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सत्यमेव जयते

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EDITORIAL

India holds the record for second-largest agricultural land in the world, with around 60% rural Indian households making their living from agriculture. In India, the agriculture sector employs half of country's population and we are greatly dependent on the farmers to provide us with means of sustenance. In the last decade, agriculture sector has witnessed the inflow of educated youth with ideas, innovations and business models to lead the way for hi-tech agriculture. In this journey, startups are providing the missing links in agri value chain and delivering efficient products, technologies and services to the farmers on one hand and desired products to consumers on the other hand. The startups are examples of how the great things are done by a series of small things brought together. Taking one small step at a time, moving from one problem to another and solving the issues by innovation is what these startups are trying to achieve.

The Government of India has recently proposed that a fund with blended capital, raised under the co-investment model, will be facilitated through NABARD. This is to finance startups for agriculture & rural enterprise, relevant for farm produce value chain. The activities for these startups will include, inter alia, support for FPOs, machinery for farmers on rental basis at farm level and technology including IT-based support. The objectives of this fund are to provide equity support to agri-food & allied startups, their nurturing & evolution and providing the venture debt to these startups. The proposed Fund will be hybrid in nature and will have three funding components i.e. (i) Indirect Investments Fund having two sub-components; (a).Traditional Fund of Funds (FoF), (b). FoF with a managed/segregated portfolio, (ii) Direct Investments Fund for direct equity investments in agri-food startups and (iii) Venture Debt Fund.

The startups are not only creating new jobs which means more employment but are also leaving a ripple effect on the socio-economic fabric of the demography in which they are operating. The startups are set to revolutionize the food and agriculture sector from ICT apps to farm automation, from weather forecasting to drone use, from inputs retailing & equipment renting to online agri-produce marketing and from protected cultivation to innovative food processing, packaging and marketing. There is a decent growth of startups in the country in various sectors and it needs a strong push in the agri sector also. It is time to make agri startups successful and propel India forward as a leader in this sector.

Dr. Sanjay Kumar Joshi

Precision Weed Management Techniques: A smarter Way to Manage the Weeds

C.R. Chethan, P.K. Singh, R.P. Dubey, J.S. Mishra, V.K. Choudhary, D.V. Pawar and D. Sreekanth

Weeds are a perennial problem associated with the crops and pose a serious biotic constraint in agricultural production systems globally. They compete with crop plants for moisture, nutrients, sunlight and have detrimental impact on crop yields. Of the total losses caused by various pests in agriculture, on an average, weeds cause 37% yield loss. However, in some cases it may goes up to 90%. The weeds are controlled by chemical, mechanical, cultural and biological methods. However, in India manual weeding using traditional weeding tools are the common practice followed by the farming community. Reports suggest that, even after using traditional weed control methods, farmers are losing closely up to 15-20% of crop yield. Therefore, there is a tremendous scope for enhancing crop yields by adopting improved weed managing practices. The traditional manual and mechanical weed management involves agricultural labours to perform the weeding operation. This is drudgerous and becomes costlier compared to chemical weed management. Moreover, human labour is a single costliest input in farming operations contributing 20-25% of the total cost of cultivation. To maximize the input use efficiency of the system and increase the field operational capacity, an ergo-refined precision mechanical weeders need to be developed.

Under chemical method of controlling the weeds, herbicides applied over a plant through different kinds of sprayers. In order to achieve higher herbicide usage efficiency, their application must be accurate and uniform. Herbicides are applied as pre-planting, pre-emergence and post-emergence. Also, herbicides are applied throughout the field at constant rate without considering the spatial variability and weed population distribution. This constant application rate may not be appropriate, because weeds are present heterogeneously throughout the field. Therefore, application in the absence of weed, repetitive and excessive usage may results wastage of chemicals, harmful effect on crops and humans, increase cost of cultivation, induce resistance in weeds and also raise a concern about soil health and environmental pollution. The existing mechanical or chemical-based weed control methods are less accurate, labour-intensive, seasonal, time bound with more time and resource consuming practices. Thus, an immediate intervention of reliable, cost-effective and efficient weed management practices are need of hour.

Spatial variability of the weeds

The crop fields are usually infested with different kind of weed species in varying densities. Of the many weed species present in the field,

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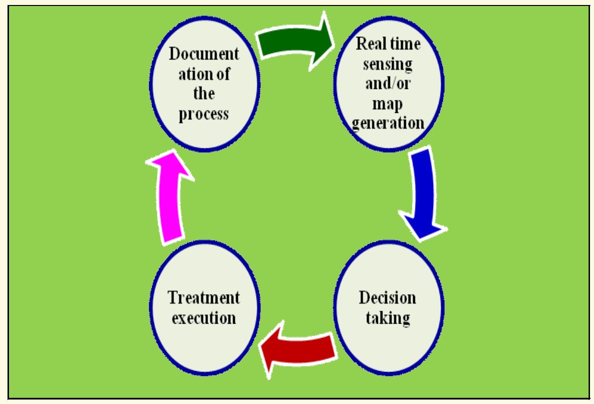
only three to four weed species are of dominant in nature i.e. they have high weed density and coverage area. This variation of weed patches and density may also vary with the kind of weed species, time of emergence, growth rate, weather parameters and weed management practices. The high weed density patches are less susceptible to control than the less density patches. Moreover, high density of weeds indicates high seed bank and produce more seeds, which will severely affect the next cropping cycle. In addition, control measures such as tillage or herbicide application are less likely to control all the plants in a high-density patch than in a low-density patch. Studies showed that, application of herbicide only to the patches and also applied at variable rate according to the weed density controlled the weeds effectively and reduced the seed bank. In addition, the region where herbicide was not treated within the same field, did not develope a weed population which can cause crop yield loss. During the field operation of the weeders, the high density weed patches may get elongated and efficiency of the weeding may get reduced. Therefore a site-specific precision weed management practice needs to be followed to obtain higher profit and to reduce dumping of chemicals.

Precision weed management practices

Precision weed management is a technique where it involves identification and discrimination of variance in weed population at sub field level. It manages the weeds effectively by using the advanced technologies like sensors, GPS, robotics, MAP-based approaches, laser thermal beam, microwaves, mechanical arms etc to optimize agricultural inputs and improve crop yields. The recent advancement in agriculture and precision management made the possibility of site-specific management of weeds with limited inputs like herbicides. The target oriented and variable rate based application of herbicides is an effective way to minimize herbicide usage, input cost, increase herbicide usage potency and weed control efficiency with reduction in environmental waste.

The Site-Specific Weed Management (SSWM) is the component of precision agriculture, which includes sensor-based machinery embedded technique, where it observes, records and executes the controlling operations



Components of the Site-specific weed management practices

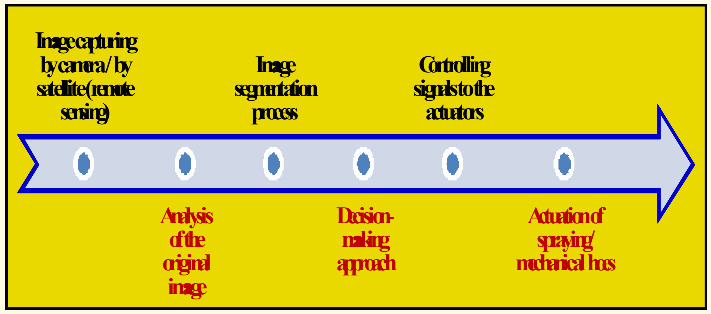
according to the predefined weed management plan. The main purpose of SSWM is to apply the herbicide at right dose place and time. Incase of mechanical weed management, the role of SSWM is to actuate the weeding tool at right time and at right place. Through SSWM, one can save 30-90 % of operating cost and 50-80 % of herbicide over conventional practices. The SSWM mainly has four components through which it executes the different weed controlling strategies.

Under precision weed management practices, the weed control measures have to be executed in following ways:

- Real-time or online method: involves real time detection of weeds, decision making to adjust the dose of herbicides or weeding operation and execution of all controlling operations by using the sensors.
- Offline method: Prior information on location specific weed data is available before performing the weed controlling measures. This data will be loaded to the system and all controlling

operations are executed afterwards.

Since the weed populations are spatially varied within a field, positioning of the weed data plays an important role. To do so, a global navigation satellite system GPS (global positioning system) are widely used to mark the absolute position of the data.



Operational methodological process of the machine vision system

Weed detection techniques

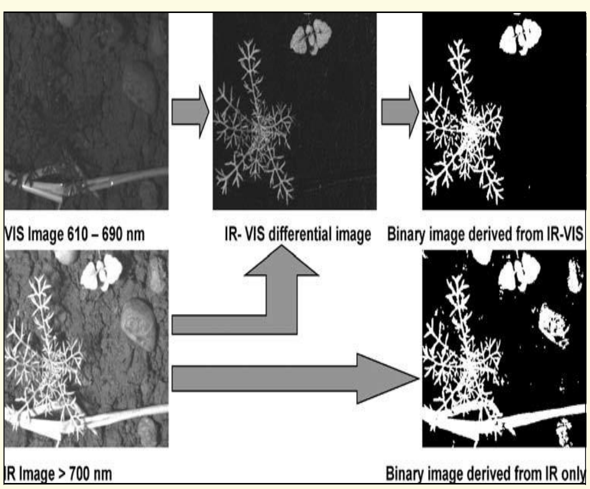
The detection of weeds through automation has the capability to increase sample point density and accuracy of the system. Mainly three approaches were used to detect the weeds under automation, they are:

1. **Biological morphology:** recognition of shape and structure of the plant species.
2. **Spectral characteristics:** recognition based on the plant reflectances. Pixel based color or hyper spectral classifiers are used for these purposes.
3. **Visual texture:** recognition based on the gray scale calculation and color of the images.

Machine vision based weed detection from images:

Machine vision is an optical sensor based system, which discriminates and differentiates the weeds from crop.

Main components of the system include image capturing device (by camera or optical sensors), micro processors (image processing and system control) and weed control actuators.



Weed identification from the images

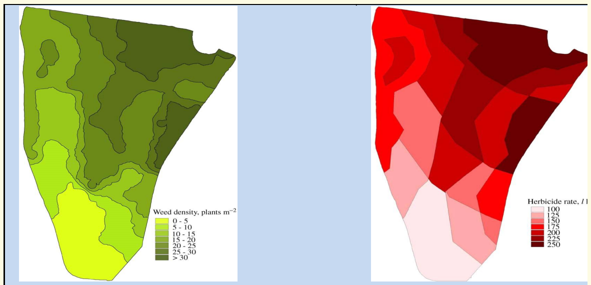
GPS-controlled patch spraying

In GPS-controlled patch spraying, an application map has to be developed based on the interpolated maps of weed distribution and economic weed threshold value. The developed application map will be feeded into the spraying system where it sprays the herbicide according to the pre-decided dose. The herbicide application dose will be decided on the basis of weed density and area of coverage.

Variable rate herbicide applicator (VRA)

The variable rate herbicide applicators can be operated with both real time (optical sensor) and/or with interpolated maps of weed distribution and economic weed threshold (offline)

Real-time VRA developed at IIT Kharagpur



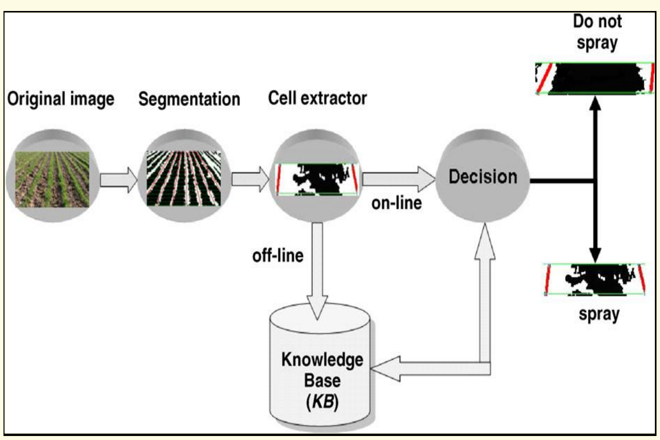
a. Weed distribution map **b.** Herbicide rate application map

Variable rate herbicide application map developed on the basis of weed distribution.

method. Under optical sensor based system, the sensors detect weed, their density and area of coverage and then decides the dose of herbicide needs to be applied. In map based approach, variabale dose of herbicide applicaion will be developed on the basis of weed economic threshold value and then the herbicide will be applied accordingly.

Machine vision based online spraying system

The machine vision based online spraying system integrated with optical sensors and spraying system detects the weeds in real time, differentiates it from the crops and applys the hericide accordingly.



Conceptual diagram of machine vision based online spraying system

Herbicide application through drones (UAVs)

The drones are unmanned aerial vehicles (UAVs) which are used to develop weed map and to apply the herbicide as part of the precision weed management practice. Through drones, a target oreinted as well as the variable rate application of herbicides is also possible with increased field capcacity and efficiecny. In addition, around 96% of water can be saved in drone based spraying system.

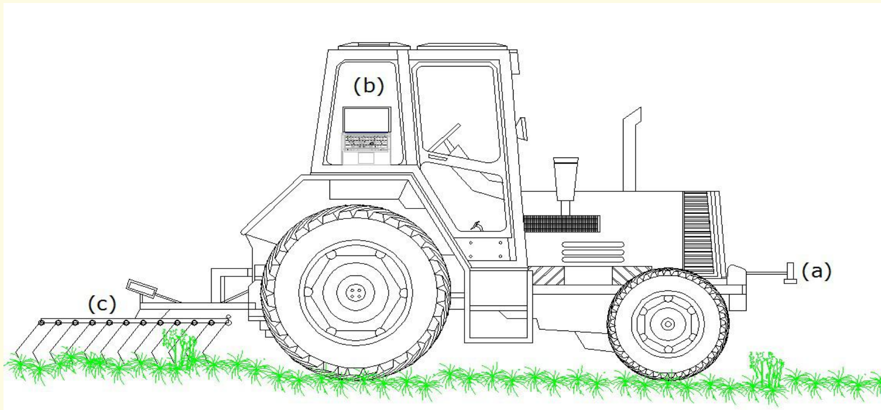
Hebicide application through drone

Machine vision based/ sensor based weeding machines and robots

An automatic control of weeding operation is possible by using the RTK-GPS, optical and position sensors like camera, laser, ultra sonic sensor and robotic arms/ weeding tools, etc. Under this system both online (real time) and offline method of weeding can be possible. In online method, a machine vision based system or an object detection based system is used to detect and differntiate the weeds from crops. Later, a decision will be made by system to perform the weeding operation. In offline method, a GPS based position detection system is used to perfrom the weeding operation.

Microwave weeding

The microwave weeding involves the projection of microwave energy on the



a) the ultrasonic sensor mounted in front of the tractor;

(b) the computational unit responsible for gathering the sensor data, interpreting them, running the decision making algorithm and controlling the actuator; and

(c) the harrow actuator

Ultrasonic sensor based online weeding

Machine vision based online weeding

Autonomus RTK-GPS based weeding robot

weeds and on soil through suitable devices to kill the plants and their seeds. The advantage of the microwave energy is that, it is not affected by weather parameters. An ultra high frequency (UHF) electromagnetic energy with wavelengths much greater than those of light (frequency 2450 Mhz and wavelength 12.25 cm) were used in the weeder system to kill a plant and weed seed bank.

Microwave weeder

A portable microwave weeder has been developed and is available commercially.

Laser thermal beam based weeders

In this system, laser thermal beams were used to kill the weeds. System involves application of laser radiations on the plants, which affect the thermal balance of a plant and partially destroys the plant tissue through thermodynamic heat transfer

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Single Cross Hybrid Maize Seed production

A. K. Rai, Shakti Khajuria, Raj kumar, Kanak Lata and B. S. Khadda

Maize is the third most important cereal crop of the country after paddy and wheat. As per the data of the maize cultivation in country, India ranks third in productivity (3024 kg/ha) of maize, fourth in total production (16.72 m.t) and fifth in total area (9.26 m. ha). In India, 35% of the total produce is directly consumed as human food while rest is used in industry and as poultry feed. It has over 3000 kinds of uses like human food, cattle and poultry feed and in industries. Most of the human feed is derived from grain i.e. raw (as green cobs) or mature grain (as corn-meal). In Gujarat, it is grown on 0.497m ha area with production of 0.80 m ton and productivity of 1356 kg/ha. During recent years, Panchmahals district of central Gujarat has emerged as the leading district in maize production in the state. Farmers of area are preferring maize over all other crops owing to its adoptability with batter productivity. However, the productivity of maize in the district is very low as compared to average national productivity. Lacks of suitable high yielding varieties especially the Single Cross Hybrids, as well as poor knowledge about cultivation practices are ascribed as main reasons for low productivity of maize.

Single cross hybrid is a cross between 2 inbreeds. A x B. A genotype will be detasseled and crossed with B genotypes. Selection of right seed production site alongwith practicing proper seed production technology and maintaining high genetic purity are the key to increase the hybrid seed yield in maize. The following important points should be kept in mind and implemented during Single Cross Hybrid maize seed production:

Season

There should be cloud free, clear climate for seed production (Kharif and Rabi).

Site selection

Site should be near main road which is accessible for frequent monitoring during flowering. This in turn affects the genetic purity and hybrid stability due to pollen contamination.

Soil type

The soil should be well drained and fertile having sandy loam to clay texture. Avoid seed production in poor, saline soil and brackish water.

Isolation Distance

Seed production should be taken in fertile well drained, weed and disease free soil and preferably the fields where preceding crop was not

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maize to minimize rouging and maintain the genetic purity. At least 400-500 meter distance is required to avoid any contamination.

Male: female ratio

The male: female ratio depends on (a) pollen shedding potential and duration of male parent; (b) male: female synchrony : for better seed setting,

flowering of female should be earlier than male or male pollen dehiscence should coincide with female silking and (c) season. In general the male: female ratio should be 1:2 or 1:3 or 2:4. Even farmers can go for 1:5 to 1:6 ratios if they go for paired male rows so that pollen load can be maintained for proper pollination and seed setting.

Time of Sowing

To avoid flowering from heavy rains during *kharif* and low/high temperature during winter season, the optimum time of sowing is first week of July during *kharif* and first week of November during winter. These adverse conditions affect seed setting due to pollen wash by rain or the extreme low temperature affects anther mortality whereas, high temperature affects the pollen viability due to blasting of pollen grains which in turn reduces the hybrid seed yield. Harvesting should not coincide with rainy period as it affects drying, shelling and viability.

Seed Rate

The seed rate depends on size of seed/test weight, plant type and male: female ratio. 15 kg per ha for female and 10 kg per ha for male is recommended.

Method of sowing and layout

It is desirable to plant the crop on ridges. Depending upon the plant type, the row and plant spacing should be kept at 60-75 cm and 20 cm, respectively. Identification labels/tags for distinguishing should be put on the male and female lines.

Nicking of parental lines:

Female should flower earlier than male for proper fertilization. Tassel of male should have longer pollen shedding duration. Silk in female should come out from husk completely i.e. complete silk exertion which helps in complete seed setting i.e. up to tip. Complete and strong husk covering is desirable to avoid moisture penetration, bird damage, discoloration and mould development. Wherever, there is problem of nicking, farmers can even go for paired rows of male and paired rows is also suggested if female parent is tall and male parent is dwarf.

Rouging

Should be done periodically based on position of cob, colour of silk, arrangements of seeds in cob, leaves etc. Shedding tassels are to be removed in rouging. It refers to the tassels in female parents rows, shedding pollen or that has shed pollen in hybrid maize plots. During field inspection a tassel whose main spike or any side branch or both have shed pollen or shedding pollen in more than 5 cm of branch length is counted as a shedding tassel. During inspection the shedding tassels are taken into count for acceptance or rejection of production plot.

Field standards –specific

Specific factors	Certified stage
Off types shedding pollen when 5 % or more of seed parent in receptive silk	0 .50 %
Seed parent shedding pollen when 5 % of the seed parent is having receptive silk	1.0 %
Total of pollen shedding tassel including tassel that had shed pollen for all 3 inspections conducted during flowering on different dates	2 .0 %
Off types in seed parent at final inspection	0 .5 %

Thinning

Thinning must be done at 10-15 DAS for providing each plant equal space for proper growth, which avoids confusion while rouging. Improper spacing will lead to unnecessary rouging of right plants which in turn increases the cost of seed and labour and also reduces the yield due to improper plant population.

Weed management

Timely weed management is very much required for achieving the optimum yield and to overcome competition between crop and weeds for space, moisture and nutrients.

Nutrient management

Proper growth of plants is very important therefore proper fertilization is very much required to reduce the heterogeneity in soil fertility gradient. The applications of FYM increases the height, enhances the germination percentage, helps in substitution and uptake of micronutrients by holding more nutrients in the root zone. It also enhances the root development, retention of moisture for long time, helps in faster growth, and also improves soil health and fertility. Fertilizer application should be done properly for higher seed yield and profitability in seed production.

Water management

First thinning (15-20 DAS), flowering and grain filling are the most critical stages of the crop for irrigation. Mild irrigation and mild fertilization is a rule in hybrid seed production to achieve higher seed yield.

Detasseling

Detasseling is the removal of tassel from female parent. Detasseling is done when the tassel emerged out of the boot leaf but before anthesis have shed pollen. Anthers take 2-4 days to dehisce after complete emergence. Only in few cases, the anthers, start dehisce before its complete emergence. In such cases detasseling should be done earlier. Detasseling is done every day from the emergence of tassel upto 14 days.

Method of Detasseling

- Hold the stem below the boot leaf in left hand and the base of the basal in right hand and pull it out in a single pull.
- Grasp entire tassel so that all the pollen parts

are fully removed.

- Do not break or remove leaves as removal will reduce yields and will result in lower quality of seed.
- Do not break or remove leaves as removal will reduce yields and will result in lower quality of seed.

Precautions to be adopted during detasseling

- No part should be left on the plant as it causes contamination.
- It should be uniform process done daily in the morning in a particular direction.
- Do not break the top leaves as the yield may be reduced due to the earning of source material to accumulate in seed as removal of 1 leaf cause 1.5% loss, 2 leaves cause 5.9% loss and 3 leaves cause 14% loss in yield.
- Detassel only after the entire tassel has come out and immature detasseling may lead to reduced yield and contamination.
- Mark the male rows with marker to avoid mistake in detasseling.
- Look out for shedders [shedding tassel] in female rows as they may cause contamination.
- After pulling out the tassel, drop it there itself and bury in soil. Otherwise late emerging pollen from detasseled tassel may cause contamination.
- Do not carry the tassel through the field as any fall of pollen may lead to contamination.
- Do not practice improper, immature and incomplete detasseling.

- **Improper detasseling**: A portion of the tassel is remaining in the plant while detasseling.
- **Immature detasseling:** Carrying out detasseling work when the tassel is within the leaves.
- **Incomplete detasseling:** The tassel is remaining in lower or unseen or unaccounted in within the whole of leaves.
- There should not be any shedding tassel.

Shedding tassel

Either full or part of tassel remains in female line after detasseling and shedding pollen which may contaminate the genetic purity of the crop.

Stages of crop inspection

- At the time of sowing: to monitor the land, isolation distance, planting ratio of male: female, proper sowing time, seed treatment
- During pre-flowering/vegetative stage: to verify the rouging and removal of off type plants
- During flowering stage: to check disease and pest infestation
- During post-flowering and pre-harvest stage: to remove the late and diseased plants
- Differential type of tassel/silk plants
- Harvesting time: to see the proper time of harvesting

Disease and pest management

The area of hot spots for pests and diseases can be avoided for hybrid seed production, because inbred lines are more sensitive to incidence of pests and diseases. Bacterial stalk rot is a problem in water logging areas so avoid such site for seed production. Resistant inbred lines can be used to overcome the losses due to pests and diseases.

Management of abiotic stresses

To maintain the humidity during pollination, irrigation is required to prolong the viability of the pollen grains.

Harvesting

Male parent should be harvested after pollination, if possible. Optimum moisture content in grain at harvesting should be around 20 %. The harvested cobs should be spread evenly instead of making heap.

Drying and sorting of seed parent cobs

The drying of the cobs should not be done either on the kuccha or pucca flour, rather it should be dried on tarpoline sheets to avoid seed injury and during night the cobs should be kept covered. To maintain the purity, dissimilar, diseased and pest infested cobs should be removed before shelling. The female cobs should be dried up to 13-14 % moisture content before shelling.

Shelling

Shelling of female parent should be done earlier than male to avoid mechanical mixture**.** Shelling can be done manually or by power operated maize Sheller.

Seed processing

All under size, broken, damaged seeds should be removed for maintaining the quality of seed.

Storage and marketing

Seed drying should be done till the moisture content of the seed is reduced to 8 % and it should be kept in aerated jute bags. Seed should be stored at cool and dry place preferably in cold storage. Poor storage conditions will lead to loss of vigour and poor germination. Marketing should be done with specifications and standards.

Continued from page 8

mechanisms. Laser beams can selectively impair the growth of plants by destroying the sensitive growth centers, the so called meristems, thus weed can be controlled effectively. However, the system requires a high spatial resolution for more accuracy. The commercially available laser beam based weeders can take out 1,00,000 plants per hour.

Laser beam based autonomus Weeder robot

Conclusion

Precision weed management technologies are need of the hour to meet out the ever increasing food demand. Through sensor based site-specific weed management, we can reduce 30 to 90 % of operating cost and 50 to 80 % of herbicide usage over conventional practices. It also reduces the weed seed bank in the soil effectively. Both the online (real-time) and offline (map based approach) method of weed management can be effectively used. However, real-time based weed control systems are much effective and less complex compared to the map based approach.

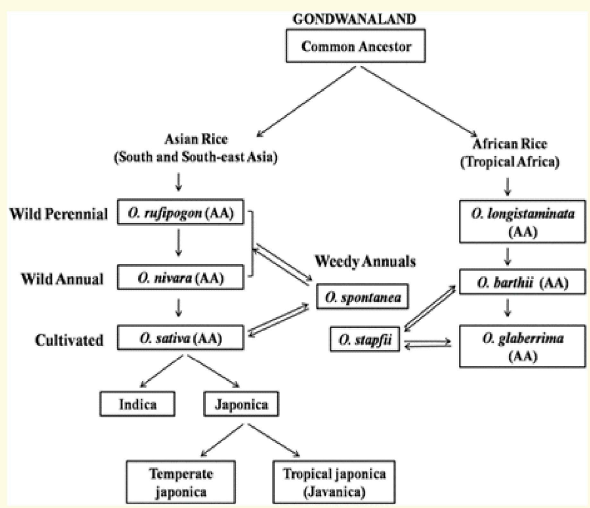
Weedy Rice -A Menace to Rice Farming

Dr. P. Prameela

Weedy rice (*Oryza* spp.) is the most troublesome weed to control in rice fields, causing as high as 90% reduction in rice yield or even abandonment of severely infested fields. The infestation of weedy rice is increasing due to global shift in rice establishment from puddled transplanting to direct-seeding. Because of the increasing labour and water scarcity and environmental concerns, direct-seeding of rice (DSR) is gaining popularity in many rice growing areas of India (especially Punjab and Haryana), where puddled transplanting was the major practice of rice establishment. Therefore, the problem of weedy rice is expected to increase in these areas as well in future.

In India, weedy rice is known by different names such as, wild rice, red rice, *padiangin*, windy rice, and air rice in different parts. South-east Asia has been identified as the centre of origin of rice. Weedy rice grains frequently have a red pigmented pericarp and hence the term 'red rice' is commonly adopted in the international literature to identify these weedy forms. Indian weedy rice is identified as *Oryza sativa* f. *spontanea* which belongs to the *indica* group. Wild and weedy forms of rice are problematic in Eastern India (Eastern U.P., Bihar, Orissa, Manipur and West Bengal) and Southern India (Kerala).

A rice field with severe infestation of weedy rice



Evolutionary pathways of cultivated rice and weedy rice

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In North Western states like Punjab and Haryana, weedy rice is rarely seen, but expected to increase due to change in rice establishment technique from puddled transplanting to DSR. Because of the morphological similarity with rice plants, weedy rice control is very difficult in rice fields.

Origin and spread

Weedy rice and cultivated rice are included in the genus *Oryza* of the grass family Poaceae. This genus includes two cultivated species (Asian rice – *Oryza sativa*, and African rice - O. *glaberrima*) and more than 20 wild species with ten different genome types, i.e., AA, BB, CC, BBCC, CCDD, EE, FF, GG, JJHH, and JJKK. The two names *O. sativa* L. that applies to weedy rice populations has been derived from cultivated rice, whereas *O. sativaf. spontanea* applies only to weedy types that primarily descended from *O. rufipogon*.

The spread is generally favoured by the planting of commercial rice seeds that contain grains of the weed. The spread of weedy rice is likely to be accomplished by several means, including water, cattle, farm machinery and as contaminants of new varieties.Weedy rice has become a menace by seed shattering, lack of rouging, mimicking cultivated rice, shift to direct seeding, early maturity and lack of selective herbicides.

Rice production scenario in India

Rice is the second most widely grown cereal crop and staple food for more than half the world's population. India has the largest rice growing area (43.80 Million hectares) in the world but contributes to less than a quarter of global production (177.65 Million tonnes in 2019) with consumption of 106.5 million tonnes per year). Rice accounts for more than 40 per cent of the food grain production of the country. India had the highest export volume of rice worldwide, at 15.5 million metric tons as of 2020-2021. Rice cultivation in India extends from 0.5 to 2.0 m below MSL in Kuttanad in Kerala to as high as 3000 m altitude in Assam and Arunachal Pradesh.

Rice field

Characters of weedy rice

Weedy rice plants show wide variability in morphological, biological, anatomical, and physiological features. At seedling stage, it is difficult to distinguish weedy rice as they mimic the crop, while it is possible after tillering with many morphological differences with the rice varieties i.e. more numerous, longer and more slender tillers, leaves which are often hispid on both surfaces, tall plants, pigmentation of several plant parts, grains with awns and red pericarp and shattering of seeds. The grains of weedy rice ripe earlier than those of cultivated rice and are extremely prone to shattering. The stem of weedy rice is comparatively more brittle and round in cross section than that of cultivated rice; the surface of the leaf sheath of weedy rice types are generally softer and spongier than that of cultivated rice; weedy rice plants flowered earlier than cultivated rice plants.

Panicles of cultivated and weedy rice

Variation in awn length

Competitive ability and yield loss in rice

Weedy rice is a superior competitor to rice cultivars due to its early vigour, greater tillering and plant height. Yield losses largely depend on season, weed density, growth rate and density of weeds, as well as the rice cultivar. Weedy rice at 35% infestation can cause about a 60% yield loss and under serious infestation, yield loss of 74% is reported in direct seed rice. Dwarf short varieties are usually more susceptible to weedy rice competition than tall ones. Generally high nutrient use efficiency also imparts weedy nature to this group of plants.

Integration of measures for control of weedy rice

Prevention is the basic means of reducing weedy rice infestation and can be achieved mainly by sowing clean rice seeds that are free from weedy rice grains and cleaning the equipment used for rice harvesting to avoid the spread of seeds to non-infested fields. Another method is water management. A standing water column can prevent weed seed germination. Hence through transplanting of rice seedlings, followed by water stagnation population can be considerably reduced. Also volunteer weedy rice seedlings can be rouged out easily. It should be noted that only transplanting method is recommended for seed production.

Another method is application of pre-emergence herbicide to the soil before sowing the paddy seeds. After the land preparation, keep the field in flooded condition to a depth of 2-4 cm and spray herbicide oxyfluorfen 23.4 EC @ 3-4 ml/l of water. Maintain this condition for two to three days so that the herbicide is absorbed into the soil and

A list of morphological and physiological features of weedy rice

Morphological traits of weedy rice		
Trait	**Characteristic**	**Impact**
Plant mimicry	Mimics cultivated rice	Difficulty in weeding
Height	Taller (140-150 cm)	Causes lodging
Grains	Awned/awnless, red or straw coloured awns. Black glumed types are also found	Contaminant in seed, Reduce rice quality
Panicle	Usually smaller than rice Less number of filled grains	Shatters easily
Physiological traits of weedy rice		
Dormancy	Variable period	Persistence / Longevity
Seed longevity	Long viability	Persistent seed bank
Germination	Variable soil conditions	Adapt to wet seeding
Reproductive phase	Early maturity, staggered grain filling and shattering	Add to soil seed bank
Herbicide selectivity	Tolerance to rice herbicides	Chemical control ineffective

prevents germination of weed seeds, including weedy rice seeds. Germinated paddy seeds can be sown three to four days after this method. This method is suitable only for direct seeded rice under wetland situation.

Stale seed bed technique can be successfully adopted in situations where there is sufficient time before sowing/ transplanting of rice. After preparing the land, allow weedy rice and other weeds to germinate. These can be destroyed after two or three weeks and then crop establishment can be undertaken. Repeating stale technique twice will significantly reduce weed seed bank.

Using KAU Weed Wiper technology, already emerged panicles of weedy rice can be dried off by herbicidal means. Panicle formation in weedy rice is usually earlier (55 – 65 DAS) compared to cultivated rice. At this time the panicles are 15 - 20 cm taller than the rice canopy level. During this time with the help of simple equipment weed wiper developed by Kerala Agricultural University, herbicide can be smeared on weedy rice panicles without contacting the rice plants, which results in the drying of seeds, thus reducing built-up of weed seed bank in soil.

Smearing herbicide on panicles of weedy rice using KAU weed wiper

Allowing ducks to feed in the paddy fields can also help to lower weed seed population. Efficient management of weedy rice cannot be obtained by single technology, but should rely on an integrated approach using an appropriate combination of preventive, cultural, mechanical, and chemical means. Weedy rice infestation requires a collective management programme aimed at eradication at the field level.

Way forward

There is a need for developing an integrated approach by collaborating biotechnology together with conventional agronomic practices and technologies. Studies on functional trait diversity among Indian cultivated and weedy rice population has found that difference in days to panicle emergence was the most variable trait and awn length, the least variable one. It is concluded that diversity in functional traits is not sufficient to devise strategy for management of weedy rice and interventions at the molecular level are desirable. The developing herbicide resistant rice varieties such as Imazethapyr resistant 'Clearfield' rice and 'Liberty Link Rice' which is tolerant to phosphinothricin or glufosinate ammonium are novel options in weedy rice management. At IARI, the first herbicide tolerant near isogenic lines (NILs) of Pusa Basmathi 1121 rice namely 1979-14- 7-33-99-10, 1979-14-7-33-99-15 and 1979-14-7-33-99-66 has been developed through marker assisted backcross breeding (MABB). PB 1121 is interrogated with mutated *AHAS* allele from the donor parent (DP) Robin which confers tolerance to imidazolinone group of herbicides. Other approaches should include development of potential bio agents like microbial pathogens against weedy rice and isolation of soil microbes infecting seeds of the weedy rice.

Vegetable Crops: Major Tools for Crop Diversification

S. K. Singh, Shubhadeep Roy, Neeraj Singh and T. K. Behera

Vegetables are important constituents of Indian diet and are consumed for nutrition, maintenance of health, while many are valued for their therapeutic values and prevention of diseases. As food crops, vegetables can play an important role in achieving the nutritional security. More than 70 types of vegetables are grown in our country. Most of the vegetables, being short duration crops, fit very well in the different multiple and inter-cropping system and are capable of giving very high yields and very high economic returns to the growers in a short period of time, besides generating on farm and off farm employment. As a result, in recent years major emphasis is given for commercial exploitation of vegetable crops. Varieties of vegetables crops having speciality traits and different durations suitable for sowing at different time (dates) have been developed in recent times which has enabled growers to fit vegetable crops in different intensive cropping systems.

In the recent decades, agricultural diversification has increasingly been considered as a panacea for the severe problems that have afflicted agriculture. Crop diversification in the form of including different cereal and horticultural crops in the cropping sequence can provide farmers with better income realization & profitability, resource use efficiency and productivity. Therefore, a key step to the economic development of Indian farmers will be to diversify their cereal based production system through inclusion of vegetable crops in cropping sequence. The inclusion of vegetables in the major cropping systems will not only improve the availability of vegetables and help in the food self-sufficiency drive but will also provide means to earn foreign exchange by exporting fresh vegetables and vegetable seeds. Moreover, these vegetable crops are suitable for production on small pieces of land and their inclusion in traditional cropping systems can improve the nutritional potential of the system.

Farmers FIRST Programmee

The major objective of the Farmers FIRST Programme, with project entitled "Intervention of Improved Agricultural Technologies for Livelihood and Nutritional Security Adhering Local Resources and Working Knowledge of the Farmers", is to strengthen crop diversification by supplying quality inputs for nutritional and livelihood security. To achieve this target, the interventions carried out in this project were target specific and as per available resources and working knowledge of the people. The vegetable crops were used as major tools for crop diversification. The project was initiated by adopting 960 farm families in 6 villages namely, Paniyara, Dhanapur,

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Lashkariya, Upaddhaypur, Baburam ka pura and Rajapur in Araziline block of Varanasi district. Varanasi is located at an elevation of 80.71 m in Ganges valley in Eastern Uttar Pradesh. Humid subtropical climate with large variations between summer and winter temperature is common feature of Varanasi. Average annual rainfall is 1,110 mm; the land is very fertile.

Rice-wheat is the most widely adopted cropping system in the Indo -Gangetic plains of Eastern Uttar Pradesh. However, it is realized that the system is not sustainable due to various reasons. The dominant paddy – wheat cropping system of cultivation has led to serious economic, social and ecological problems such as deceleration in the productivity of ground water resources, decline in soil fertility and increase in environmental pollution. Need was felt to diversify the traditionally grown less remunerative cropping system through suitable interventions of vegetable crops to achieve sustainable productivity, profitability and resource use efficiency. Since there is potential for compensation among components of the system, such diversification can bring higher productivity, profitability and economic stability. Following important interventions were introduced to promote crop diversification and increase cropping intensity:

1. Double transplanting of rice for increasing cropping intensity through catch crop of vegetable pea and potato

For improved livelihood and enhanced food security of rural farmers in the Eastern Indo-Gangetic Plains of India, double-transplanting technology of kharif rice was introduced in the rice wheat cropping system. The main objective was to reduce the duration of land occupied by kharif rice so that an additional crop could fit in before wheat crop to increase the productivity and profitability of the kharif rice-based cropping systems. Rice variety HUR-917 developed by BHU Varanasi, is a medium duration (130-135 days), high yielding, aromatic, resistance to lodging and neck blast disease, having good grain quality with yield potential of 45-55 q/ ha. This variety was planted under double transplanting.

The rice nurseries for double-transplanting were seeded between May 15 - 20. Kharif rice in the traditional system of kharif rice-wheat system was seeded between June 20 to July 20 depending upon arrival of monsoon rain. The sowing dates in the nursery differed among the farmers and between years, therefore, the range of sowing dates are provided. Under double transplanting, nursery bed was sown in an area of 75m^2 with 3-5 kg seed. Twenty-five days old seedling were uprooted from nursery beds and transplanted into a small plot of 225m^2 at 10x10 cm spacing with 8-10 seedlings per hill. This was the first transplanting. The ratio of area covered from nursery to the first transplanted plot was about 1:3. From the first transplanted plot, 30-35 day old rice tillers were uprooted and transplanted for a second time into the main field. The tillers were transplanted at 20 x15 cm row to row and plant to plant spacing with 2-3 tillers per hill. The split tillers planted in the main field covered 8-10 times the area of the first transplanted plot. The seedling /split tillers from 225m^2 were sufficient for an area of 2500 m^2. In the case of the double-transplanting of rice, 30:15:15 kg/ha of NPK were applied for the first transplanting and 90:45:60 kg/ha of NPK were applied to the main field at the second transplanting. The mature rice was harvested 65-75 days after the second transplanting during first fortnight of October. Under traditional system rice seedlings were transplanted @2-3 seedlings/hill at spacing of 25 X 20 cm. It took another 110 to 120 days for the crop to mature. The crop was harvested during first fortnight of November.

After the harvest of Double transplanted rice, potato variety Kufri Pukhraj and Pea variety Kashi Udai was planted during October 18-22. The potato and pea crop were harvested at 70 and 75 days after sowing respectively. Thereafter wheat variety HD-2967 was sown with seed rate of 125 kg/ha during last week of December to first week of January. The wheat crop was harvested during second fortnight of April. Under conventional sys-

tem wheat crop was sown during third to fourth week of November after HUR-917 and first fortnight of December after MTU-7029, with variety HD-2967 @ 80-90 kg/ha. Four to five irrigations are applied to the November sown wheat while three irrigations were given to the late sown wheat.

Yield: The yield of long duration rice variety MTU-7029 harvested during second fort night of November under traditional system was 49.5 q/ha. The yield obtained of medium duration rice variety HUR 917 under traditional system was 40.16 q/ha. The yield of medium duration rice variety HUR 917 under double transplanting was 45.34 q/ha. The early crop of Kufri pukhraj produced yield of 220.6 q/ha. The Green pod yield of Pea was 82.4 q/ha. The wheat crop yield was 33.6 q/ha and 35.4q/ha when sown after potato and pea respectively. The wheat crop sown after harvesting of long duration rice variety MTU -7029 in first fort night of December produced yield of 34.4 q/ha. The wheat crop sown after harvest of Rice crop HUR-917 at normal time in 20-25 November yielded 43.5 q/ha.

Impact: Sale price of rice HUR-917 was Rs.1750/q while MTU-7029 was Rs.1590/q. sale price of wheat was Rs.1840/q, potato (K. Pukhraj) Rs.1200/q and pea green pod was Rs.1500/q. Double transplanting not only increased the yield of rice, but it also provided enough time to grow a catch crop of short duration potato and pea without sacrificing the yield of wheat. The yield of rice, potato and pea was converted in terms of wheat equivalent yield. It is evident from table-1 that rice-potato-wheat produced highest Wheat Equivalent Yield (WEY) of 208.87q/ha followed by rice-pea-wheat (126.89 q/ha). Inclusion of catch crop increased the overall productivity by 148 and 50.6 percent respectively over sole Rice-Wheat system. The yield of double transplanted rice was 4-5 q/ha more than normal transplanted crop. The farmers were encouraged to adopt the DT rice-pea/potato-wheat system by the overall increase in income from the system. The timely sowing of wheat allowed by the introduction of the new technology has enabled the farmers to harvest higher yield of wheat as also reduced the effects of risk factors such as higher temperature at maturity stage. These trials assessed the feasibility and economic viability of double transplanting to enhance the productivity and profitability of the rice-based cropping system. Based on the initial observations the participatory trials were extended to a greater number of farmers. Other farmers of the same and adjoining villages also introduced the double-transplanting technology after seeing the encouraging results from the fields of fellow farmers. The enhanced grain yield of rice crop and the higher income from the overall cropping system promoted by the double-transplanting technology, encouraged confidence among the farmers of the region. The introduction of double-transplanting technology of rice has provided an effective way for a

Table 1: Effect of double transplanting of rice on yield and economics of the cropping system

Cropping system	Rice yield (q/ha)	Wheat yield(q/ha)	Additional crop yield (q/ha)	System productivity (WEY q/ha)	Net Income (Rs)
Rice (MTU-7029) - Wheat	49.5	37.3	0	80.07	82337
Rice (HUR -917) - Wheat	42.6	47.4	0	84.21	97701
DT Rice (MTU-7029)-Wheat	53.6	42.6	0	88.92	98608
DT Rice (HUR -917)–Potato-Wheat	47.8	34.6	220.6	208.87	225839
DT Rice (HUR-917)-Pea-Wheat	48.4	35.4	82.4	126.89	164226

better use of natural resources for enhanced and sustainable productivity and profitability of the system.

Table 2: Yield and economics of the rice-wheat system Diversified through French bean

Cropping system	Rice Yield (q/ha)	Rabi crop yield (q/ha)	System productivity REY(q/ha)	Net Income (Rs/ha)
Rice-Wheat	40.54	46.5	89.43	93505
Rice -French Bean	43.45	60	146.31	158038

Sale price: Rice- Rs.1750/q; Wheat=Rs1840/q; French bean pod= Rs 3000/q; REY= Rice equivalent yield

2. Crop diversification

The focus area was Crop diversification for increasing cropping intensity and productivity leading to income enhancement. Under low land and low midland, rice is the default crop during kharif season due to its capability to grow and produce reasonable yield under water logged condition, where no other crops can be grown. High yielding, disease resistant varieties of vegetables were introduced for higher productivity during rabi season. The main focus was given on promotion of improved vegetable varieties through demonstrations and comparing with existing cultivar in both quality and yield. Small and marginal category of farmers were beneficiaries for demonstration.

Farmers of Dhanapur, Laskaria and Paniyara are small and marginal with very small size land holdings. They mostly practice rice-wheat cropping system from which the income is very meagre. In order to promote diversification and improve livelihood options of these small farmers, vegetable French bean was introduced in these areas under FFP. After harvest of rice, vegetable French bean can be successfully grown during winter season in these areas. Farmers in these villages where project was implemented were not cultivating French bean earlier. French bean variety Kashi Rajhans was developed by ICAR-IIVR, is a bush type, high yielding and resistant to collar rot and bacterial blight disease.

Farmer first team in order to promote multiple cropping pattern in the area organized training programme for scientific cultivation of French bean. Farmers were trained to grow French bean during winter season. Seeds of French bean variety Kashi Rajhans were supplied to a group of 15 farmers for growing during Rabi season. Farmers took up the cultivation of vegetable French bean for the first time in the area. The crop was raised in an area of one-acre which yielded 24.3 quintals of marketable French bean pods. The French bean was sold in the market @ Rs. 30/-kg and earned a net profit of Rs. 46560/- from land of 1 acre. Farmers are happy with the performance of French bean.

Similarly, after harvest of rice crop farmers in the Rajapur and Laskaria village were growing tomato. However, tomato growers were very much worried about leaf curl disease of tomato which decreases the yield drastically. Tomato leaf curl disease is caused by Virus and it spreads through vectors. Farmer adopts frequent chemical spray to control the leaf curl disease thus spending a lot of money on spraying chemicals. FFP team suggested farmers to grow leaf curl resistant tomato var. Kashi Aman. This open pollinated variety of tomato was developed at IIVR, Varanasi and is resistant to TYLCV disease. Tomato variety Kashi Aman was demonstrated with 20 farmers for raising crop in one Acre area.

The crop was free from leaf curl disease and produced a bumper crop with marketable yield of 113 q in one acre. The fruit size, colour and quality of Kashi Aman were very good having market-

Table 3: Yield and economics of the rice-wheat system Diversified through tomato

Cropping system	Rice Yield (q/ha)	Rabi crop yield (q/ha)	System productivity REY (q/ha)	Net Income (Rs/ha)
Rice-Wheat	42.7	46.9	92.01	98021
Rice -tomato (K. Aman)	41.6	280.4	169.78	174620
Rice-Tomato (local Var)	42.3	210.6	126.54	98945

Sale price: Rice-Rs 1750/q; Wheat=Rs1840/q; Tomato (Aman)= Rs 800/q; Tomato (Local)= Rs 700/q; REY= Rice equivalent yield

Continued on page 29

Oyster Mushroom Cultivation

Satish Kumar and Simranjeet

Mushrooms are multicellular, fleshy, spore-bearing fungi that have been consumed as food since the time immemorial. Edible mushrooms are currently in high demand for their medical benefits and therapeutic attributes, in addition to their nutritional worth. *Pleurotus* sp. grows natively in temperate and tropical forests on dead and decaying organic debris, wooden logs and occasionally on dying deciduous or coniferous tree trunks and are easily artificially cultivated. It is the most popular edible mushroom after button mushrooms at the global level. It belongs to the genus *Pleurotus* and the family *Pleurotaceae.* It is popularly known as 'Dhingri' in India. These mushrooms, unlike other mushroom species are the easiest, quickest and cheapest to grow. It has cheap capital expenditures, takes less time to prepare and uses low-level production equipment, making it more profitable to cultivate than other mushrooms on commercial scale. These mushrooms are appealing because they can use a wide range of agricultural waste products and convert the lignocellulose biomass into high-quality food, flavour, and nutritional value.

Oyster mushroom production status in India and world

The world production of all mushrooms is about 40 million tonnes contributed largely by countries like China, USA, Netherlands, Poland, Spain, France, Italy, Ireland, Canada, and UK. India produces less than one per cent of mushrooms of total world mushroom production, with white button mushroom accounting for 73% of total mushroom production and other tropical mushrooms such as oyster mushroom, paddy straw mushroom, and milky mushroom accounting for 16, 7, and 3 per cent of total mushroom production, respectively. However, a twenty fold increase in mushroom production has been achieved in India during the last four decades. Haryana is one of the leading states in white button mushroom production contributing about 15 per cent of total mushroom production in India.

Among different mushrooms, the world production of oyster mushrooms is estimated to be about a million tonnes, the third-highest among other mushrooms at the world level. China is responsible for about 85% of the total world production. Korea, Japan, Italy, Taiwan, Thailand and Philippines are among the nations that produce oyster mushrooms.

In India, the cultivation of various species of oyster mushroom began in the early 1960s, and commercial farming began in the mid-1970s. Now

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India annually produces about 21,000 tonnes of this mushroom and is popularly grown in Madhya Pradesh, Andhra Pradesh, Orissa, Karnataka, West Bengal, Maharashtra and North Eastern states. In Haryana, the total production of oyster mushroom is only 50 tonnes, however, there is a great potential to produce oyster mushrooms.

Nutritional and medicinal value of oyster mushrooms

Edible mushrooms are currently in high demand for their medical benefits and therapeutic attributes, in addition to their nutritional worth. Mushrooms are high in vitamin B, particularly niacin and riboflavin and have the greatest protein level of any vegetable. Fresh mushrooms have an average moisture content of 85-90 per cent, 3.0 per cent protein, 4.0 per cent carbohydrates, 0.3-0.4 per cent lipids, and 1.0 per cent minerals and vitamins. Mushrooms have many medicinal properties such as antimicrobial, antiviral, anti- HIV, antineoplastic, antitumor, antimutagenic, antioxidant, hyperglycaemic, hypotensive, anti-inflammatory, hepatoprotective, hypocholesterolemic, immunomodulatory, anti-aging properties.

Oyster mushrooms are very effective in reducing total plasma cholesterol and triglyceride levels, lowering the risk of atherosclerosis and other cardiovascular and artery-related illnesses e.g. *P. Florida* possesses antioxidant and anticancer properties. Inflammation and platelet aggregation are inhibited by methanol preparations of *P. florida*. *P. sajor-caju* has hypertensive effects through its active ingredients which affect the renin-angiotens in system. Oyster mushrooms are reported to have high nutritional values. It has protein (25-30%), fat (2.5%), sugar (17-44%), mycocellulose (7-38%) and about 8-12% of minerals (potassium, phosphorus, calcium and sodium). It also contains folic acid which aids in the treatment of anaemia. It is rich in B complex and Vitamin C. The Niacin concentration is almost 10 times that of any other vegetable. The mushrooms' economic value is mostly derived from its use as human food.

Cultivated species of oyster mushroom

Different species of temperate, tropical and sub-tropical mushrooms are cultivated throughout India due to the varying agro-climate and plenty of farm waste. Widespread malnutrition with the ever-increasing protein gap in our country has further necessitated the search and cultivation of an alternative source of protein. As the production of pulses has not kept pace with our needs, and there is an ever-increasing protein deficit and need for quality food, mushroom growing is now developing as an important industry in several sections of our country. Although *Pleurotus* is a popular mushroom in the country, most of the production relies on a few species only. Despite rising demand, there is a scarcity of oyster mushrooms throughout the year. As a result many oyster mushroom species which give production under different climates, may be the ideal year-round oyster mushroom alternative.

Among all the cultivated mushrooms *Pleurotus* has the maximum number of commercially cultivated species suitable for round the year cultivation. All the varieties or species of oyster mushrooms are edible except *P. olearius* and *P. nidiformis* which are poisonous. *Pleurotus* Species commercially cultivated all over the world include *P.ostreatus, P. sajor-caju, P. florida, P. flabelltus, P. citrinopileatus, P. fossulatus, P. sapidus, P. membranaceous, P. eous, P. cornucopiae, P. eryngii, etc.*

Availability of crop residues

India produces about 600 million tonnes of crop residue each year, with the majority being permitted to degrade naturally or burned on the spot. This may be used to grow high-nutrition value foods like oyster mushrooms and the wasted

mushroom substrate can be turned into organic manure. Haryana produces around 22 million tonnes of wheat and paddy straw per year. In Haryana and neighbouring states, paddy straw burning in the fields is an issue and it's critical that efforts should be made for the best use of these straws in terms of both cost and environmental impact.

Pasteurization of substrate

Pasteurization of substrates is one of the most crucial factor to optimize the yield of oyster mushrooms. Different states have different crop residues and even within a state, the crop residues are different in different parts. Like in Haryana, in northern districts paddy and wheat straws are the major crop wastes which can be used in oyster mushroom cultivation whereas in southern Haryana, mustard, cotton wastes etc. are the major crop residues which may be used for oyster cultivation. Standardization of technology of substrates preparation from different crop residues has not been recommended in most states of India.

Successful cultivation of mushroom often requires pasteurization of the substrate, before inoculation with spawn. In India, oyster mushroom producers typically utilise chemicals for substrate pasteurisation, which are both expensive and environmentally unfriendly. Other sources like solar energy, which is free and available throughout the year, may be a better option for pasteurization but it requires exhaustive studies before any recommendation. Similarly, hot water treatment provides a low-cost alternative to substrate pasteurisation, which is an important pasteurisation approach.

Use of different pasteurisation methods of different substrates like steam pasteurisation, hot-water treatment and chemical sterilisation with formalin are practised in different parts of India. Chemical sterilization is expensive and not eco-friendly practice to cultivate oyster mushrooms. Steam pasteurization is also not becoming popular because of high cost of establishment of structures or equipments. Hot water treatment or pasteurization in chambers are the two best options but establishment of pasteurization chamber is beyond reach of small farmer. Soaking of substrates in normal water (no hard water and neutral in pH) upto 12 hours (depends upon the substrate hardness) and then hot water treatment of substrates at 70 degree celcius for 20 minutes was found most effective for pasteurization of wheat and paddy straw. It yielded early and maximum yield

P. sajor-caju cultivation under hanging and rack method of cultivation

P. florida cultivation under hanging and rack method of cultivation

of *P. florida* and *P. sajor-caju* on paddy straw followed by wheat straw.

Oyster mushroom cultivation methods

A profitable method of cultivation is not followed by oyster mushroom growers in India, generally due to lack of information on cultivation methods most suited to oyster mushrooms. In India, it is primarily grown using the rack method in which bags are placed on the racks, which has very low economic returns. Other methods of cultivation i.e. hanging rope system method was found to be comparatively less costly and accommodated more bags per unit area and produced more yield. Oyster mushroom farmers are now opting hanging method because there is no cost involved in racks formation as well as a conducive climate is met in mushroom house for optimum growth, maximum space for development of fruiting body which results in early spawn run, early pin head formation, early harvest and higher yield. A mushroom grower in a thatched hut of 30 * 60 ft. can accommodate about 1800 oyster mushroom bags in rack system but in hanging method about 2200 oyster mushroom bags can be accommodated which may give better returns to the oyster mushroom growers.

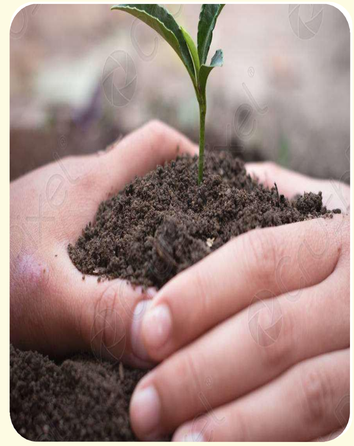
Value addition of oyster mushrooms

Various value added products like pickle, biscuits, cakes, papads, nuggets, curry, rasgullas, soups, pakoras, paranthas, rice pulav, fried oyster mushroom, mixed vegetables etc. can be prepared from the fresh/dry oyster mushroom. The dried oyster mushroom is powdered and can be used in the main ingredients of abovesaid value added products.

Constraints in oyster mushroom production

- Lack of standardization of technology of cultivation of different oyster mushrooms on different crop residues.
- Marketing of oyster mushroom is a major constraint.
- Lack of spawn availability and awareness of species for round the year cultivation of oyster mushrooms.
- Lack of awareness on its value addition and post-harvest processing.
- Lack of schemes of State and Central Government for oyster mushroom production, processing and value addition.
- In India, the vegetarian food is liked by most of the people and people consider it a non-vegetarian food.
- People are not aware about its nutrional and medicinal values.

Integrated Nutrient Management: A Key to Improve Soil Health and Crop Productivity



Dr. Rajan Bhatt[1] and R. K. Gupta[2]

Rice, maize, sugarcane and cotton are the most important Kharif crops in Punjab, accounting for over a quarter of the total planted area. All of these crops deplete soil fertility by removing enormous amounts of nutrients from the soil. Farmers have been applying fertilizers indiscriminately for a long time to restore soil fertility and increase crop yield. This practice not only endangers the land and the ecosystem but also increases the cost of cultivation. All available organic sources of plant nutrients must be harnessed and put to use in order to interrupt this vicious cycle, limit soil mining and sustain soil productivity. To address nutritional demands and achieve sustainable yields with greater profitability, combined management of organic manures/*prali-char*/bio-fertilizers and chemical fertilizers is proposed.

Integrated use of organic manures and chemical fertilizers

Sugarcane

Mix Farm Yard Manure (FYM) or ressmud at the rate of 8 tonnes per acre in the soil before 15 days of sowing of sugarcane. Application of 40 kg N (90 kg urea) is sufficient if FYM or pressmud has been applied. 10 percent more yield can be obtained if the recommended dose of nitrogen is applied along with FYM or press-mud.

Rice

Application of 6 tonnes of FYM or 2.4 tonnes of dried gobar gas plant slurry or 2 tonnes of *prali char* will help in saving 16 kg N per acre. Similarly, application of 6 tonnes of press mud or 2.5 tonnes of poultry manure per acre before preparatory tillage will help in saving 25 kg of nitrogen.

Half dose of nitrogen (25 kg per acre) can be saved in those fields where dhaicha or sunhemp or cowpea of 6-8 weeks age has been incorporated one day before transplanting of rice. Similarly, burying the residues of summer moong grown as a green manure crop after plucking the beans one day before transplanting of rice will help in

Saving of nutrients with the application of different manures/prali char in rice

Organic manure/*prali char*	Quantity (ton/acr)	Saving of nitrogen
Farm Yard Manure	6	16 Kg (35 Kg urea
Pressmud	6	25 Kg (50 Kg urea)
Poultry manure	2.5	25 Kg (50 Kg urea)
Dried gobar gas slurry	2.4	16 Kg (35 Kg urea)
Green manuring with dhaincha/sunhemp/cowpea	-	25 Kg (55 Kg urea)
Incorporation of residue of summer moong	-	16 Kg (35 Kg urea)
Prali char	2.0	16 Kg (35 Kg urea)

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saving one-third of nitrogen (35 kg urea) per acre. Dhaincha should be preferred in *kallar* and recently reclaimed soils. Green manuring with dhaincha also ameliorates iron deficiency in rice. Likewise in basmati, there is no need to apply nitrogen if 45-55 days old dhaincha or sunhemp or residues of summer mung has been buried in soil just one day before transplanting. Application of 2 tonnes of prali char to rice will help in saving of 16 kg nitrogen. The application of organic manures and prali char also helps in improving soil health.

Maize

Maize production can be increased by burying 50 days old green manure crop (dhaicha or sunhemp or cowpea), 10 days before sowing along with recommended dose (50 kg/acre) of nitrogen. It will also help in improving the soil health. In the absence of green manuring, 6 tonnes of well rotten FYM should be applied before sowing. It will minimize the application of fertilizers at the time of sowing., If Farm Yard Manure is not available then 180 kg compost prepared from rice straw should be applied.

Other crops

To get a higher yield of soybean, 4 tonnes of FYM per acre should be applied along with recommended dose of chemical fertilizers. 40-45 days old sunhemp may be buried, 5 to 7 days before sowing as green manure. Application of 10-15 tonnes of well rotten farmyard manure to mentha helps in increasing its productivity. Application of 10-12 tonnes of well rotten farmyard manure before sowing of turmeric helps in increasing the soil health. In case of maize fodder, application of FYM ameliorates deficiency of zinc, phosphorus, potash and also helps in saving one-third of nitrogen application. 10 tonnes of FYM or compost sould be applied in the soil in case of bajra or 20 tonnes of FYM or compost before planting of Napier bajra hybrid or guinea grass for increased production.

Use of bio-fertilizers in different crops

In rice crop, dissolve 500 g of the azorhizobium bio-fertilizer in 10 to 15 ltr of water and dip the seedlings for 45 minutes and then go for transplanting. Inoculating rice seedlings with azorhizobium bio fertilizer has resulted in a 1 to 3 percent increase in grain yield of rice. In some crops like sugarcane and turmeric, the bio fertilizer is mixed with soil. Mixing the bio fertilizer in furrows before planting sugarcane resulted in 4 to 5% increase in yield. In maize, moong, soybean, arhar and mash the bio fertilizer is mixed with seed. For this purpose, dissolve the specific bio fertilizer in half liter of water. Inoculate the seed with the solution of bio fertilizer and water, then spread the seed on pucca floor or turpal/polythene sheet and dry it under shade. Thereafter, sow the seed immediately. This practice helps in increasing the yield of maize by 4 to 6% and that of moong by 12 to 16 percent. Similarly, inoculating the seed of arhar and mash with recommended rhizobium culture (biofertilizer) at the time of sowing will also give 5 to 7 percent more yield. The use of consortium

Use of bio fertilizers in different kharif crops

Crop	Bio fertilizer	Dose /acre	Method of application	Expenditure /acre(Rs)	Increase in yield(%)
Rice	Azorhizobium	500 g	Apply to rice seedlings before transplanting	40	1-3
Maize	Consortium	500 g	Apply to seed	40	4-6
Sugarcane	Consortium	4.0 kg	Mix in soil	280	4-5
Turmeric	Consortium	4.0 kg	Mix in soil	280	5-6
Moong	Rhizobium	250 g	Apply to seed	30	12-16
Soybean	Rhizobium	250 g	Apply to seed	30	8
Arhar	Rhizobium	250 g	Apply to seed	30	5-7
Mash	Rhizobium (LUR 6)	250 g	Apply to seed	30	5-7

bio fertilizer not only helps in increasing grain yield but also maintains/improves soil health.

Recommended dose of fertilizers for different crops

It is recommended to apply the balanced dose of different fertilizers based on soil tests for higher fertilizer use efficiency. The fertilizer's doses can be increased or decreased based on soil test report. If a nutrient is low in soil test, increase the amount of fertilizer of that particular nutrient by 25 percent. On the other hand, reduce the dose of fertilizer by 25 percent if the nutrient falls in the high availability range as per the soil test report.

- Reduce the dose of urea by 10 and 20 kg per acre if the crop has received 27kg or 55 kg DAP per acre, respectively.
- Omit phosphorus application in rice, basmati, maize, cotton, and groundnut following wheat which received the recommended dose of phosphatic fertilizer. However, in soybean, apply only 24 kg P_2O_5 per acre instead of 32 kg P_2O_5, if it follows wheat crop which has received recommended dose of phosphorus.
- Do not apply urea to the basmati rice if the field has been green manured with 45-55 days old sunhemp/*dhaincha* or summer moong straw after picking of pods.
- Apply potassium fertilizer only to soils deficient in this nutrient (if soil available potassium is less than 55 kg per acre).
- Always prefer Single Super Phosphate over DAP as a source of phosphorus in light-textured soils to meet the sulfurrequirement of crops. In case, single super phosphate is not available, apply 50 kg gypsum per acre to groundnut.

Nutrient requirement of different crops on medium fertility soil

Crop	Fertiliser (kg/ acre)		
	Urea	DAP/ Single Super Phosphate	Muriate of Potash
Rice (Transplanted): PR-113, 114,121,122,123,124,126 & 127	90	27/75*	20
Rice (Direct Seeded): PR-126	130	27/75*	20
Basmati 386, 370 and CSR 30	18	75*	-
Pb Basmati 5,4, 3 and 2 Pusa basmati 1121,1637 and 1718	36	75*	-
Pusa Basmati 1509	54	75*	-
Basmati(Direct sowing): Pusa basmati 1121 and 1509	54	75*	-
Maize: PMH1&11, Parbhat and Pb Sweet Corn 1	110	55/150**	20
PMH2 Kesri and Pearl Popcorn	75	27/75*	15
Cotton			
Non-Bt varieties	65	27/75*	20
Bt variety (PAU Bt 1)	80	27/75*	20
Bt and Non-Bt hybrids	90	27/75*	
Moong: ML 818 &2056	11	100*	-
Mash: Mash-338 &114	11	60*	-
Arhar: AL 201, PAU 881 &AL 882	13	35/100*	20
Soybean: SL 525, 744 &958	28	200*	-
Guara: Guara 80, AgetaGuara 112 &HG 365	17	120*	-
Groundnut: M 522, SG 99 &TG 37A	13	50*	17
Sugarcane plant	130	27/75*	-
Sugarcane ratoon	195	27/75*	-
Sugarcane autumn	195	27/75*	-

*Single Super Phosphate ** only to soils tested low in these nutrients

Time of fertilizer application

- Full dose of phosphorus and potassium should be applied to all the crops at the time of sowing.
- Apply one-third of the recommended nitrogen, 7 days after transplanting and remaining in two equal splits at 3 and 6 weeks of transplanting in all long varieties except short duration (PR-124 and 126) varieties where the third dose should be applied after 5 weeks of transplanting.

- In direct seeded rice, apply the recommended dose of nitrogen in three equal splits at 4, 6, and 9 weeks of sowing.
- In basmati, apply recommended dose of nitrogen in two equal splits at 3 and 6 weeks of transplanting. In direct seeded basmati, apply the recommended dose of nitrogen in three equal splits at 3, 6 and 9 weeks of sowing.
- In maize, apply nitrogen in three equal splits at sowing, at knee height and pre tasseling stage.
- In cotton, apply half nitrogen at thinning and the remaining half at the appearance of the first flower. In Bt cotton, four sprays of 2.0 per cent potassium nitrate (13-0-45) at the weekly interval, starting from flower initiation are recommended for getting a higher yield. Reddening of cotton foliage can be controlled by two sprays of 1.0 per cent magnesium sulphate at 15 days intervals at flower/boll formation stage.
- Apply all the recommended fertilizers at the time of sowing in moong, mash, arhar, guara, and groundnut.
- In sugarcane plant crop, apply half of the recommended nitrogen at first irrigation and the remaining half during May or June.In autumn planted crops apply nitrogen in three equal splits at planting, during March and April. However, in ratoon sugarcane apply nitrogen in three equal splits during February, April, and May. Also, drill therecommended phosphorus (only to soil low in phosphorus) along the rows during February.

Continued from page 21

able importance. At the prevailed market price of Rs 8/kg, farmer get net return of Rs. 70700 from one acre. The performance of new tomato variety was accepted and appreciated by the farmers.

Table 4: Yield and economics of the rice-wheat system Diversified through chilli

Cropping system	Kharif crop Yield (q/ha)	Wheat yield (q/ha)	System productivity WEY (q/ha)	Net Income (Rs/ha)
Rice-Wheat	41.6	47.2	86.77	96648
Chilli-wheat	120.5	44.9	143.13	168366

Sale price: Rice-Rs 1750/q; Wheat=Rs1840/q; Chill green= Rs 1500/q; WEY= wheat equivalent yield

Under upland and upper midland where there was no water stagnation during kharif season green chilli crop -wheat system was promoted to diversify the system. Traditionally green chilli varieties are of seven to eight-month duration, however chilly variety Kashi Anmol is short duration improved OP variety. Plants are determinate, dwarf (60-70 cm) with nodal pigmentation on stem and bear green attractive pendant fruits. First picking starts 55 days after transplanting; average green fruit yield of 125-150 q/ha in only 120 days of crop duration. After last harvesting of chilli in end of December, wheat was sown with recommended seed rate of 125kg/ha in lines at 20 cm. The other cultural practices followed were as per the recommendations. Wheat crop was harvested during second fortnight of April and gave yield of 38.9 q/ha. Thus, inclusion of chilli crop in place of rice not only increased the overall productivity of the system by 65% but it also increased the net income by more than Rs.71,000/ha

Conclusion: The objective was to diversify the existing cropping systems, through vegetable crops, economise resources and increase the efficiency of resources so as to increase the income of the farmers. In Rice -French bean, Rice -Tomato and Chilli-wheat system, inclusion of vegetable increased the overall productivity and profitability of the system. These trials, assessed the feasibility and economic viability of diversifying through vegetable crops to enhance the productivity and profitability of the cropping systems. Thus, by diversify the existing cropping system with suitable crop and appropriate variety the farmer earned an extra income. Stability and profitability of a system depends not only on higher productivity but also on consistency in production of individual crops over the years.

Earn Health and Wealth with Milk

Rajni Goel, Jaspreet Kaur and Vipan Kumar Rampal

Multiple farming is need of the hour and dairy farming along with production of value added dairy products can easily become an important component of multiple farming. There is vast scope for dairy based business due to a huge domestic market which includes traditional products like cottage *butter, ghee, paneer, khoya, curd, malai* etc. Such products are high in terms of nutrition, for example, *paneer* prepared from milk, used in various vegetarian dishes and snacks is rich source of protein and fat. Besides, it has minerals like calcium and phosphorous and fat soluble vitamins – A & D. As protein rich paneer is low in sugar, it is highly recommended for diabetic patients. Similarly, curd is easily digestible and more nutritious than milk itself and is thus highly recommended for patients suffering from fever, common flu or any stomach disorder. Also, milk based beverages e.g. whey, *lassi* etc. are nutritious and popular drinks especially during summer months when they can be consumed to quench thirst as an alternative to colas or sodas that have no nutritional content at all. At rural level, the milk producers especially from villages adjoining the cities can take up this enterprise and milk products can be sold in readily available consumer market in the cities. The transformation of raw milk into processed milk and milk products can benefit entire farming community by generating off-farm jobs in milk collection, transportation, processing and marketing.

Requirements for milk processing plant

Plant site and design

The milk processing plant should be located in adequate area having good transportation facilities, preferably on a railway siding or a paved highway. This would ensure easy supply of raw material to the plant and easy transportation of final products from the plant. Utilities such as water, power supply, fuel and waste disposal should be available. The building should be carefully planned so as to have provision for future expansion. The plant layout should be according to the product line, i.e. keeping in mind the various operations. There should be adequate space for storage of finished products as well as for washing/ sanitizing. Proper lighting and ventilation is must for a dairy plant. All requirements as per the FSSAI should be met.

Equipment

For starting a small dairy plant for market milk, the important equipments required include milk cans, milk chilling tanks, chilled water tank,

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weighing balance, cream separator, homogenizer, pasteurizer, clarifier, form-fill seal machine, bottling machine, cheese/paneer vat etc. These are available in various capacities and can be purchased from manufacturers/dealers across the country. Further expansion into dairy products would require stainless steel double jacketed vats, wooden/steel moulds, power operated *madhanis*, butter churning machine, wooden butter maker, sterilizer, ghee kettle, *paneer* cutting table etc. In addition, cold storage facilities for milk and milk products are required in the form of refrigerators and deep freezers.

Product Development

Several products can be handled by a small to medium milk processing plant.

1. Market milk

Market milk refers to the fluid whole milk mainly meant for direct consumption. Liquid milk processing involves several operations such as receiving, pre-heating, filtration/clarification, standardization, pasteurization, homogenization, bottling/packaging, cooling and storage. This milk can also be sold as raw material for manufacturing of processed milks and dairy and non-dairy manufactured products.

2. Flavoured milk

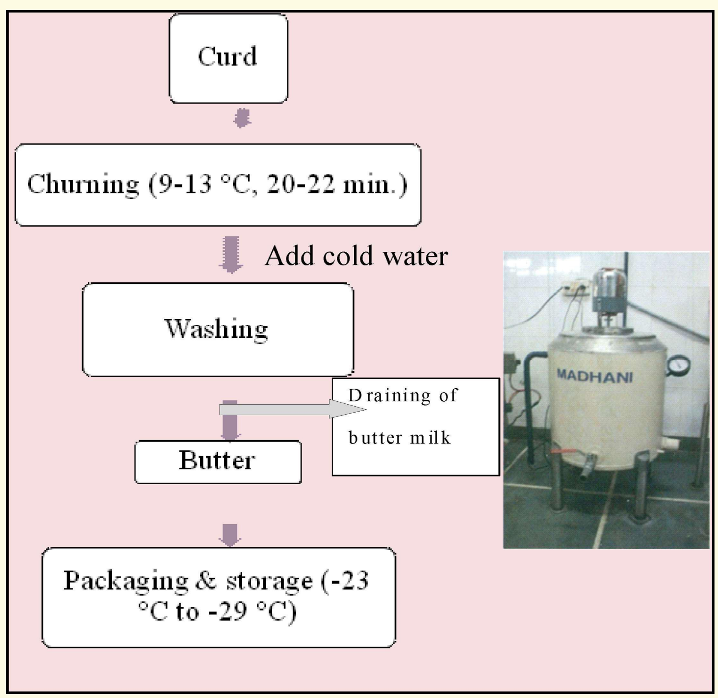
Flavoured milks/ drinks are prepared to increase the popularity of milk as a beverage with the addition of flavour, color and sugar/ sucrose. When the term "milk" is used, the product should contain a milk fat percentage at least equal to the minimum legal requirement for market milk. However, if the fat level is lower (1-2%), the term "drink" is used. The main types that could easily be prepared are fruit flavoured milks/drinks, chocolate milks/ drinks and long- life (sterilized) flavoured milks/drinks.

3. Cream

Cream is a fat-rich portion of milk with fat content varying from 25 to 85 per cent. Cream may be used for direct consumption or for manufacturing of dairy products. Production of cream involves several operations such as cream separation, neutralization, standardization, pasteurization, packaging and storage.

4. Butter

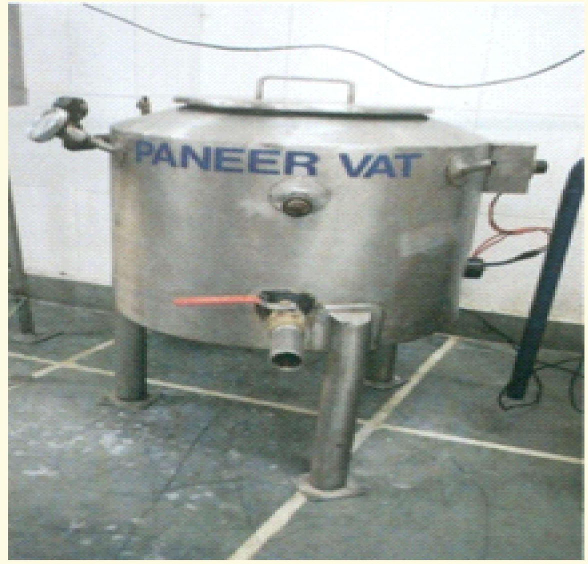
Butter is a fat concentrate which is obtained by churning cream, gathering the fat into a compact mass and then working it. It may be obtained from cow or buffalo milk or a combination of both. It may contain salt. Colour can be added in the form of annatto or carotene. It may contain cultures of lactic acid producing bacteria. It is of various types such as table butter, white (cooking butter), salted, unsalted, sour, sweet etc. Butter is also used by baking and confectionary industries and in manufacture of ice cream, butteroil and ghee. The milk fat should not be less than 80% by weight and moisture not more than 16% in prepared butter. However, curd prepared should not be sour in taste, hence starter used should be 2.5% in winters and 1% in summers. The vessel which is to be used for preparation of curd should be of aluminium. The period of ripening of curd should never go beyond 24 hrs.



Preparation of Butter

5. Desi ghee

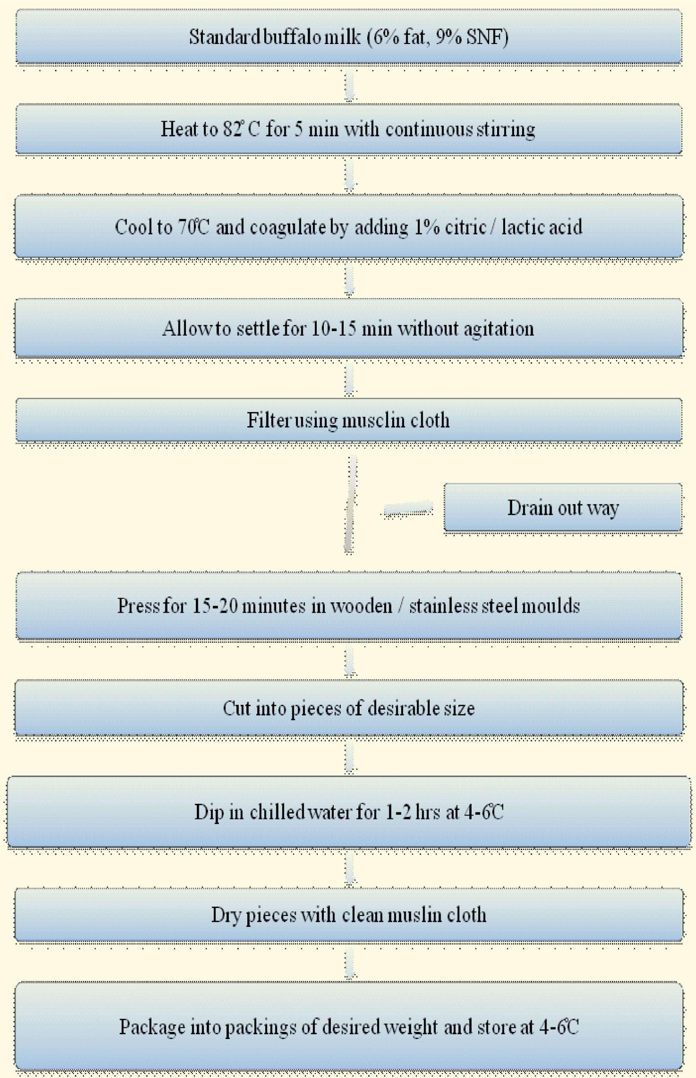
Ghee is one of the oldest dairy products which has a large production in India due to good keeping quality and huge market demand. It is the only source of animal fat for predominantly vegetarian Indian population. It is prepared by clarifying cow or buffalo milk. It should contain at least 99.5% milk fat as per FSSAI. It is being manufactured by several methods which include traditional and modern improved methods. Ghee is a high value product and there is a huge demand for pure unadulterated ghee.



6. Paneer

It is primarily acid coagulated milk product. Mostly, buffalo milk is used for the production of paneer. However, buffalo milk, if mixed with cow milk in the ratio of 3:1 provides good quality paneer. The best quality product is made from milk with 5-6% fat content and 8.5 – 9 % SNF content. According to FSSAI, *paneer* should not contain more than 60% moisture and not less than 50% fat on dry weight basis.

Addition of spices, black pepper, mint, *jeera* immediately after coagulation step may lead to production of flavoured *paneer* which can be marketed in different attractive packing.



Preparation of Paneer

Precautions to be taken while preparation of paneer

- The utensils to be used should essentially be of stainless steel (SS304) and never be of iron or any other metal.
- Citric or lactic acid to be used for coagulation of milk should be of food grade only.
- Excessive moisture in paneer may lead to fungal infestation and hence deterioration of the product. Therefore, it is essential to press paneer for prescribed time and also to dry it thoroughly with muslin cloth before packing.
- Paneer prepared from low fat milk will be hard.

- Milk should be coagulated at prescribed temperature (70° - 80 C°) not more otherwise it will become very coarse.

7. Whey Beverages

The liquid that remains after the coagulation of milk during preparation of *paneer* is called whey. Generally, whey is wasted in households but it is nutritious as it comprises of lactose, vitamin B and various proteins. The whey can be utilized for kneading the flour, making *pakodas* or *puris*. To make whey beverage, mix 3 parts of whey with 1 part of any fruit juice (carrot/pineapple) along with 6.5 % sugar and 0.5 % salt. The prepared mixture is filtered through muslin cloth and packaged in about 200 ml glass bottles. The bottles are capped and pasteurized at 64º C for half an hour. These can be refrigerated and used in households on daily basis. This whey beverage, because of its nutrient value, is better than any available soda or cold drinks available in the market. Its production can easily be taken at rural level and it can be made available in the shops for local consumption.

8. Curd (*Dahi*)

According to PFA standards, curd is prepared using pasteurized or boiled milk, inoculated with either lactic acid bacteria or other harmless bacteria for producing desired acidity. Also, curd is the first step by-product while preparing indigenous butter and *desi ghee*. It is estimated that about 40% of total milk produced is converted into curd for further preparation of desi ghee and butter in India. Starter bacteria culture used is *Streptococcus Lactis, S. di-acetilactis, S. cremoris, S. thermophilus or Lactobacillus bulgaris.* Procure fresh good quality milk, warm it to 40ºC and filter through muslin cloth. It is recommended that milk fat should be 3% and SNF 10% for better quality curd. Milk is pasteurized at 80-90º C for 15-30 minutes and further cooled to 22 – 25º C. Inoculate with 1-3 % Lactic acid bacteria starter, package in to packaging cups of desired volume and incubate at 22-25º C for 16-18 hours. The prepared curd is stored in refrigerator at 5-10º C. The color of best quality curd should be clear with light yellowish tinge and should have a mild acidity of 0.75-0.85%.

Precautions to be taken while preparation of curd

- The starter culture should always be stored at 10-15º C and should not be added to very hot milk.
- Acidity/Sourness of curd should not be more than 0.85.

9. Lassi (Butter milk)

The liquid product left after churning of curd or milk during the preparation of buttter is called lassi. The quality of lassi depends upon composition of curd or milk used for its preparation and volume of water used. On an average, it should constitute about 1% fat, 3% SNF, 96% water. Due to presence of proteins and phospholipids, it helps in quenching the thirst. It can be consumed after addition of ice, sugar, salt or any other flavouring agent.

10. Khoa

Khoa is a popular dairy product in northern parts of India and is used as a base for preparing traditional sweets such as *gulab jamun, burfi, kalakand, peda* etc. It is a partially dehydrated milk product prepared by continuous heating, stirring and scraping of milk in a *karahi* over direct fire till a semi-solid consistency is achieved. It has a huge market, especially in the days of festivals and in marriages for preparing traditional sweets.

At present, availability of milk products of good quality viz. paneer, khoa and other indian sweets is much less than that of demand. Normally, quality of khoa, which is base of all the sweets, is far lower than FSSAI standards. Similarly, Paneer being prepared by the un-organised sector is also of low quality and has lesser nutrition. Also, packing, storage, transportation and handling practices are not as prescribed by Hazard analysis and critical control points (HACCP). Hence, there is need to setup mini milk processing units to fulfil increasing demand of quality milk and milk products.

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