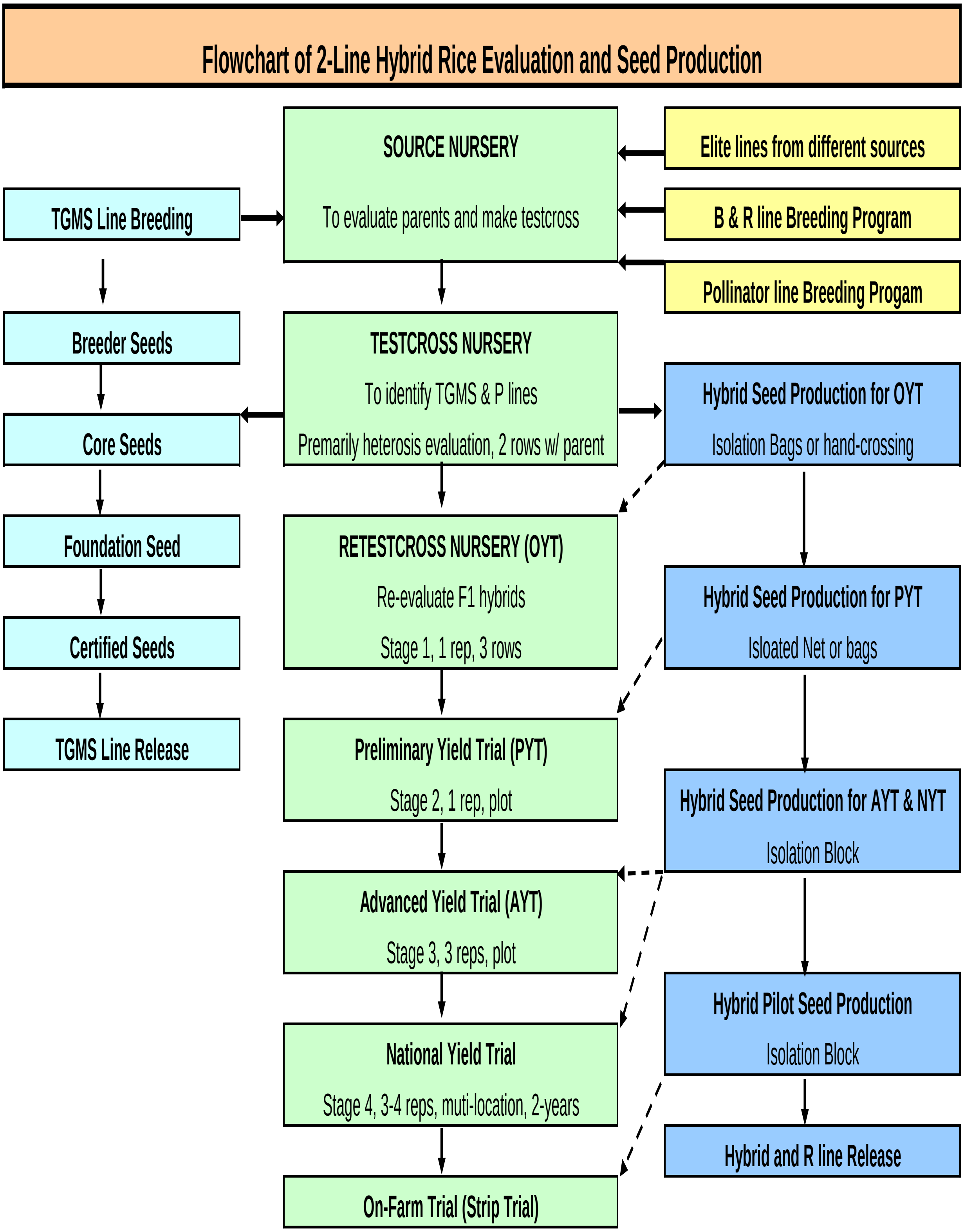
Ideotype of super rice

- High yield potential of 13,000 – 15,000 kg/ha
- 3 to 4 tillers per plant
- 200 to 250 grains per panicle
- Plant height of 90 to 100 cm

- Thick and sturdy stems, dark green, thick and erect leaves, vigorous root system
- 100 to 130 days growth duration, and high harvest index




Flowchart of 3-Line Hybrid Rice Evaluation and Seed Production
Elite CMS line
SOURCE NURSERY
To evaluate parents and make testcross
Elite lines from different sources
B & R line Breeding Program
P line Breeding Progam
CMS BACKCROSS NURSERY
BC2- BC4, CMS Evaluation
TESTCROSS NURSERY
To identify B, R & P lines
Backcross CMS pairs (BC1)
Premarily heterosis evaluation, 2 rows w/ parent
R & P Line
Hybrid Seed Production for OYT
Isolation Bags or hand-crossing
AxB Paircross
Breeder Seeds
RETESTCROSS NURSERY (OYT)
Re-evaluate F1 hybrids
Stage 1, 1 rep, 3 rows
Hybrid Seed Production for PYT
Isloated Net or bags
AxB Increase
Core Seeds
Preliminary Yield Trial (PYT)
Stage 2, 1 rep, plot
Hybrid Seed Production for AYT & NYT
Isolation Block
AxB Seed Production
Foundation Seeds
Advanced Yield Trial (AYT)
Stage 3, 3 reps, plot
AxB Seed Production
Certified Seeds
National Yield Trial
Stage 4, 3-4 reps, muti-location, 2-years
Hybrid Pilot Seed Production
Isolation Block
A & B Line Release
On-Farm Trial (Strip Trial)
Hybrid and R line Release



**** Hybrid Seed Production Technology of Rice ****

Choice of Areas and Growing Season for Seed Production

- Daily mean temperature of 24-30^{0}C
- Relative humidity ranging from 70-80%
- The differences between day and night temperatures should not be more than 8-10^{0}C, preferably 5-7^{0}C
- Sufficient sun shine with moderate wind velocity.
- Absence of rains continuously for three days during the period of flowering.
- Temperatures is below 20^{0}C and above 35^{0}C adversely affect seed yields
- The seed production areas near forest, rivulets and valleys are better for getting higher seed yields.

Selection of Field

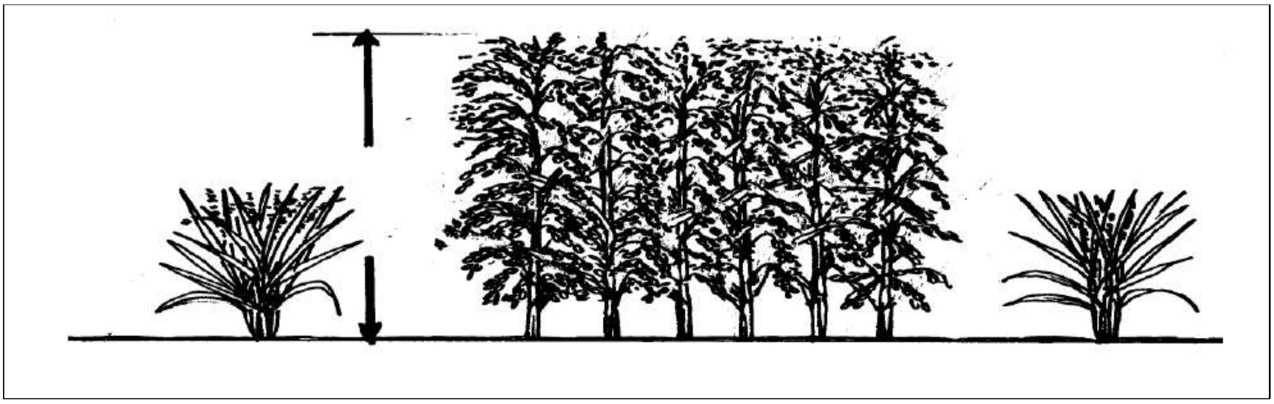
- The selection of prime field plots is necessary. The seed fields should be free of volunteer plants, well levelled, should have fertile soil with good physical and chemical characteristics and well drained.

Isolation

- The hybrid paddy fields should be isolated from the other paddy fields, including commercial hybrid of same variety, and same hybrid not conforming to varietal purity requirements for certification at least by 200 meters for foundation seed class (A, B and R line Production) and by 100 meters for hybrid seed production (AX R production).

Isolation Barrier

- From other rice variety to prevent cross contamination



A x R other rice variety

Seed rate

- A line or female parent: 15 kg/ha
- B or R line or male parent: 5 kg/ha

BRIEF CULTURAL PRACTICES FOR HYBRID (AXR) PRODUCTION NURSERY

- Raising of vigorous seedlings is an important factor for obtaining high seed yields. The root system of vigorous seedlings are flourishing, leaf sheaths have high carbon content and all this contributes to produce green growth and tillering at the lower nodes so that more dry matter is accumulated, leading to more panicles and a high seed setting rate per panicle. It has been observed that tillering at the lower nodes gives more and bigger panicles which helps to achieve the goal of 100 kernels per ear.

- Prepare the seedling bed with basal manure. Seed at 150 kg/ha for the female parent and 100-150 kg/ha for the male parent. At present the appropriate methods for raising seedlings are either to sow under plastic film in the field or in a green house.

Sowing time

- The proper sowing time is dictated by the number of days required from sowing time to panicle formation. The sowing should be so adjusted that the crop comes to panicle stage soon after the end of high temperature period.

Transplanting time

- Seedlings with healthy tillers are the basis for increased panicle size. For hybrid seed production, the seedlings of both parents should be standardized. Seedlings of the male parent for short duration varieties should be 20-30 days old with 5.5-7 leaves and 2-3 tillers and for long duration varieties 30-35 days old with 5.5-7 leaves and 2-3 tillers.

Planting ratio

- The ratio of female and male lines is generally kept at 2:10-12, and row spacing 10 cm X10 cm for male parent and 20 cm X 15 cm for female parent. Two seedlings are planted per hill.

Fertilizer application

- Adequate fertilization in necessary. In general, a seed field with moderate fertility should be treated with 200 kg N, 50 kg P, and 150 kg K per ha, 90 percent applied as a basal dose and 10 percent after panicle differentiation.

Techniques for increasing seed setting

- Application of GA_3 at 5 - 15 % heading
- Uniform plant population – GA_3 spray at 5 % heading
- Plant population not uniform – GA_3 spray 10 % and 15 % heading separately

Synchronization in flowering

- GA_3 180 - 210 g + 525 liters water/ha

Non-synchronized flowering

- Pollen parent is earlier – spray extra GA_3 15 g/ha
- Female parent is earlier – spray extra GA_3 30 - 45 g/ha

Uniform parental line

- First day 75 g GA_3 + 375 liter water/ha
- Second day 105 - 120 g GA_3 + 375 liter water/ha

Parental lines not uniform

- First time - 45 g GA_3 + 375 liters water /ha
- Second time - 60 - 75 g GA_3 + 375 liters water/ha

- Third time - 70 - 90 g GA_3 +375 liters water/ha

Corrective measures for adjustment of flowering synchronization (in India)

A. Methods for delaying the flowering					
Sr. No.	**Name**	**Chemical Quantity**		**Stage of Application**	**Adjustment**
		Male	**Female**		
1.	Urea (Broadcasting) Urea (Spray)	50-60 Kg/ha 1-2%	75-100 Kg/ha 1-2%	Before III Stage Before III Stage	4-5 days 2-3 days
2.	Paclobutrazol (Spray)	1.0 Kg/ha	1.5 Kg/ha	Before III Stage	6-8 days
3.	Draining out water	Effective	Not effective	I – V Stage	2-3 days
4.	Leaf clipping	Effective	Effective	VII – VIII Stage	2-3 days
5.	Removing panicles	(1-3 times)	(1-3 times)	At heading	5-6 days
6.	Delayed GA_3 application	Effective	Effective	At 40-50% flowering	1-2 days
7.	Walking on root zone	Effective	Effective	After P I	2-3 days

B. Methods for advancing the flowering					
Sr. No	**Name**	**Chemical Quantity**		**Stage of Application**	**Adjustment**
		Male	**Female**		
1.	SSP (Broadcasting)	50-60 Kg/ha	100 Kg/ha	Before III Stage	4-5 days
2.	MOP/KCL Broadcasting	10-20 Kg/ha	30-40 Kg/ha	Before III Stage	4-5 days
3.	KH_2PO_4 (Spray)	1.0 Kg/ha	1.5 Kg/ha	Before III Stage	2-3 days
4.	Flooding	Effective	Not effective	Before III Stage	2-3 days
5.	GA_3 application	10-15	10-15 g/ha	At heading	2-3 days

		g/ha			
6.	Boric acid/ KNO_3	100 g/ha	150 g/ha	Before III Stage	2-3 days

Water Management

- Good water management is very important for regulating water, fertilizer, air and temperature of soil. Give shallow irrigation at the transplanting and tillering stages.
- In soils where water permeability is poor the field must not be allowed to remain under water for too long so that root growth could be drained the booting stage.
- During heading, if the air temperature is above 35^{O} C, water should be applied during the day and drained – off at night so as too decrease soil temperature.

Leaf Clipping

- Leaves taller than the panicles are the main obstacles to cross pollination. Clipping leaves 1-2 days before initial heading increases the probability of pollination and out crossing rate. The blade of flag leaf is cut back ½ to 1/3 from the top. GA3 spray. Spraying seed parent with 75 gm GA_3/ha 60 ppm or more 2 or 3 times increases panicle excertion and help increased seed setting.

Supplementary Pollination (Rope Pulling)

- On calm days during anthesis, supplementary pollination can be carried out. Panicles of the restorer lines are shaken by pulling a long nylon rope (5mm diameter) back and forth every 30 minutes until no pollen remains on the restore line. This method if often used on even topography and regularly shaped plots. In hilly, uneven topography with small, irregular plots, a bamboo pole may be used.

Rouging

- The seed field should be free of rogues. Remove off- type plants in both the parents first before the onset off flowering stage and then soon after emergence of the panicle. Rogue out the plants of maintainer line, if any and the semi-sterile plants in the seed parent as often as necessary.

Harvesting of Seed Crop

- Harvest male rows first to avoid chances of mechanical admixture

Guidelines
for the Conduct of Test for
Distinctiveness, Uniformity and Stability

Protection of Plant Varieties and Farmers' Rights Authority
(PPV & FRA)
Government of India

Subject: These test guidelines shall apply to all varieties, hybrids, transgenics and parental lines of Rice (*Oryza sativa* L.)
Seed material required: The minimum quantity of the seed to be provided by the applicant shall be 3000 grams in case of the candidate variety or hybrid and 1500 grams for each of the parental line of the hybrid. At least 100 panicles each representing the normal ear size and drawn from the main tiller of the candidate variety shall be submitted. The seed and ears submitted shall have at least 80% germination, 98% physical purity, highest genetic purity, uniformity, sanitary and phyto-sanitary standards. In addition, the moisture content of the seed shall not exceed 11-12% to meet the safe storage requirement.

Conduct of tests: The minimum duration of DUS tests shall normally be at least two independent similar growing seasons.2. The tests shall normally be conducted at two test locations. If any essential characteristics of the candidate variety are not expressed for visual observation at these locations, the variety shall be considered for further examination at another appropriate test site or under special test protocol on expressed request of the applicant. 3. The field test shall be carried out under conditions favouring normal growth and expression of all test characteristics. The size of the plots shall be such that parts of plants could be removed for measurement and observation without prejudicing the observations on the standing plants until the end of the growing period. Each test shall include about 2500 plants, in the plot size and planting space specified below across three replications. Separate plots for observation and

Test plot design

Number of rows	: 30
Row length	: 6 m
Row to row distance	: 30 cm
Plant to plant distance	: 20 cm
Expected plants /replication	: 900
Number of replications	: 3 for irrigated and shallow lowland tests
	: 5 for upland, saline-alkaline, semi-deep water and deep-water tests.

Observations shall not be recorded on plants in border rows.
Additional test protocol for special purpose shall be established by the PPV & FR Authority.

Grouping of varieties

The candidate varieties for DUS testing shall be divided into groups to facilitate the assessment of Distinctiveness. Characteristics, which are known from experience not to vary, or to vary only slightly within a variety and which in their various states are fairly evenly distributed across all varieties in the collection are suitable for grouping purpose.

The following characteristics are proposed to be used for grouping rice varieties:

- Basal leaf: Sheath colour (Characteristic 2)
- Time of heading (50% of plants with panicles) (Characteristic 20)
- Stem: Length (excluding panicle; excluding floating rice) (Characteristic 29)
- Decorticated grain: Length (Characteristic 54)
- Decorticated grain: Shape (in lateral view) (Characteristic 56)
- Decorticated grain: Colour (Characteristic 57)
- Endosperm: Content of amylose (Characteristic 59)
- Decorticated grain: Aroma (Characteristic 62)

Table of Characteristics

Sr. No.	Characteristics	States	Note	Example variety/line	Stage of observation	Type of assessment
1	**2**	**3**	**4**	**5**	**6**	**7**
1. (+)	Coleoptile: Colour	Colourless	1	Krishna Hamsa, Prasad	10	VS
		Green	2			
		Purple	3			
2. (*)	Basal leaf: Sheath Colour	Green	1	Rasi, Heera	40	VS
		Light purple	2	Annada, Bhogali		
		Purple lines	3	Mahamaya		
		Uniform purple	4	IR 24, Aruna		
3.	Leaf: Intensity of green colour	Light	3	Rasi, Vandana	40	VG
		Medium	5	Heera, Sugandha		
		Dark	7	IR 24, Swarna		
4.	Leaf: Anthocyanin colouration	Absent	1	Sugandha	40	VG
		Present	9	IR 24, Aruna		
5.	Leaf: Distribution of anthocyanin colouration	On tips only	1	Vivek Dhan 62, CSR 10	40	VG
		On margins only	2	Aruna, IR 24		
		In blotches only	3			
		Uniform	4	Shyamala		
6. (+)	Leaf Sheath: anthocyanin colouration	Absent	1	Prasad, Govind	40	VG
		Present	9	IR 24, Aruna		
7.	Leaf sheath: Intensity of	Very weak	1	—	40	VG
		Weak	3	Rongilee		

	anthocyanin colouration	Medium Strong Very strong	5 7 9	Aruna, IR 24 Shyamala		
8. (*)	Leaf: Pubescence of blade surface	Absent Weak Medium Strong Very strong	1 3 5 7 9	Sneha, Sugandha Nagarjana, Vibhava IR 24, Aruna Jaya, Pantdhan 10 Govind, Jaishree	40	VS
9. (*) (+)	Leaf: Auricles	Absent Present	1 9	Vikramarya Jaya, Bas. 370	40	VS
10. (*)	Leaf: Anthocyanin colouration of auricles	Colourless Light purple Purple	1 2 3	IR 24 Aruna, Amulya Hemavathi, Janaki	40	VS
11. (+)	Leaf: Collar	Absent Present	1 9	— Rasi, IR 24	40	VS
12.	Leaf: Anthocyanin colouration of collar	Absent Present	1 9	Rasi, IR 24 Hemavathi, Aruna	40	VS
13. (+)	Leaf: Ligule	Absent Present	1 9	— Triguna, IR 24	40	VS
14. (*)	Leaf: Shape of ligule	Truncate Acute	1 2	—	40	VS

(+)		Split	3	Vijetha, IR 24		
15. (*)	Leaf: Colour of ligule	White Light purple Purple	1 2 3	Rasi, Pantdhan 10 Aruna, Jitendra IR 24, Shyamala	40	VS
16.	Leaf: Length of blade	Short (<30 cm) Medium (30-45 cm) Long (>45 cm)	3 5 7	VL Dhan 221, CSR 10 Bas.385, Bas.386 Bas. 370, Dubraj	40	MS
17.	Leaf: Width of blade	Narrow (<1 cm) Medium (1-2 cm) Broad (>2 cm)	3 5 7	Bas. 386, Bas. 370 Pant Dhan 4, Vajram PTB 56	40	MS
18.	Culm: Attitude (for floating rice only)	Non procumbent Procumbent	1 9	—	40	VS
19. (+)	Culm: attitude	Erect Semi-erect Open Spreading	1 3 5 7	Pantdhan 11, IR 24 IR8,VL Dhan 206 Janaki, Prasad	40	VS
20. (*)	Time of heading (50% of plants with panicles)	Very early (<71 days) Early (71-90 days) Medium (91-110 days)	1 3 5	Heera Rasi, Ravi Vikas, Triguna	55	VG

		Late (111-130 days) Very late (> 131 days)	7 9	Bas. 370 Kushal, Sabita		
21. (*) (+)	Flag leaf: Attitude of blade (early observation)	Erect Semi-erect Horizontal Drooping	1 3 5 7	IR 24, Indira VL Dhan 81, Jawahar	60	VG
22. (*)	Spikelet: Density of pubescence of lemma	Absent Weak Medium Strong Very strong	1 3 5 7 9	--- Krishna Hamsa Rasi, NDR 359 Vasumati, Vandana K 429	60-80	VS
23.	Male sterility	Absent Present	1 9	IR 24 IR 580 25A	65	VG
24. (+)	Lemma: Anthocyanin colouration of keel	Absent or very weak Weak Medium Strong Very strong	1 3 5 7 9	IR 24, Swarnadhan Bhadra, Remya Aruna Makom, Janaki Malaviyadhan	65	VS
25. (+)	Lemma: Anthocyanin colouration of area below apex	Absent Weak Medium Strong Very strong	1 3 5 7 9	IR 24,VL Dhan 81 Remya, Mandya Vijaya Bhadra, Aruna Bhogali, Makom	65	VS

				Janaki, Malaviyadhan		
26. (*) (+)	Lemma: Anthocyanin colouration of apex	Absent Weak Medium Strong Very strong	1 3 5 7 9	Phalguna Mandya Vijaya, Jalpriya Anjali, Shyamala RasiJanaki	65	VS
27. (*) (+)	Spikelet: Colour of stigma	White Light green Yellow Light purple Purple	1 2 3 4 5	Jaya, Bas. 370 --- Mahi Sugandha IR 24, Poornima Rasi, Mahamaya	65	VS
28.	Stem: Thickness	Thin (<0.40 cm) Medium (0.40-0.55 cm) Thick (>0.55 cm)	3 5 7	Sneha, K 429 Lachit, Govind NDR 359, Janaki	70	MS
29. (*)	Stem: Length (excluding panicle; excluding floating rice)	Very short (<91 cm) Short (91-110 cm) Medium (111-130 cm) Long (131-150 cm) Very long (>150 cm)	1 3 5 7 9	Heera PR 106, Vajram Sabita Niraja ---	70	MS
30. (*)	Stem: Anthocyanin	Absent	1	Chaitanya, IR 24	70	VS

	colouration of nodes	Present	9	Amulya, Hemavathi		
31.	Stem: Intensity of anthocyanin coloration of nodes	Weak Medium Strong	3 5 7	CSR 27, RCM 5 Shaymala, Rongilee Amulya, Saraswati	70	VS
32.	Stem: Anthocyanin colouration of internodes	Absent Present	1 9	IR24, Krishnaveni Prasanna, Janaki	70	VS
33. (*) (+)	Panicle: Length of main axis	Very short (<16 cm) Short (16-20 cm) Medium (21-25 cm) Long (26-30 cm) Very long (>30 cm)	1 3 5 7 9	K 429, Sneha VL Dhan 221, Poornima NDR 359, Shyamala Bas. 370, Rongilee ---	70-90	MS
34. (*) (+)	Flag leaf: Attitude of blade (late observation)	Erect Semi-erect Horizontal Deflexed	1 3 5 7	IR 24 Prasanna, VL dhan 81 VL Dhan 206 ---	90	VG
35. (*) (+)	Panicle: Curvature of main axis	Straight Semi-straight	1 3	--- Barh-avarodhi, Lachit	90	VG

		Deflexed Dropping	5 7	Govind, ADT 37 Poornima, Bas. 386		
36.	Panicle: Number per plant	Few (<11) Medium (11-20) Many (>20)	3 5 7	Kranti, Heera Tulasi,Krishna Hamsa ---	80-90	MS
37. (*)	Spikelet: Colour of tip of lemma	White Yellowish Brown Red Purple Black	1 2 3 4 5 6	Aditya,Pantdhan 6 Prasanna, Pantdhan 12 Madya Vijaya, Bas. 385 --- Rasi, Hemavathi ---	80-90	VS
38. (+)	Lemma and Palea: Colour	Straw Gold and gold furrows on straw background Brown spots on straw	1 2 3	Aditya, Chaitanya Vibhava, Pant Dhan 11 CTH 3	80-90	VG
		Brown furrows on straw Brown (tawny) Reddish to light purple Purple spots /	4 5 6 7	--- --- Bhogali Shyamala		

		furrows on straw Purple Black	8 9	--- ---		
39. (*) (+)	Panicle: Awns	Absent Present	1 9	Jaya,Krishnaveni Pusa Bas.1	90	VG
40. (*)	Panicle: Colour of awns (late observation)	Yellowish White Yellowsh Brown Brown Reddish brown Light red Red Light purple Purple Black	1 2 3 4 5 6 7 8 9	Nidhi, Pantdhan 11 Nagarjuna, Bas. 370 - Bas. 385 --- --- --- --- Bhogali	90	VS
41.	Panicle: Length of longest awn	Very short Short Medium Long Very long	1 3 5 7 9	Nidhi, Pantdhan 11 Shamyala Bas. 385 Kasturi, Bas. 386 ---	90	VG-MS
42. (*)	Panicle: Distribution of awns	Tip only Upper half only Whole length	1 3 5	Jawahar, Pantdhan 11 Bas. 370, ASD 20 Pusa Bas. 1, Bas. 385	90	VS

43. (+)	Panicle : Presence of secondary branching	Absent Present	1 9	--- Rasi, Bas. 370	90	VG
44. (+)	Panicle: Secondary branching	Weak Strong Clustered	1 2 3	Pantdhan 10, Bas. 386 Annada, Pantdhan 11 ---	90	VG
45. (*) (+)	Panicle: Attitude of branches	Erect Erect to semi-Erect Semi-erect Semi-erect to spreading Spreading	1 3 5 7 9	--- Sasyasree Mangal Pantdhan 10 Pantdhan 4	90	VG
46. (*) (+)	Panicle: Exertion	Partly exerted Mostly exerted Well exerted	3 5 7	Suraksha, Vibhava Chaitanaya, Pantdhan 4 VL Dhan 221	90	VG
47.	Time maturity (days)	Very early (< 100) Early (101-120) Medium (121-140) Late (141-160) Very late (>160)	1 3 5 7 9	Heera Rasi, Ravi Vikas, Triguna Bas. 370 Kushal, Sabita	90	VG
48.	Leaf: Senescence	Early	3	VL Dhan 81,	92	VG

				K 429		
		Medium	5	IR 8, Bas. 385		
		Late	7	Bas. 370		
49. (*) (+)	Sterile lemma: Colour	Straw Gold Red Purple	1 2 3 4	Tulasi, Pantdhan 11 Vibhava, Shanti Ambemohar 157 Bhogali	92	VS
50.	Grain: Weight of 1000 fully developed grains	Very low (<15 g) Low (15-20 g) Medium (21-25 g) High (26-30) Very high (>30 g)	1 3 5 7 9	PKV HMT, Sugandha Dubraj, Sita Bas. 370, Bas. 386 Mahamaya, PR 113 Pant Dhan 4	92	MG
51. (+)	Grain: Length	Very short (<6.0 mm) Short (6.1-8.5 mm) Medium (8.6-10.5 mm) Long (10.6-12.5 mm) Very long (>12.5 mm)	1 3 5 7 9	Tarunbhog Vajram, CSR 10 Pant Dhan 4, CSR 13 Sabita, Bas. 386 IET 18004, IET 18006	92	MS
52.	Grain: Width	Very narrow (<2.0 mm) Narrow	1 3	Sugandha Dubraj, Bas. 370	92	MS

		(2.1-2.5 mm) Medium (2.6-3.0 mm) Broad (3.1-3.5 mm) Very broad (>3.5 mm)	 5 7 9	 Pant Dhan 4, Sabita Kranthi, Matangini ---		
53. (+)	Grain: Phenol reaction of lemma	Absent Present	1 9	--- ---	92	VG
54. (*) (+)	Decorticated grain: Length	Short Medium Long Long* (Long for Basmati type) Extra long	1 3 5 7 9	Kushal Samba Mahsuri Ratna, Triguna Kasturi, Bas. 370 ---	92	MS
55. (*) (+)	Decorticated grain: Width	Narrow (<2.0 mm) Medium (2.0-2.5 mm) Broad (>2.5 mm)	3 5 7	Shanti Heera ---	92	MS
56. (*) (+)	Decorticated grain: Shape (in lateral view)	Short slender Short bold Medium slender Long bold Long slender	1 2 3 4 5	Dubraj Salivahana Samba Mahsuri Vikramarya Krishna Hamsa	92	MS

		Long slender* (For Basmati type) Extra long slender	5 6	Kasturi ---		
57. (*)	Decorticated grain: Colour	White Light brown Variegated brown Dark brown Light red Red Variegated purple Purple Dark purple	1 2 3 4 5 6 7 8 9	Sugandhamati --- --- --- Jyothi Red Triveni --- --- ---	92	VG
58. (+)	Endosperm: Presence of amylose	Absent Present	1 9	--- Vasumati	92	MG
59. (*) (+)	Endosperm: Content of amylose	Very low (<10%) Low (10-19%) Medium (20-25%) High (26-30%) Very high (>30%)	1 3 5 7 9	Hiyokumochi Norin 18 Taroari Basmati Jaya ---	92	MG
60. (+)	Varieties with endosperm of amylose absent	Absent or very small Small	1 3	---- —	90	MG

	only Polished grain: Expression of white core	Medium Large Fully chalky	5 7 9	— — —		
61. (+)	Gelatinization temperature through alkali spreading value	Low Medium High medium High	1 3 5 7	Pusa Basmati 1 Taroari Basmati Kasturi	92	MG
62. (*) (+)	Decorticated grain: Aroma	Absent Present	1 9	Jaya Bas. 370	92	MG