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POLLINATION TECHNIQUES IN DATE PALM

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Introduction

Date palm (*Phoenix dactylifera* L.) belongs to the family Arecaceae (Palmae) and is one of mankind's oldest cultivated plants. Based on archeological evidence, Iraq is considered as the center of origin of date palm. Along with the olive and the fig, the three represent an ancient group of fruit trees closely associated with the beginnings of agriculture and the sustenance of humankind in the arid regions of the old World (Al-Khayri, *et al*., 2013). The scientific name *Phoenix dactylifera* is derived from the word phoenix, in Greek mythology it means a long lived bird and dactylos meaning finger, which refers to the shape of the fruit.

Distribution

Egypt, Saudi Arabia, Iran, Algeria, Iraq, Pakistan and Sudan are the top date producing countries. The major date palm growing areas in India are Kutch (Gujarat), Rajasthan, and certain parts of the Punjab, as well as Tamilnadu (Shah, 2014). India is the world's largest importer of dates with over 2,50,000mt and an expenditure of 70 million USD per year. Iran became the leading exporter with over 2,40,000mt, generating annual revenues of over 80 million USD. Medjool is the most popular and appreciated cultivar and Deglet Noor is the most exported cultivar (Al-Khayri *et al*., 2015a, b). Date fruit is not only a staple food of the local population of the many countries but also yield significant contributions towards the economic status of those countries.

Importance

Since time immemorial, date fruits have comprised a vital component of the human diet and a staple food for millions of people. Dates are also consumed by people as a religious practice and as nutritional therapy in different traditions around the world. Dates are good source of carbohydrates (fructose and glucose) constituting about 70–80%. Dates are rich source of essential minerals such as calcium, iron, magnesium, phosphorus, potassium, zinc, selenium and manganese which enhance their nutritional values (Elleuch, *et al*., 2008). Aqueous extracts of date have a potential antioxidant and anti mutagenic activity (Saafi*et al*., 2009). Dates also comprise a good source of vitamins, especially β-carotene, thiamine, riboflavin, niacin, ascorbic acid and folic acid (El Hadrami *et al*., 2011). Dates have potential to treat cardiovascular, cerebrovascular diseases and bacterial and fungal infections (Vayalil, 2012).

Botany

The mature tree of date palm reaches up to height 30 m, branches are absent on the trunk and it is the tallest among the Phoenix species. Date palm having a well-developed root system and also one terminal shoot apex responsible for linear growth. The leaves are arranged alternatively, pinnate and erect with a number of stiff leaflets. An adult tree contains about 100–120 leaves of about 3–6 m in length and forms the terminal rosette crown. Plant produces approximately 12 leaves in a year and each leaf having life span of 3–7 years. The leaf is very tough and needlelike, adaptations which may be to protect the growing tip against grazing animals during its early years of development and under drastic environmental conditions. Auxiliary buds are produced from the leaf axil that may be vegetative, floral or intermediate.

Flower biology

Female spath

Male spath

Date palm is a dioecious fruit plant in which male and female flowers are found in seperat plants and only female plant capable to produce fruits. Date palm flowers are small in size and white in color, richly branched, the spadix surrounded by a large single spathe. Three-toothed and cup-shaped calyx and petals are found in date palm flowers (El Hadrami and Al-Khayri, 2012). Flowers consist of three ovaries out of which only one develops into a fruit. Six stamens have a linear dorsifixed anther arrangement. Mode of pollination is anemophilous and artificial pollination is recommended to enhance productivity of date palm. Morphologically date palm fruit is considered in simple fruit and type of fruit is berry. The date fruit is usually in cylindrical shape, with a single elongated seed, variable in size, 2.5–7.5 cm long and 4 cm wide. Date palm fruit have fleshy sweet mesocarp covered with a thin epicarp, yellowish to reddish brown in color (Saker, 2011). Economic life of date palm plantation is about 50 years, subsequently yield decreases (Johnson *et al*., 2015).

Artificial pollination

Date palm requires artificial pollination for fruit set due to dioecious in nature. In date palm, generally the male flowers mature before female flowers by one week to two or three months, depending on cultivar and climatic conditions. Sometimes, male flowers does not open at the time of pollination due to unfavorable climatic condition (Hegland *et al*., 2009). At the time of early appearance of female spathes absence of adequate number of male spathes creates a problem for farmers in pollination of date palm. In such a case, farmers use pollen with unknown characteristics, since the source of pollen influence the quality and quantity of fruits. To overcome from this problem storage of pollen is necessary. Artificial pollination is a major practice in date palm production. Pollen powder require for pollination. For this firstly well develop male spath cut down and dry it under shade till the moisture reduces up to 10%. After drying pollen shed from male spike, sieve the shaded pollens and use them for pollination or store them for future use in freeze.

Hand pollination

In hand pollination 4-5 male flower of date palm place on female spathand tie this with a twine. After 10 days of pollination remove twine from female spath. This practice is very labor intensive and time consuming. Mostly farmer's use hand pollination techniques in various ways.

Inserting cotton ball

This is very common technique follow by farmers in many date palm growing areas. In this technique small cotton bolls impregnate in dry pollens and these balls insert in upper 1/3 portion of female spath. In this technique wind play a major role, when wind flow in different direction pollens shaded from cotton ball and pollinated to the oval of female spath. This technique is less labor intensive and pollen requirement also low as compare to the hand pollination.

Liquid pollination

In this technique required quantity of pollen mix in water. This suspension spray on female spath when they open. This technique make pollination too easy in date palm. Liquid pollination offers many advantages over current practice like ease of application, low costs, relatively low pollen requirements, and high fruit set resulting from more effective pollination. Low quantity of labor require for pollination purpose.

Mechanical duster

This method used in different foreign date palm growing countries. This technique use when large area cover in small time period. In this method more quantity of pollen and less number of person require. Wastage of pollen is more in this technique.

Hand pollination

Inserting cotton balls

Developing a pollination technique that results in an acceptable level of fruit set with a minimum amount of pollen grains and without a further need for thinning is critically required for date palm production, especially under arid conditions. Therefore, it is needed to find the best pollination technique for improving fruit setting percentage.

Liquid pollination

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POTATO CULTIVATIONUSING TPS (True Potato Seed)

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Potato is a high input crop and is traditionally cultivated through seed tubers. About 40-50 % of the total cost of production is needed to procure seed tubers. Constraints of poor availability of high quality seed tubers in adequate quantity and at reasonable cost, inadequate availability of important inputs like fertilizers, pesticides etc., coupled with lack of knowledge of the improved technologies for potato production and inadequate facilities for storing seed potatoes in north eastern states are the major reasons responsible for poor potato productivity. It is in this context that TPS (True Potato Seed) technology assumes potential as an alternative method of potato production that iseco-friendly, economically viable, scientifically sound and technically feasible to generate low cost and high quality planting material for enhancing the productivity, production and reducing the cost of potato cultivation.

Introduction

Potato is highly consumed tuber crops in all the section of society. Potato is a high input crop and is traditionally cultivated through seed tubers. But the major limitation in potato production is less availability of good tuber seed as a planting materials. It is in this context that TPS (True Potato Seed) technology assumes potential as an alternative method of potato production that iseco-friendly, economically viable, scientifically sound and technically feasible to generate low cost and high quality planting material for enhancing the productivity, production and reducing the cost of potato cultivation.

TPS (True Potato Seed)

True Potato Seed is the actual botanical seed which is produced by the sexual reproduction, and is formed inside the fruits/berries, resembling tomatoes. Once the flowering of potato has finished, TPS is formed occasionally. TPS is very cheap and efficient source of planting material for potato crops. When seed tubers used as planting material faces several problem such as high quality seed tubers, transplanting problem, virus infestation in seed tubers, high cost of seed etc. In early fifties, Dr. S. Ramanujan, the founder director of CPRI (Central Potato Research Institute) was developed potato rising from true potato seeds or botanical seeds in India. TPS C-3, HPS 1/13, HPS II/63, 92-PT-27 etc. are important varieties of TPS.

(a)

(b)

Figure 1:1(a) shows potato berries each can contain several hundred true potato seedsand **1(b)**shows true potato seeds

Importance of True Potato Seed

- Only 100 grams TPS seed is required for one hectare area while in case of potato seed tuber 2-2.5 tons are required.
- TPS is not requiring cold storage facility.
- It is absolutely diseases free seed material.
- TPS has more pests and diseases resistance than potato seed tuber.
- Transportation cost for TPS is negligible unlike seed tuber.
- Less cost of cultivation and more production per hector leads to more net profit.
- Low cost planting materials.

Methods of tuber production

i. Transplanting TPS derived seedlings

ii. Planting seedling tubers raised from TPS

Preparation of nursery bed for raising seedlings

Mark the nursery bed area keeping its breadth as 1m and length as per convenience. Beds may be separated by 80 cm wide pathway. Soil for nursery bed should be taken from a depth of 20-25 cm to avoid weeds and soil borne diseases. Mix the soil in 1:1 proportion with fully rotten FYM or compost. Add the basal dose of N, P and K at the rate of 13 gm urea, 75 gm SSP and 10gm MOP per square meter. Cover the top of nursery beds with half-inch thick layer of screened FYM. Make proper arrangements to protect nursery beds from direct rain and sunlight.

Sowing of TPS in nursery beds:

About 50 -100 gms TPS and around 375 square meter nursery bed area are required for producing enough seedling tubers for planting one hectare area in the next year. Soak the TPS in water for 24 hours, remove from water, and again soak in 0.2% Diathane M-45 solution for 15 minutes. Then air-dry the seed in shade for 2 hours. Mix the dried TPS with dry soil or sand or fine FYM. Spread the mixture evenly on nursery bed at a rate of 1-2 gms of TPS per meter square and cover it with half inch of the layer of FYM dust. Irrigate the nursery bed using a sprayer ensuring that the soil is kept moist without any runoff water. Keep the nursery bed open during day and night when germination starts. Foliar spray of 0.1% urea (one gram urea in 1 liter water) after 2-leaf stage is beneficial for quick growth and vigor of seedling. Seedlings are ready for transplanting in 30 days of sowing when it attains a height of 10-12 cm. Seedling must be transplanted before stolon initiation to avoid yield losses. Best time for raising TPS nursery is in the month of March (for summer crop) and July-August (for autumn crop).

Transplanting of Seedlings in the field:

Transplant seedling in field during afternoon only, to reduce damage due to water stress. Broad cast 60 Kg N/ha (130 kg urea) and full-recommended dose of P (750 kg SSP) and K (100 kg MOP) at the time of final land preparation for seedling transplants. If FYM application is done, first apply fertilizer mixture in furrows and then cover with FYM. Furrows should be 4-5 inches deep at 40cms apart and prepare irrigation channels as practiced in the region. Now Spray 0.2% Dursban/Chlorpyriphos 20EC (25 ml in 10 liters of water) or Endosulfan 35EC (20 ml in 10 liters of water) on fourth day to protect seedlings from cutworms. Do weeding after 25-30 days of transplanting depending upon the intensity of weeds and perform the earthing up operation and also apply ¼th dose of recommended Nitrogen i.e., 30 Kg N/ha (urea 65 kg/ha). Care should be taken to cover maximum nodes with soil leaving the top 5-6 leaves open in the air. Final dose of N (30Kg/ha) is applied at 2nd earthing up which is performed after 25-30days of first earthing up operation. Dehaulm the crop 10-15 days prior to harvest and allow the skin to harden. Harvest the crop after 110-120 days. Produce should be graded and small to medium sized tuber should be retained as the planting material for the subsequent season. Large size tuber, however, could be used for table purpose.

Plant protection measures

Control of insect pests:

Occasionally cutworms and defoliators damage the crop particularly during the dry season. If cut worm appear in significant numbers drench the ridges with Chlorpyrifos (Dursban) 20 EC @ 2.5/hectare in 800-1000 liters water. For controlling defoliators and leaf eating caterpillars, spray the crop with carbaryl @ 2.5 kilogram/hectare in 1000-1200 liters water. If needed, additional sprays should be given. Chlorinated hydrocarbon insecticides (e.g. Heptachlor, Aldrin) dust should not be applied because of residual toxicity problems. Potato tuber moth (PTM) damages the potato both in the field and in the store. To control tuber moth in the standing crop, spray the crop with carbaryl @ 2.5 kilogram/hectare in 1000-1200 liters water. In Country stores, the tubers should be covered with dried and chopped leaves of Lantana or Eucalyptus plant for protecting them from the attack of potato tuber moth.

Control of fungal and bacterial diseases:

In the North- eastern hill region, fungal diseases such as late blight homa and early blight damage the potato severely. To control them, periodic sprays with 0.2% solution of mancozeb at 8-10 days interval should be given from mid-May. While spraying, it should be ensured that the lower surface of the foliage is thoroughly drenched with the fungicide solution particularly when sprayings are done during rainy days. Brown rot is another important disease in North-eastern hill region. Infected seed tubers and soil are the primary sources of infection carrying the disease from one season to another. It is, therefore, important that healthy seed, free from brown rot infection, is used for planting. Severity of the disease can be reduced by planting the crop between the second weeks of February to first week of March and harvesting before first week of June. Apply bleaching powder 12 kilogram/hectare mixed with fertilizer at planting.

Haulms killing:

Irrigation is stopped 10 days before haulms killing in the valley / low hills. Haulms should be killed with gramaxone @ 3 litre/hectare by 15-20th August in hills and 25th December to 15th January in valley depending upon the date of planting in the region. Crop should get a duration of 80-90 days before dehaulming. Exposed tubers should be covered with soil immediately after haulms killing. Crop should be harvested 10-15 days after dehaulming. This will allow hardening of tuber skin.

Harvesting:

Crop is harvested 10-15 days after haulms cutting for allowing hardening of skin of potato tubers to prevent disease infection through skin. Harvesting should be carried out on bright sunny days. Tubers may be kept for 15 days in the shade for further hardening of the skin. Remove the cut/crack/bruised and damaged tubers.

Grading of produce:

Grading of produce is important because of marketing purpose and also for giving uniformity to the next emerging crop. Produce is graded into four grades i.e. large (>150 in hills), medium (80-125 grams), seed size (40-80 gram) and small (20-40 grams).

Storage

TPS was extracted at normal temperature (25°C) with low relative humidity from dried berries. By storing seed from several months to few years (2 years) can retain their viability and at 4° C without losing germination ability in low relative humidity condition. Dormancy period of TPS is longer than tuber potato. Dormancy period of TPS hold from 4 to 9 months but it can be broken by gibberellic acid treatment.

Availability of TPS

- For TPS ordering through DD (Demand Draft) on following Address-
  Vegetable Seed Production Officer, Horticultural Research complex,
  Nagicherra, Agartala, Tripura (West), Pin - 799004. Phone-(0381)-2400068.
    - TPS rate-In India @ Rs. 16,000/kg and for abroad @ 650 US $/kg

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PRODUCTION TECHNOLOGY OF AZOLLA AS A FODDER CROP

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Azolla is a water fernhaving short sized, free floating branched stem and roots hanging down in the water.Azolla is grown on water surface as green fodder. Importance of Azolla cultivation among farmers are based on their ability to fixing nitrogen in paddy field and enriching nutrients in fodder feed of livestock. Due to this azollacan be used as green manure and bio-fertilizerin paddy crops.A symbiotic relationship of azolla with BGA (blue green algae) is complete the process of nitrogen fixation in paddy fields. Cultivation of azolla can be done in ditches, ponds and warm- temperate and tropical regions of worldwide rice fields.A dairy farmer can get additional income by using azolla as an excellent fooder feed for livestock, fish and poultry and also increased milk production.

Introduction

Azolla is a highly productive plant. It belongs to the group of ferns. The plant are very small and float on surface of water by means of numerons, small closely overlapping scal like leaves with roots having in water. Azolla cultivation helps the farmer to reduce the cost of Livestock Feed supplement and it is useful to feed supplements for livestock, poultry, and fish. It is rich in protein, amino acid, vitamin & minerals.Eight species of Azollasuch as; *Azollapinnata, Azolla japonica, Azolla Mexicana, Azollacaroliniana, Azolla microphylla, Azollacircinata, Azollanilotica and Azolla Rubra* are grown worldwide.

Importance of Azolla cultivation

- Cultivation of azolla can be done in ditches, ponds and warm- temperate and tropical regions of worldwide rice fields.
- Reduce cost of fodder by adding excellent nutritional supplements.
- It can make a symbiotic relationship with BGA (blue green algae) for nitrogen fixation in paddy fields.
- It can be used as green manure and bio-fertilizer in paddy crops.
- Easily digestible by livestock because of high protein and low lignin content.
- Poultry bird grew faster and 10-12% increase by weight.
- Less investment gives more profit.
- It is rich in protein, amino acid, vitamin & minerals.

Relevance of the problem

- Increase feed cost as well as decreasing nutritive value of the fodder available to the cattles.

- Lack of fodder crops during the period of 4-5 months.
- Can full fill the nutritive demands of the cattles.
- Easy to cultivate by small and marginal farmers.
- Also used as a biofertilisers and fixes N_2 in the rice fields.

Nutritional composition ofAzolla

As follows-

- Protein (25-35%),
- Calcium (67 mg/100g)
- Iron (7.3 mg/100g)

Table: comparative analysis of protein content and biomass of Azolla with other fodders

Sl.No.	Fodder crops	Production of biomass (MT/ha/year)	Dry matter content (MT/ha)	Protein content (%)
1	Hybrid Napier	250	50	4
2	Kolakattao grass	40	8	0.8
3	Lucerne	80	16	3.2
4	Cowpea	35	7	1.4
5	Subabool	80	16	3.2
6	Sorghum	40	3.2	0.6
7	Azolla	1,000	80	24

(Source:Dr P Kamalasanan *et al*. 2004)

Pre-requisite condition for azolla cultivation

- Maintain 10cm water level.
- Choose shady place.
- Put fertile soil on 30 days interval.

Materials required per pond preparation–

- Plastic sheet (25m X 3m) and Agro net
- Healthy Azolla culture (500 gm.) and Fertile soil
- Fresh cow dung (Cowdung : water=1:2) and SSP (100gm)

Procedure for pond preparation-

- Prepare a pit of dimension 2 x 1.5 x 0.25m and lay plastic sheet.
- Spread fertile soil in thin layer in pond over the plastic sheet.
- Fresh cow dung slurry is added to soil after sieving.
- Make 7-10cm standing water.
- Add 500gm healthy Azolla.
- Sprinkle 1-2 lit. Water over Azolla in order to make roots intact.
- Split 100g SSP in 3 parts (30-35g). Add one part in initial stage and rest 2 parts at 4 days interval.

Figure: Azolla Cultivation in pond

Maintenance of pond in Azolla cultivation

Application of 100 -120 gm of super phosphate and 1 kg of cow dung is used for better growth and maintenance of azolla is required once in 2 weeks. Complete removal of weeds from pond on regular interval.Cultivation of azolla should be done with fresh culture and soil in emptied pond at every 6 to 8 months interval.

Azollacultivationharvesting and feeding

After 2 to 3 weeks when stalling the culture will appeared in pond, then azolla will be harvested. At the daily basis azolla can be harvested after its attaining full growth stage. Ponds surface biomass should be harvested by using of plastic sieves. The average yield of 4 feet x 6 feet pond size is one kg/day of fresh azolla. These harvested fresh Azolla can be used as a direct feed or mixed with other nutrients to livestock such as poultry, cattle, goats, sheep, rabbits and pigs. Dried azolla can also be used as feeding components in livestock production. Azolla washed with clean water before feeding to livestock. A dairy farmer can get additional income by reducing use of concentrate feed for livestock and increased milk production by using azolla as feed.

Precautions

- Use contamination free fresh culture of Azolla.
- Avoidance of overcrowding in Azolla shall be done by harvesting at regular interval.
- Sprinkle water over Azolla in order to make roots intact.
- Optimum temperature for Azolla cultivation should be around 35°C.
- Adequate sunny places is preferablecultivation.
- Adequate pH should be ranging from 5.5 to 7.
- Use nylon net to remove excess water from pond.

Azolla cultivation economics

The pond preparation cost of Azolla cultivation is depend upon labour, bricks and other element costs. Generally, the pond of plastic sheet sized 6 feet x 4 feet incurred costs

Rs.2000. A farmer can get additional income by reducing use of concentrate feed for livestock and increased milk production amounting over Rs.10, 000/year.

Limitations in Azolla cultivation

Azolla dies in case of lack of water, higher summer temperatures, extreme lower temperature, low humidity, poor quality of waterand less awareness among farmers can affect its growth and cultivation.

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PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR) AS BIOFERTILZER

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Introduction

Rhizobacteria are the bacteria linked to the root system having symbiotic relationships with many plants. It is made up of Greek word *rhizo*, meaning root. Rhizobacteria are often known as plant growth-promoting rhizobacteria, or PGPRs. PGPRs have different relationships with different species of host plants. Plant growth promoting rhizobacteria are of two types rhizospheric and endophytic. Rhizospheric bacteria mainly colonize on the surface of the root, or superficial intercellular spaces of the host plant and sometimes forms root nodules. Bacteria that grows and reside inside the host plant or in apoplastic space are called endophytic bacteria. These beneficial bacteria improves the physical, chemical and biological properties of soil. Presence of these can enhance plant defense system, nutrient uptake capacity and various metabolic processes. Microbes like bacteria, fungi, actinomycetes, protozoa and algae are dominant in rhizospheric region in soil. But bacteria are the dominant microorganism present in soil.Plant Growth Promoting Rhizobacteria (PGPR) are a group of bacteria that promote and enhance plant growth and yield by secretion of various plant growth promoting substances and act as bio fertilizers. In order to supplement soil with essential nutrients so many chemical fertilizers are used. These chemicals may prove harmful to the environment, thus using microbes as bio fertilizer is a viable option for improving the fertility of soil.

Importance of PGPR as biofertilizer in sustainable agriculture

PGPR plays an pivotal role in mushrooming plant growth through a wide variety of mechanisms. The mode of action of PGPR that promotes plant growth includes (i) abiotic stress tolerance in plants; (ii) nutrient fixation for easy uptake by plant; (iii) plant growth regulators; (iv) the production of siderophores; (v) the production of volatile organic compounds; and (vi) the production of protection enzyme such as chitinase, glucanase, and ACC-deaminase for the prevention of plant diseases (Vegan et al 2016). PGPR can prove a major component of crop production. PGPR are known to improve plant growth in many ways when compared to synthetic fertilizers, insecticides and pesticides. They enhance crop growth and can help in sustainability of safe environment and crop productivity. The rhizospheric soil contains diverse range of PGPR communities, which have potent beneficial effects on crop productivity.Some common examples of PGPR genera exhibiting plant growth promoting activity are: *Pseudomonas, Azospirillum, Azotobacter, Bacillus, Burkholdaria, Enterobacter, Rhizobium, Erwinia, Mycobacterium, Mesorhizobium, Flavobacterium, etc.*

1. **Nitrogen fixation**

Nitrogen fixation is the process of conversion of atmospheric nitrogen (N_2) into utilizable nitrogen that changes to ammonia.Nearly about two third of the nitrogen is fixed by the process of Biological nitrogen fixation. There are two methods of symbiotic nitrogen fixation 1) by symbiotic interection and 2) by non symbiotic interaction. Symbiotic PGPR, which commonly fix atmospheric N_2 in soil, include strains of *Rhizobium sp., Azoarcus sp., Beijerinckia sp., Pantoea agglomerans*, and *K.* pneumoniae (Goudaa *et al*., 2018). All the nitrogen fixing microbes have nitrogenase enzyme in them. Non symbiotic nitrogen fixer includes *Azospirillum spp., Azotobacter spp., Psedomonas* sp. etc.

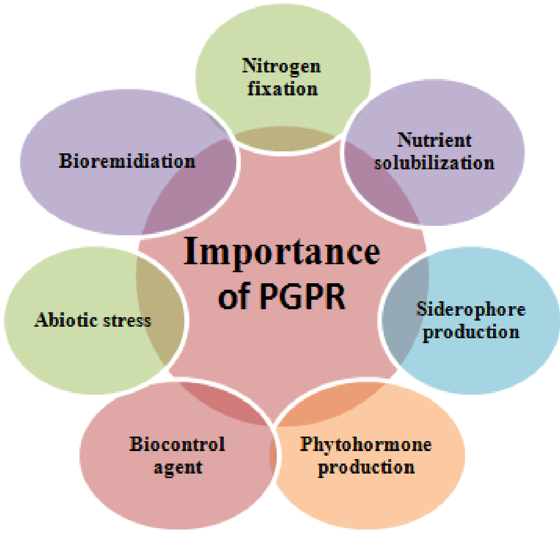

Fig. 1. Importance of PGPR

2. Phytohormones Production

The enhancement in various agronomic yields due to PGPR has been reported because of the production of growth stimulating phytohormones, such as indole-3-acetic acid (IAA), gibberellic acid (GA3), zeatin, ethylene and Abscisic acid (ABA).

Phytohormones	**PGPR**
Indole-3-aceticacid (IAA)	*Acetobacter diazotrophicus*and *Herbaspirillum seropedicae*
Zeatin and ethylene	*Azospirillum sp.*
Gibberellic acid (GA3)	*Azospirillum lipoferum*
Abscisic acid (ABA)	*Azospirillum brasilense*

3.Phosphate Solubilization

Phosphorus (P) solubilizing bacteria are important to plant nutrition. Phosphorous is second most important nutrient essential for plant. It is necessary for root growth of plant, ATP production, nucleic acid and growth of plant. Phosphorous availability is increased in soil either by mobilization or solubilization. Phosphorous solubilizing bacteria are*Arthrobacter, Bacillus, Beijerinckia, Burkholderia, Enterobacter, Microbacterium Pseudomonas, Erwinia, Rhizobium* and *Mesorhizobium* (Oteino *et al*., 2015).These bacteria secrete different types of organic acids (e.g., carboxylic acid) thus lowering the pH in the rhizosphere and consequently release the bound forms of phosphate like $Ca_3(PO_4)_2$ in the calcareous soils. Utilization of these microorganisms as environment-friendly biofertilizer helps to reduce the use of expensive phosphatic fertilizers.

4. Siderophore Production

PGPR are reported to secrete some extracellular metabolites called Siderophore. Siderophore are commonly referred to as microbial Fe-chelating low molecular weight compounds. The presence of Siderophore- producing PGPR in rhizosphere increases the rate of Fe^{3+} supply to plants and therefore enhance the plant growth and productivity of crop. Further, this compound after chelating Fe^{3+} makes the soil Fe^{3+} deficient for other soil microbes and consequently inhibits the activity of competitive microbes.

5. PGPR as Bio control Agents

PGPR produce substances that also protect them against various diseases. PGPR may protect plants against pathogens by direct antagonistic interactions between the biocontrol agent and the pathogen, as well as by induction of host resistance. **PGPR** helps in synthesis of various lytic enzymes which reduces the deleterious effects of plant pathogens on the growth . Chitinases, cellulases, 1, 3-glucanases, proteases, and lipases secreted by the plants can lyse a portion of the cell walls of many pathogenic fungi. PGPR induces systemic response in the plants when any pathogen attacks on it. Induced systemic response (ISR) is not specific against particular pathogen but helps the plant to control diseases. ISR involves jasmonate and ethylene signaling within the plant and these hormones stimulate the host plant's defense responses to a range of pathogen. Rhizobacteria also act as bio control agents of weeds that can colonize plant root surfaces and are able to suppress plant growth. Cyanide being toxic is produced by most microorganisms including bacteria, algae, fungi and plants as a means of survival by competing with the counterparts. Generally there is no negative effect on the host plants by inoculation with cyanide-producing bacterial strains and host-specific Rhizobacteria can act as biological weed control agents. HCN which is usually synthesized by Pseudomonas and Bacillus species.

6. Bioremediation

Bioremediation is a technique to remediate or immobilize the nutrients by help of living orgsnisms. Microbes can immobilize or convert the harmful chemicals into non toxic for.in process of completing their metabolic functions. PGPR as tools for bioremediation is the need of present era. Microbial species, such as Pseudomonas aeruginosa, genetically engineered Pseudomonas fluorescens, and certain Bacillus species can degrade harmful and resistant hydrocarbon molecules. Pseudomonas putida and Pseudomonas fluorescens can neutralize the toxic effect of cadmium pollution on barley plants due to their ability to scavenge cadmium ions from soil.

7. Abiotic stress

Abiotic stress (high wind, extreme temperature, drought, salinity, floods etc.) are the major threats to the crop production. . Aridity stress imparted by drought, salinity, and high temperature is the most dominant abiotic stress limiting plant growth and productivity (Vejan *et al*., 2016). Tolerance to this stress is multigenic and quantifiable in nature, and includes accumulation of certain stress metabolites, such as poly-sugars, proline, glycine-betaine, abscisic acid, and upregulation in the synthesis of enzymatic and nonenzymatic antioxidants, as superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), glutathione reductase, ascorbic acid, αtocopherol, and glutathione. Apart from these, several other strategies that alleviate the degree of cellular damage caused by water stress and improve crop tolerance include exogenous application of PGPR in compatible osmolytes, such as proline, glycinebetaine, trehalose, etc., which has gained considerable attention formitigating the effect of stress.

Conclusion

Considerable progress has been achieved in the area of PGPR bio fertilizer technology. For replenishing the nutrients in available and mineralizable form PGPR are the best option. It has been also demonstrated and proved that PGPR can be very effective and are potential microbes for enriching the soil fertility and enhancing the agriculture yield. PGPR have good impact in terms of biofertilization, biocontrol, phytohormone production, abiotic and biotic stress management and bioremediation. It exerts a positive influence on crop productivity and ecosystem functioning and its encouragement should be given and progressed to its implementation in agriculture.

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Biochar: OPPORTUNITIES KNOCK FOR SUSTAINABLE AGRICULTURE

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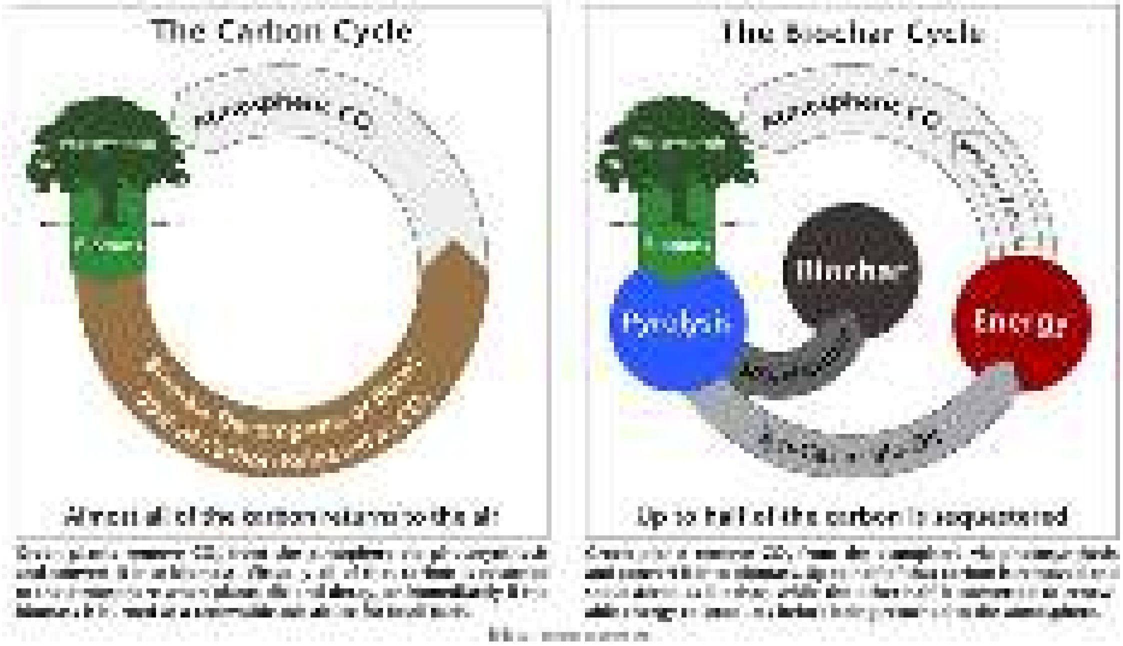
Introduction

Now a day's agriculture is the back bone of many countries, production as well as security of good quality food, fiber and any other agricultural commodity without reducing soil quality is main goal for development of country. In the last few decades, awareness about health, social and environmental issues have increased due growing of crop without proper management of soil. For solving this problem, we need to develop more sustainable agriculture systems and improve economic status of rural farmer is a major change in agriculture management. Soil degradation, including decreased fertility and increased erosion, is a major concern in global agriculture, and particularly in subtropical and tropical areas. Intensive as well as long-term cultivation of soils could result in soil degradation, containing soil acidification, soil organic matter depletion, and severe soil erosion. Resulted decrease aggregate stability of soil. Therefore, it is critical to recover the degraded soils by simple and sustainable methods. This 2,000 year-old practice converts agricultural waste into a soil enhancer that can hold carbon, boost food security, and increase soil biodiversity, and discourage deforestation. The process creates a fine-grained, highly porous charcoal that helps soils retain nutrients and water. Biochar is found in soils around the world as a result of vegetation fires and historic soil management practices. Biochar also improves water quality and quantity by increasing soil retention of nutrients and agrochemicals for plant and crop utilization. More nutrients stay in the soil instead of leaching into groundwater and causing pollution.

Manures and composts contain pathogens, heavy metals, and other toxins, which may cause long-term contamination of farmland. Moreover, manures and composts have the potential to lossof ammonia and methane by volatilization process, which can increase global warming and serious groundwater and stream nutrient pollution. Therefore, we need a alternative method which was more effective then organic manure and compost with safety of environment.

So, now a day's biochar is best alternative because of it is a renewable resource, economically viable and environmentally sustainable. Biochar is a promising resource for soil's fertility management. The main properties of biochar are the following: high surface area with many functional groups that increase the nutrient retention capacity of biochar, high nutrient content, and slow-release fertilizer. Biochar also loaded with ammonium, nitrate, and phosphate could be also proposed to be a slow-release fertilizer to enhance soil fertility with improving soil structure as well as aggregate stability.



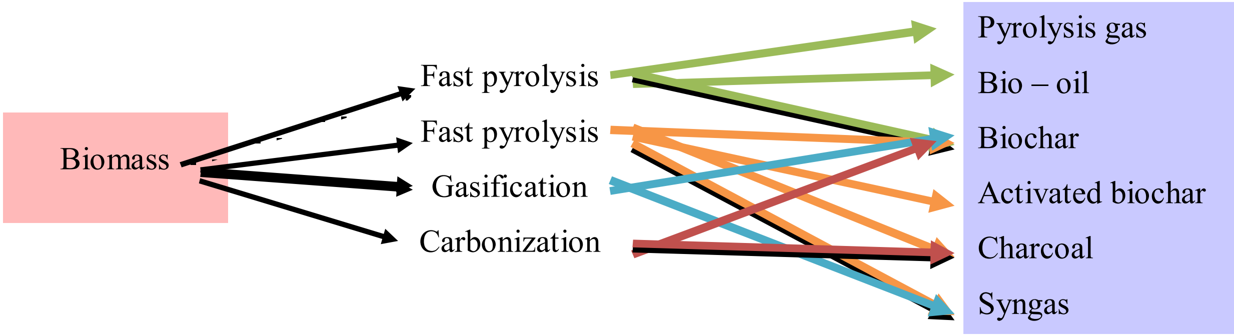
What is biochar: -

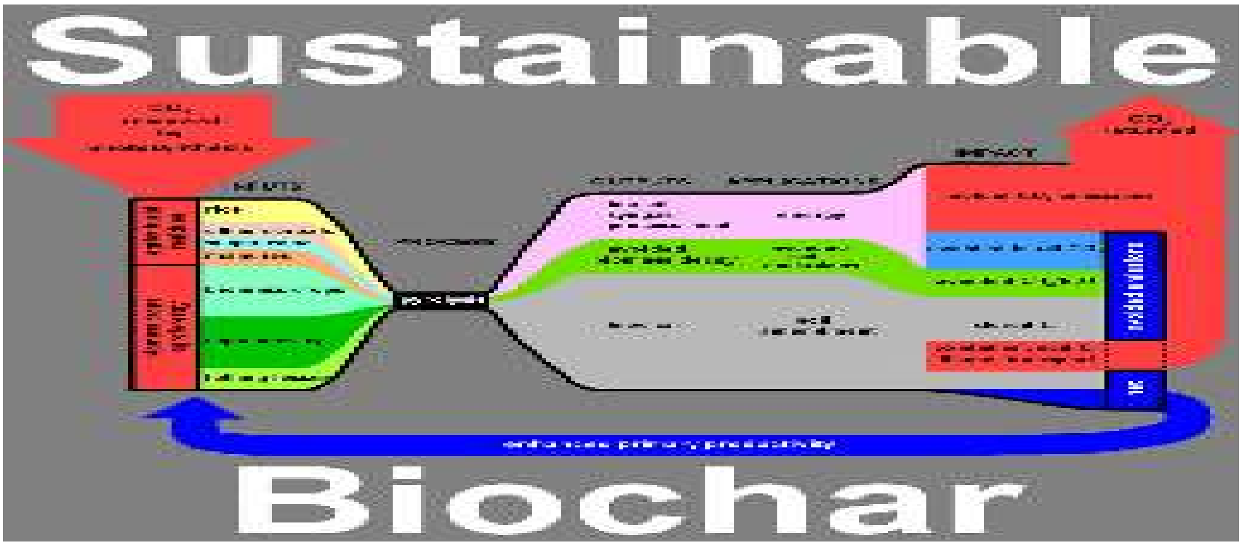
Biochar is a charcoal-like substance produced from agriculture and forest wastes throughout the pyrolysis process under high temperature (450-500). It contains high active carbon (70%) that is produced through anaerobic heating of biomass and the remaining elements are hydrogen, oxygen and nitrogen. It is used as soil enhancer to increase fertility, prevent soil degradation and to sequester carbon in the soil. It improves soil fertility by retaining water and nutrients in soil, encouraging beneficial soil organisms and therefore minimize the need of additional use of fertilizers. Biochar can store carbon in the soil for as many as hundreds to thousands ofyears. So, it is store house of carbon in soil.

Process of biochar production (Pyrolysis):

Biochar technology is different from the conventional charcoal production because it is highly efficient in the conversion of carbon with free from harmful pollutants during combustion. Hence, it is a cleaner and more efficient technology. If this technology is used sustainably, the by-products in the form of oil and gas can substitute for a cleaner and renewable fuel option. Biochar can be produced at small as well as large scales. Small scale production done at low cost through simple pyrolysis technics using modified stoves and kilns.While in case of large scale production, larger pyrolysis plants and adequate feed stocks are required which is more capital cost intensive. The main quality of biochar is its carbon-rich fine-grained, highly porous structure and increased surface area that makes it an ideal soil amendment for carbon sequestration.

The intensity of pyrolysis determines the product and by-product obtained from the process. In case of slow process of biochar production more biochar produce then by-product while, in case of fast pyrolysis at high temperature more by-product is produced such as bio-oil and syngas. The by-product(syngas and bio-oil) are clean and which can be used for producing heat, power or combined heat and power.





Advantages

- Use of locally available feedstock reduces dependence on fossil fuel.
- Use of biochar also environmentally safe because it produces less air pollutants.
- Sufficient amounts of carbon can be sequestered for a long period of time.
- During manufacturing of biochar, sufficient amount of heat and gases can be store which can use to produce energy.
- It also reduces the dependency on fertilizer that minimize the cost of cultivation.
- The application ofbiocharin soil enhanced nutrient use efficiency, water holding capacity, and microbial activity.
- The application of biochar increases the yield of crop that improve financial status of farmer.
- Biocharcan be used for forestry management and hence wildlife habitat conservation.
- Farmers can get additional income through collection and sale of Agri-residues for production of biochar.
- Revenue can be generated through carbon trading.

Disadvantages

- It also helps the growth of undesirable weeds.
- The cost involve in biochar production are high when it is produced on large scale.
- The applications of biochar sometimes cause the nutrient imbalance in rhizosphere.

Conclusion: -

From ongoing discussion, it can be concluded that application of biochar in soil improve overall properties of soil such as soil fertility, organic carbon, reduce soil degradation by improving soil aggregate stability, use as a amendment and it is also a efficient technic of residue management without toxic by-product with sustainability for longer time. Biochar is a source of active carbon with some amount of hydrogen, oxygen and carbon which can make it store house of carbon in soil for thousands of the year. The biochar also loaded with nitrogen and phosphorus to make it enriched biochar to increase crop production.

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APPLICATION OF BIOINFORMATICS IN CROP IMPROVEMENT AND SUSTAINABLE DEVELOPMENT

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Recent advancements in DNA/RNA sequencing technologies have produced a hugeamount of biological data. Deriving inferences from these biological data requires sophisticated computational tools, software and databases. For that purpose, need a subject called as Bioinformatics, which is an interdisciplinary field which consists of biological science, computer science, Information technology, mathematical science and statistics. The importance of this newly developed field will grow continuously because the development of high throughput sequencing technology and generation of huge amount of genomic, proteomic, and other types of biological data. Bioinformatics act as an interface between modern biological problem and new informatics solution which involves development of software tools and computational algorithms that enables in understanding of the biological processes with the objective to solve primarily agricultural research problem. So, bioinformatics plays a prime role in the betterment of the farming sector, agro-based industries, livestock production, poultry and fishery production, agro-by-products utilization as well as better environmental management.

Introduction

In past few decades, major advances in DNA sequencing technologies, have led to an explosive growth in the biological data generation. A genome of an organism is a complete set of DNA, including all of its genes. The sequencing of the plants and animals genomes will provide enormous benefits for the agricultural community. The understanding of biological information leads to efficient utilization of plants as biological resources in the development of new cultivars with improved quality in terms of reduced economics and environment costs. Primary interest of traits like pathogen, abiotic stress resistance, quality traits for plants and reproductive traits, which determining yield are essential factor in crop improvement. Bioinformatics is an emerging interdisciplinary field of science and technology to addressing biological data collection and warehousing, database searches, data mining, analyses and interpretation, modelling and product designing which leads to crop improvement and sustainable development.

Bioinformatics and its Scope

Bioinformatics is an inter disciplinary field comprising of computer application, information technology, mathematical science and statistics to solve complex problems of biological sciences for crop improvement. After completion of large genome sequencing projects such as human, plants and microbes huge amount of biological data are generated. Development of Bioinformatics software tools and data base to store, manipulate, analyse and interpretation in useful manner through data warehousing and data mining. These biological data include complete genomes of biological species, Nucleotide sequences, EST sequence, protein sequences, protein 3D structures, Expression data and metabolic pathways data.

Divisions of Bioinformatics

Different division of bioinformatics as the 'Omics' refer to different branches given below.

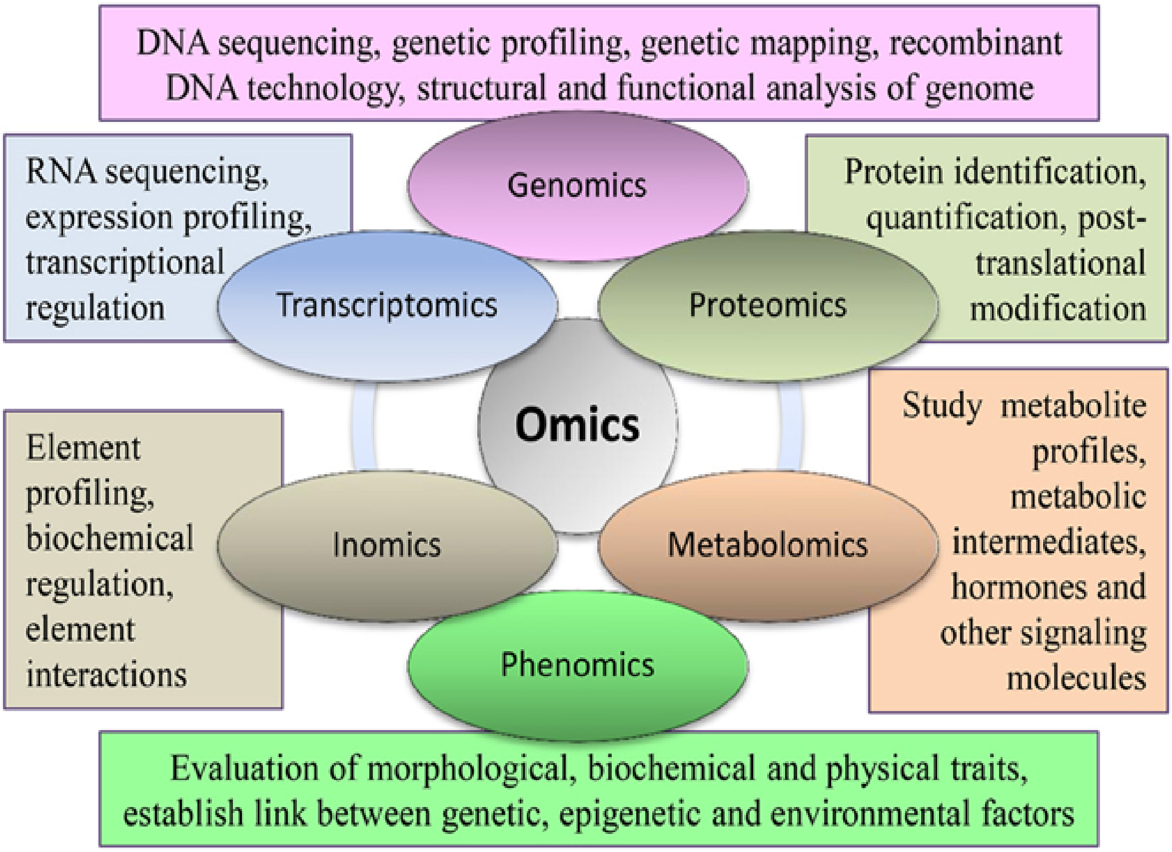

Figure 1. Different bioinformatics division with their scope (Source- Deshmukh *et al.* 2014)

Bioinformatics Database, Software and Tools

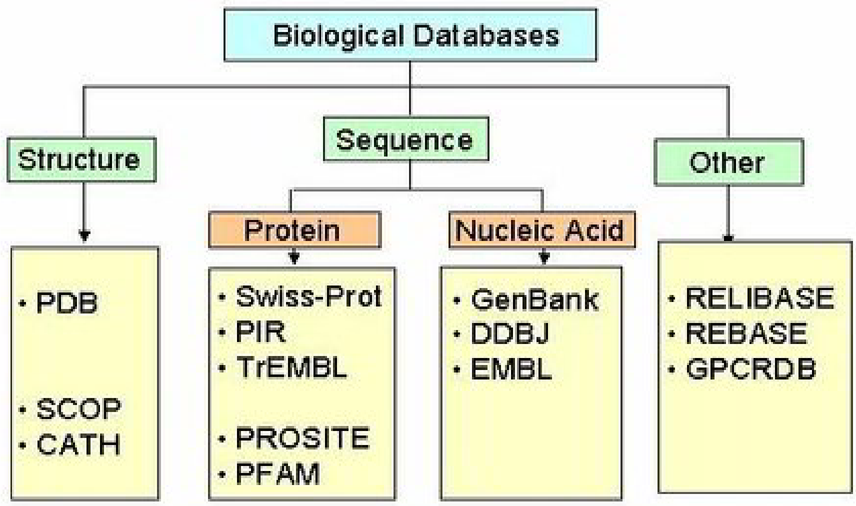

Figure 2. Different primary Biological databases

Database Name	Web Link
autoSNPdb	http://autosnpdb.appliedbioinformatics.com.au/
Brachypodiumdatabase	http://www.brachypodium.org/
Brassica rapagenome database	http://brassicadb.org/
DNA Data Bank of Japan (DDBJ)	http://ddbj.sakura.ne.jp/
European bioinformatics institute, EnsEMBL plants	http://plants.ensembl.org/
European Molecular Biology Laboratory (EMBL) nucleotide sequence database	http://www.ebi.ac.uk/embl/
GenBank	http://www.ncbi.nlm.nih.gov/genbank/
Graingenes	http://wheat.pw.usda.gov/
Gramene	http://www.gramene.org/
International Crop Information System (ICIS)	http://www.icis.cgiar.org
International Nucleotide Sequence Database Collaboration (INSDC)	http://www.insdc.org/
Legume Information System (LIS)	http://www.comparative-legumes.org/
MaizeGDB	http://www.maizegdb.org/
Maize sequence database	http://www.maizesequence.org/
Oryzabase	http://www.shigen.nig.ac.jp/rice/oryzabase/
Panzea	http://www.panzea.org/
Phytozome	http://www.phytozome.net/
PlantsDB	http://mips.helmholtz muenchen.de/plant/genomes.jsp
PlantGDB	http://www.plantgdb.org/
The Plant Ontology	http://www.plantontology.org/
Plaza	http://bioinformatics.psb.ugent.be/plaza/
Rice Genome Annotation Project	http://rice.plantbiology.msu.edu/
SSR Primer	http://flora.acpfg.com.au/ssrprimer2/
SSR taxonomy tree	http://appliedbioinformatics.com.au/projects/ssrtaxonomy/php/

Figure 3. Genomic databases related to Crop improvement (Source-Kushwaha *et, al*. 2017)

Role of Bioinformatics in Crop improvement and Sustainable development

Bioinformatics is an interdisciplinary field which is also widely used in different types of agricultural huge amount of data in their collection, collation; analysis and interpretation. Role of bioinformatics also help in development of drought resistant varieties, insect pest resistant crops, improved nutritional quality, efficient biomass energy production and disease resistant crops. Various role of bioinformatics as follows:

a) In crops improvement

Comparative genomicscan studythe complete plant genome to understand the organization of their genes for transferring information from one crop systems to other crops for crop improvement. Examples of complete model plant genomes such as water cress *(Arabidopsis thaliana*) and rice (*Oryza sativa).*

b) Renewable energy conservation

Obtaining renewable energy from plant biomass through converting into biofuels (ethanol) used by vehicle and airplanes as a fuel. Plant resources such as switch grass, maize (corn) and lignocelluloses species like bagasse and straw are the best plant biomass resources for biofuel production. Bioinformatics tools helped in sequence variants detection of plant biomass species to maximize biomass production and recalcitrant finding.

c) Insect resistant crop development

Development of insect resistant crops of cotton, potato and maize to reduce insecticidal use during insect pest outbreak by transferring *Bacillus thuringiensis* genes into these crops known as Bt crops.

d) Nutritional quality improvement

Bioinformatics tools helped in transferring genes to incrementing vitamin A level in golden rice which useful in reducing vitamin A deficiencies.

e) Development of drought resistant and poor soil condition growing varieties

Bioinformatics can help in analyzing data related to tolerance problem of crop with iron toxicities, soil alkalinity and reduced water conditions. Because these data are in huge amount which are required to study for intensive crop research.

f) Improvement in breeding techniques

Genomics is the branch of bioinformatics which used in generating biological resources for the development of improved quality new cultivar with reduced environmental and economic costs. These generated biological data can be used to develop new breeding techniques such as Marker assisted selection and genomic selection for crop improvement.

g) Microbial effect on crop improvement

Metagenomics and transcriptomics are the branches of bioinformatics which help in understanding of the genetic architecture of pathogens and microbes in host plant relationship.

h) Crop improvement in adverse climate

Adverse climate change will create a pressure on farming sector to produce and feed growing population. Advances in genomics will help in studying the agronomic traits related genomic data for use in breeding techniques remains a challenge and require better coordination of diverse skills and expertise.

i) Plant disease management

Bioinformatics will help in studying and understanding disease genetics, host pathogen interactions and pathogenicityof a pathogen which enable in designing best plant disease management practices.

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CONSERVATION AGRICULTURE: A NEW CONCEPT FOR SOIL HEALTH IMPROVEMENT

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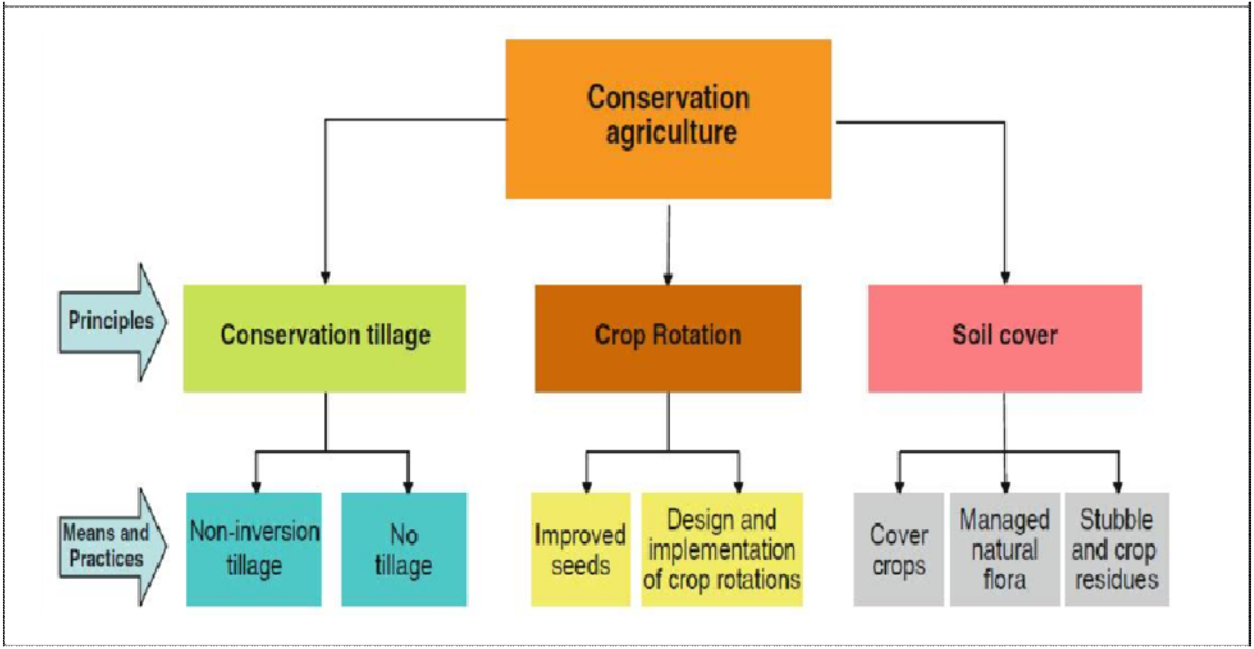
Conservation Agriculture (CA) is defined as a sustainable agriculture production system comprising a set of farming practices adapted to the requirements of crops and local conditions of each region, whose farming and soil management techniques protect the soil from erosion and degradation, improve its quality and biodiversity, and contribute to the preservation of the natural resources, water and air, while optimizing yields.

Agronomic practices included in CA are based on three core principles, which must be fulfilled concomitantly:

- Minimum soil disturbance.
- Maintenance of permanent soil covers.
- Cropping system diversity, crop rotations.



Advantages of Conservation Agriculture

Conservation agriculture is generally a "win-win" situation for both farmers and the environment. Yet many people intimately involved with worldwide food production have been slow to recognize its many advantages and consider it to be a viable alternative to conventional agricultural practices that are having obvious negative impact on the environment. Much of this has to do with the fact that conservation agriculture requires a new way of thinking about agricultural production in order to understand how one could possibly attain higher yields with less labor, less water and fewer chemical inputs. In spite of these challenges, conservation agriculture is spreading to farmers throughout the world as its benefits become more widely recognized by farmers, researchers, scientists and extensionists alike.

Specifically, conservation agriculture (CA) increases the productivity of:

- **Land** - Conservation agriculture improves soil structure and protects the soil against erosion and nutrient losses by maintaining a permanent soil cover and minimizing soil disturbance. Furthermore, CA practices enhance soil organic matter (SOM) levels and nutrient availability by utilizing the previous crop residues or growing green manure/ cover crops (GMCC's) and keeping these residues as a surface mulch rather than burning. Thus, arable land under CA is more productive for much longer periods of time.
- **Labor** - Because land under no-till is not cleared before planting and involves less weeding and pest problems following the establishment of permanent soil cover/crop rotations, farmers in Much of the reduced labor comes from the absence of tillage operations under CA, which use up valuable labor days during the planting season.
- **Water** - Conservation agriculture requires significantly less water use due to increased infiltration and enhanced water holding capacity from crop residues left on the soil surface. Mulches also protect the soil surface from extreme temperatures and greatly reduce surface evaporation, which is particularly important in tropical and sub-tropical climates.
- **Nutrients** - Soil nutrient supplies and cycling are enhanced by the biochemical decomposition of organic crop residues at the soil surface that are also vital for feeding the soil microbes. While much of the nitrogen needs of primary food crops can be achieved by planting nitrogen-fixing legume species, other plant essential nutrients often must be supplemented by additional chemical and/or organic fertilizer inputs. In general, soil fertility is built up over time under conservation agriculture, and fewer fertilizer amendments are required to achieve optimal yields over time.
- **Soil biota** - Insect pests and other disease causing organisms are held in check by an abundant and diverse community of beneficial soil organisms, including predatory wasps, spiders, nematodes, springtails, mites and beneficial bacteria and fungi, among other species. Furthermore, the burrowing activity of earthworms and other fauna create tiny channels or pores in the soil that facilitate the exchange of water and gases and loosen the soil for enhanced root penetration.

How and Why Conservation Agriculture Works

To better understand how and why the system works to enhance and sustain agricultural production while conserving natural resources, we should consider each of the essential features of conservation agriculture one by one. These include:

- **Maintaining permanent or semi-permanent soil cover**. Plants are left growing or killed and their residues left to decompose *in situ*. The primary function of this is to protect organic matter-enriched topsoil against chemical and physical weathering. Plant residues intercept energy from falling raindrops, provide a barrier from strong winds, and moderate temperatures, improving water infiltration and decreasing surface evaporation from sunlight. Surface cover also favors enhanced levels of biological activity by providing food for soil microbes, especially in tropical and sub-tropical areas.

- **Minimum soil disturbance**. No-till (NT) does not involve any loosening of the soil except for a very small area immediately surrounding where the seed is planted. This lack of soil disturbance serves to maintain overall soil structure, including aggregate stability and porosity, both of which promote the exchange of water and gases and provide habitat to an abundant and diverse population of soil biota.
- **Regular crop rotations**. Well-balanced crop rotations can neutralize many of the pest and disease problems associated with not tilling the soil, including the proliferation of insect pests and other harmful bacteria, viruses and fungi, by increasing the diversity and abundance of beneficial soil biota that can help keep pest and disease problems in check. Rotating crops also interrupts the life cycle of many weeds, thereby leading to a reduction in overall weed growth. These benefits translate to a typical yield increase of about 10 percent of crops grown in rotation, as compared to those grown in monoculture.
- **Utilization of green manures/cover crops (GMCC's)**. Cover crops are grown specifically to help maintain soil fertility and productivity. GMCC's increase soil organic matter (SOM) levels in at least one of two ways - by decreasing erosion and/or by adding fresh plant residues to the soil. Leguminous cover crops offer the added advantage of being able to fix nitrogen from the atmosphere and add it to the soil, thereby increasing overall nitrogen availability for other crops. Cover crops are usually mowed, sprayed with chemical herbicides or otherwise killed before or during soil preparation for the next economic crop. It is generally recommended that you leave a week or two between the killing of the cover crop and the planting of a primary crop in order to allow for some decomposition to occur as well as to lessen the effects of nitrogen immobilization and allelopathic effects.
- **No burning of crop residues**. Since crop residues are the principal element of permanent soil cover, they must never be burned or otherwise removed from the soil surface. Rather, plant residues are left on the soil surface in order to protect organic matter enriched topsoil from erosion while also adding fresh organic matter upon decomposition. Burning not only creates significant air pollution but also dramatically increases mineralization rates, leading to the rapid depletion of soil organic matter and nutrients from the soil. However, in some situations farmers need to think of the tradeoff between removing residues to feed their animals and leaving them to feed the soil. A win-win situation would do both and as yields and biomass increase over time, both become more feasible.
- **Integrated disease and pest management.** Conservation agriculture depends heavily on enhanced biological activity to help control insect pests and other disease causing soil organisms. Integrated pest management (IPM) entails the judicious use of crop rotations and other beneficial plant associations as well as chemical pesticides, herbicides and fungicides to control insect pest and disease problems. Over time, the enhanced biological activity and abundance brought on by no-till and other CA technologies results in decreased applications of agrochemicals.
- **Controlled / limited human and mechanical traffic over agricultural soils**. As mentioned above, the number of tractor passes over a given field is significantly reduced under CA, as compared to conventional tillage systems. However, increased bulk densities have been reported under CA, though this can be corrected by limiting the use of

heavy farm machinery when soils are wet and most prone to compaction and/or by converting to a permanent raised bed system.

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APPLICATION OF HPC (HIGH PERFORMANCE COMPUTING) FOR SUSTAINABLE AGRICULTURE

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Globally, India is second most populated country and seventh largest in geographical area.More than half of India's population is dependent on Agriculture and its allied sector. Use of geo-information technologies through High Performance Computing (HPC) which uses supercomputers clusters to solve advanced computation problems like crop production monitoring to mitigate the effect of climate change in farming, agricultural disease prediction, market fluctuation etc. Application of HPC in weather forecasting can also contribute to sustainable agriculture.

1. Introduction

Agriculture is the principal basis for livelihood in developing country worldwide. About 50% of Indian population depends their livelihood in agriculture. Modern Agriculture relied on mainly three important constituents such as mechanization, genetic manipulation and globalization. Use of HPC is becoming prime need in crop production activity, pesticides design, weather forecasting and geo-informatics technique. Data of Climate prediction are used to understand the impacts of natural calamities such as flood or drought on agriculture production, help in the management of water and agricultural resources and assist in to minimize the impact of such on vulnerable livestock in the region through improved drought management and response.

2. Major Challenges in Agriculture

Increasing demand of agricultural products would have a negative effect on the environment globally. Increased agricultural production needs the use of 70% of the world's water resources and at the same time results into rise in greenhouse gas emissions. Also, excessive use of fertilizers, pesticide along with intensive cropping detriments the soil quality. This quality degradation followed by eutrophication, successively leads to loss of biodiversity, land degradation and transformation, thereby limiting annual cultivation and agricultural produce.One way to mitigate this problem is developing new plant varieties through multilocation field trial, which are simple but are cost intensive and time consuming thus taking years to find the best varieties. The same problem can be efficiently solved by using High Performance Computing (HPC).HPC enables numerical simulations of plant growth that help breeders to achieve superior varieties instead of doing field trials which are more expensive and harmful for the environment.

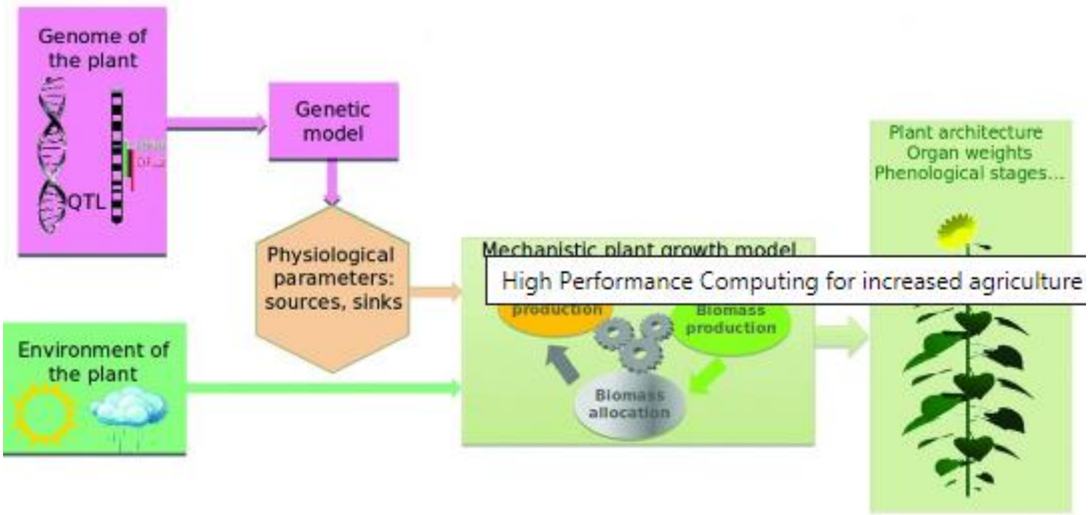


Figure 1. Generalise model depicting HPC use in Agriculture (Source: European Commission)

3. Use of HPC in Agriculture

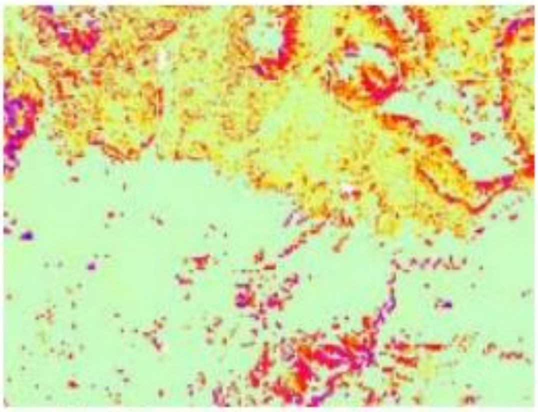
Due to rapid technological advancement HPC has become a prime technological driver for future agricultural research and crop production. HPC enable to minimize energy and time on the research by focusing on internal resources for achieving crop production goal. This technology firstly divided the problem into small fragments and then after different processors solves each fragment using parallel processing algorithms. So, the huge computation of agricultural production problem can be solved through flexible data analysis by supercomputing facility. In crop production the nature of soil, climatic changes and water availabilities are the prime factors. Microscopic details analysis of soil and climate can be done efficiently by using HPC, which can enhance the crop yield exponentially. Agricultural research on large land area are captured through satellite imagery. However, the minute details related to crop and soil cannot be capture by satellite image. For that the simulation models can assist in parallel computation of such huge auxiliary data to achieve the final result. This computation requires storage of huge data through database and fast parallel processing power handle the huge amount of generated output data, where in HPC comes into play.

4. Geographical Information System (GIS)

GIS is a system for capturing geographical data to store, manipulate, analyze and manage in the way that it solve the haphazard and non-scientific farming practices. With the current scenario, there is a need for the adoption of precision farming so as to improve crop production, minimize environmental impact on crop to manage variation in crop conditions and soil fertility across field. GIS are enable to seasonally monitoring of variations in soil moisture, crop growth, disease-pest and weed infestation, nutrient deficiency which increase the crop productivity and resource optimization.

a) GRASS(Geographic Resource Analysis Support System)

GRASS (Geographic Resource Analysis Support System) is free open source software which model geospatial features through image processing, modeling and visualization of data. GRASS assists in locating the fertile land parts for analyzing pattern and causes of soil erosion and suggesting preventive measure for crop production in advance.



Red Colour- Highly erodible soil

Yellow colour- Medium erodible soil

Green colour- Low erodible soil

Figure 2. Explains the soil erosion of a particular area(Source: www.ipcsit.com)

b) SAGA (System for Automated Geo-scientific Analyses)

System for Automated Geo-scientific Analyses (SAGA) is an open source hybrid model consisting GIS software along with an API which is specially designed for processing of geographical data. This modelenable digital terrain analysis, satellite image classification and also generate grid vector data sets and tables.

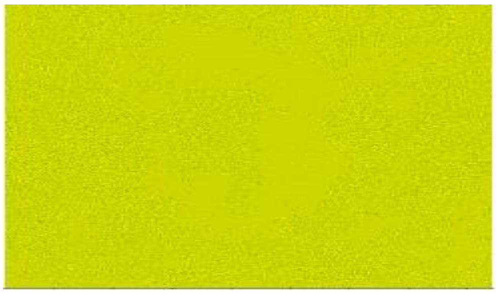


Figure-3.Modelling of Nitrogen using SAGA(Source: www.ipcsit.com)

Distributed nitrogen simulation (DNS) is a SAGA model used to simulate daily nitrogen concentration variation at grid level, considering continuous plant water uptake, fertilizer application doses, mineralization, nitrification and de-nitrification.

5. Weather Application

Temperature, rainfall and solar radiation are prime factors in agricultural production. Due to various unforeseen factors in crop growth such as abrupt rainfall pattern, causes heavy losses to crop every year. To mitigate such weather-based issues by applying climate prediction in advance which enable farmer to take appropriate steps. One of the HPC open source application called as Weather Research and Forecasting (WRF)which can be utilized in crop production.

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POST HARVEST MANAGEMENT OF VEGETABLES

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Introduction

Fresh vegetables are highly perishable and subject to the active process of senescence. Losses in fresh vegetables can be caused by high temperature, low atmospheric humidity and physical injury. The increasing popularity of minimally processed fruits and vegetables has resulted in greater health benefits. Furthermore, the ongoing trend has been to eat out and to consume ready-to eat foods **(Alzamora *et al.*, 2000).** Such injuries often results from careless handling, causing internal bruising, splitting and skin breaks, thus rapidly increasing water loss. Post-harvest management can be defined as methods and techniques applied to increase the shelf life of the products. Post harvest activities include harvesting, handling, storage, processing, packaging, transportation and marketing. Post-harvest system should be thought of as encompassing the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency and maximum return for all involved.

Objectives

- To know the post harvest management techniques of fresh vegetables.
- To get aware about post-harvest loss and their control measures.
- To recognize marketing channel and possible losses.
- To identify the various post-harvest management techniques.

Importance of Post-Harvest Management

- Maintain the quality of fresh vegetables.
- Reducing postharvest losses reduces poverty and food insecurity.
- Increase market share and competitiveness of smallholders.
- Stimulate agriculture production and prevent post-harvest losses.
- Provide extra foods to the consumer by reducing post-harvest losses.
- Improves human nutrition and health.
- It is difficult to increase 10% yield but it is easy to reduce 10% loss.

Causes of Post-Harvest Losses

- Immature/Premature/Over mature harvest.
- Faulty postharvest practices.
- Poor sorting and grading practices.
- Poor temperature and RH management in storage.
- Improper packing and washing.
- Delay and improper transport to market.
- Causes of exogenous factors (rat, insects).
- Lack of knowledge on postharvest techniques.

- Shrinkage and loss of weight caused by water loss.
- Poor air circulation in the stores.
- Limited level of production and small land holdings.
- Small, scattered, remotely located production pockets with limited access to market centres.
- Careless handling, causing internal bruising, splitting and skin breaks.
- Inadequate modern technologies and skills.

Fig: Poor Handling

Fig: Poor transportation

Types of Post-Harvest Losses

Biological: Pest and Diseases.

Chemical: Visible external contamination with pesticides and chemical products, toxics and unpleasant flavour produces by pathogens etc.

Mechanical: Injuries, cuts, bruises, grazes, scrapings, shatters during harvesting etc.

Physical: Heating, cooling, freezing, water loss.

Physiological: Sprouting, rooting, senescence and changes caused by transportation and respiration.

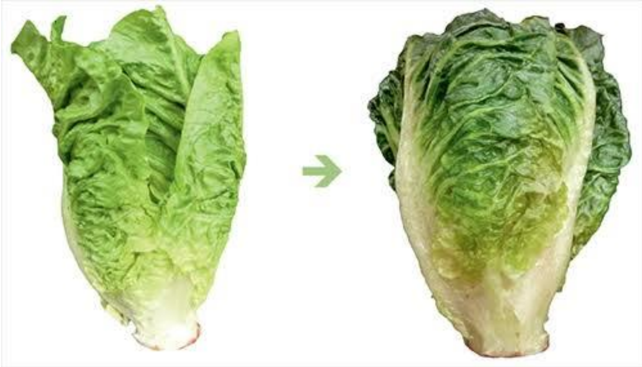

Fig: Low temperature effect (Lettuce)

Postharvest Chain

Farm: Harvesting and field handling techniques.

Pack-house: Cleaning, sorting/grading, sanitizing, microbial control, packaging, cooling and storage techniques.

Transport: Loading/unloading, stacking and product protection techniques.

Market: Re-sorting, re-packing and storage techniques.

Processing: Drying, Sauce production and Fermentation

Harvesting

- ❖ Quality cannot be improved after harvest. It is therefore important to harvest vegetables at optimum maturity.
- ❖ Harvest maturity of vegetables depends upon the purposes for which it is harvested.
- ❖ Harvesting at cooler times of the day minimizes product heat load and increases work efficiency of pickers.
- ❖ Don't harvest during rain. If you have to do it, washed and dried properly before packaging.

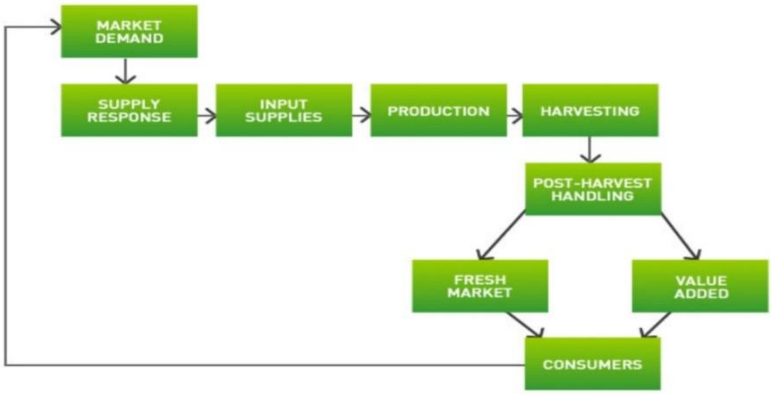

FIGURE 1. Schematic commodity value chain

Maturity

In post-harvest physiology, maturity is considered as "that stage at which a commodity has reached a sufficient stage of development that after harvesting and post-harvest handling, its quality will be at least the minimum acceptable to be ultimate consumer" (Reid, 1992).

Types of Maturity:

- **a)** Harvesting Maturity
- **b)** Physiological Maturity
- **c)** Commercial or Horticultural Maturity.

Curing

- ❖ It is technique where commodity is left in the field itself in a heap under shade for few days.
- ❖ It is an effective operation to reduce water loss during storage from hardy vegetables e.g. onion, garlic, sweet potato etc.

- In case of onion curing is a drying process intended to dry off the necks and 2-3 outer scales of the bulbs to prevent the loss of moisture and the attack by decay during storage.

Cleaning

- This is a treatment given to remove adhering dust, dirt, extraneous matter, pathogenic load etc. from the surface of a commodity.
- Cleaning basically sanitizes the produce and avoid entry of undesirable contents to enter the packaging and storage.

Washing

- Washing is done at the pack house through automated washing system fitted with overhead sprayers and smooth rotating brushes to clean and wash the vegetables.
- Washing with clean water mixed with a neutral detergent at 0.1% is effective.
- The process of cleaning and washing will take 3-5 minutes.

Sorting and Grading

Sorting: Undesirable types of vegetables i.e. diseased, damaged, deformed are removed. It can be done primarily to reduce spread of infection to other vegetables.

Grading: Vegetables are categorized according to difference in their weight, size, colour, maturity etc. It can be done to fetch better price in the market.

Packaging

- Its dimensions and design must be suited to the available transport in order to load neatly and firmly.
- It must be cost-effective in relation to the market value of the commodity for which used.
- It must be readily available, preferable from more than one supplier.
- It can reduce the amount of damage to which fresh produce is exposed during marketing.
- It should be to prevent physical damage to produce, and be easy to handle.

Fig: Packaging materials

Storing

- Different vegetables require different storage conditions.
- Most vegetables should be stored @ refrigerator temperature.
- Store vegetables away from fruits that emit ethylene gas, such as bananas. The gas will cause continued ripening and possible decay.

Storing Temperature

- It is a key factor affecting product deteriorating rate.
- It is the most effective tool for extending the shelf life of fresh horticultural commodities.
- It has key effects on spores germination and pathogen growth.

- If the temperature goes abnormal than its optimal range it has caused two types of injuries in crops, i.e. chilling injuries and heat injuries.
- So that keeps attention to maintain required temperature in the vegetable store.

Transportation

- Transportation is a big and often the important factor in the marketing of fresh produce.
- Ideally, transport would take produce from the grower directly to the consumer.
- Losses directly attributed to transport conditions can be high.
- The produce is kept in the best possible condition during transport and that the haulage of produce is quick and efficient.
- To this end, produce should be properly packaged and properly loaded on a suitable vehicle.

Transport Equipment

- Refrigerated and non-refrigerated vehicles for highway transport.
- Containers for air, rail and highway transport and for lift-on/lift-off sea transport.
- Break bulk refrigerated vessels for handling palletised loads.
- Pallets for air cargo and highway transport.
- Horse carts, donkeys.
- Wheelbarrows and carts for transport over distances of 1-8 km.

Fig: Refrigerated Vehicle

Conclusion and Recommendation

- Do not let more losses means you have contribute little more to the production.
- It is difficult to increase 10% yield but it is easy to reduce 10% loss.
- Losses can be caused by different reasons, but most important are biological, chemical, mechanical, physical and physiological.
- Lack of postharvest options has led to total loss of production.
- About 20 to 50% fresh vegetable losses are found during the period of time between harvesting and final retail marketing.
- As the numbers of marketing intermediaries are increase post-harvest losses are also increases simultaneously.
- Post-harvest management has some constrains or issues which act as a barrier to minimize post-harvest losses of fresh vegetables.
- Proper post-harvest technologies can minimize the post-harvest losses.
- Quality cannot be improved after harvest. It is therefore important to harvest vegetables at optimum maturity.
- Cleaning, sorting, grading, packaging, storing and transportation are the major post-harvest activities and that should be done appropriately and timely.

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DRAGON FRUIT: ITS NUTRITIONAL IMPORTANCE AND METHODS OF CULTIVATION

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Abstract
Dragon fruit based farming has become an effective tool in modern era for generating income and nutritional security among the farmers of tropical and subtropical dry land areas of the world. With a point of view of nutrition and health benefits this fruit has high demand in market. Once the crop is cultivated the fruits can be harvested up to twenty years with minimum protection measures and management along with its easy cultivation. Dragon fruit farming should be popularized among farmers and other growers to overcome the curse of food insecurity and poverty in developing countries.
Keywords: Dragon fruit, farmers, farming, health, nutrition

Introduction: India is a developing country and most of its rural population depends on agriculture as a source of food and income for their livelihood. Being considered as an important sector and backbone of Indian economy, the condition of the farmers is still piteous. Government of India has decided to double the farmers' income by 2022 but this objective can be achieved by making some strategies at grass root level. The dragon fruit farming can be helpful in obtaining the objective of government of India to some extent. Dragon fruit belongs to Cactaceae family. It is also called by other names as Pitaya, Strawberry pear, Night blooming Cereus, Belle of the night, etc. It is packed with excellent health benefits due to which it has high demand in local as well as international markets. It can be consumed as a fresh fruit in salad form or can be used in developing various value added processed foods like jam, jelly, fruit juice etc. It is basically a perennial, fast growing climbing vine cactus species belongs to the genus *Hylocereus*. Although this crop is native to Mexico and Central and South America but its demand among growers of various parts of the


(a) *Hylocereus undatus*


(b) *Hylocereus costaricencis*


(c) *Hylocereus megalanthus*

world is increasing day by day due to its attractive color and delicious taste with black color edible seeds embedded in the pulp with value added nutritional and antioxidant rich properties. It has been found that once the crop is cultivated it will grow for about 20 years, which is the biggest advantage in itself.

Types of dragon fruits: There are basically three major types of dragon fruits based on their outer and internal appearance. (a.) *Hylocereus undatus*:-white flesh with pink skin, (b.) *Hylocereus costaricencis*: -red flesh and pink skin (also known as *Hylocereus polyrhizus*) and (c.) *Hylocereus* (*Selenicerus*) *megalanthus*: -white flesh with yellow skin.

Nutrient composition of the dragon fruit: It is a good source of various macro and micro nutrients like protein, fiber, minerals, vitamins etc and has also antioxidant properties. It has been found that the amount of ascorbic acid in this fruit is many times higher in comparison to other fruits and vegetables.

Table 1: Average nutrient composition of various species of Dragon fruit

Amount per 100 g of Pulp			
Composition	***Hylocerus undatus***	***Hylocerus costariensis***	***Hylocerus megalanthus***
Protein (g)	0.5	0.15	0.4
Fat (g)	0.1	0.21	0.1
Crude fibre (g)	0.3	0.7	0.5
Calcium (mg)	6	6.3-8.8	10
Phosphorus (mg)	19	30.2-36.1	16
Iron (mg)	0.4	0.55-0.65	0.3
Thiamine (mg)	-	0.028-0.043	-
Riboflavin (mg)	-	0.043-0.045	-
Niacin (mg)	0.2	1.2	0.2
Ascorbic Acid (mg)	25	8-9	4

Source: Morton (1987); Jaffar *et al.* (2009)

Health Benefits: Dragon fruit helps in reducing the various risk factors like high blood cholesterol, high blood pressure, generation of free radicals etc which are responsible for occurrence of several non-communicable diseases like cardiovascular diseases, diabetes mellitus, cancer, etc. It also helps in reducing anemia by maintaining hemoglobin level in the body and also helps in neutralizes toxic substances such as heavy metals.

Type of climate and soil along with cultivation method: Dragon fruit plants can be grown in both tropical and sub-tropical dry land areas and requires less water so it is a best option of farming for dry land areas having low rain fall. Its plants can be grown in any type of soil, however a well drained sandy loam soil mixed with farm yard manure is highly preferred. The land should be well ploughed to achieve the better tilth and weed free soil. Plants should be established on well-drained beds.

Propagation method: The dragon fruit plants can be propagated by two methods:

(a) Seed propagation: In this method the seeds are collected from the fruits, washed thoroughly and sowed on sand clay mixture containing farm yard manure. After three or four days seeds begin to germinate and they can be potted within 4-5 weeks after germination and ready for field planting by 9-10 months. Although this method is easy but the quality of the new plants

can be different from the mother characteristics and seeds grow slowly taking 3-4 years to come to bearing. So this method is not appropriate for commercial cultivation.

(b) Vegetative propagation: In this method cutting is obtained from mother plants. Although cuttings can be obtained throughout the year but preference should be given after fruiting season. It should be taken in consideration that cutting should be collected early in the morning by applying the slanting cut at the stem base. In this method about 15-60 cm length mature cuttings should be used (Zee *et al.,* 2004) because in long cuttings the regeneration rate of new shoots is very fast in comparison to short cuttings. The cuttings can be treated with fungicide to check the occurrence of diseases and should be cured in a cool and dry place for 5-7 days before planting.

(c) Nursery preparation and management: Nursery can be raised before cultivation of plants of dragon fruit in the field as it is helpul in controlling of soil, water, light, nutrients and other factors. The size of the nursery depends on the number of plants required for cultivation in the farm. Usually 1100 plants could be accomodated in 10×10 m of nursery space. Although cuttings can be planted directly in the field but potting them in a suitable media for rooting is a common method. Plastic bags or natural clay pots can be used for planting the cuttings. Before planting if edges of cuttings are dipped in root hormones (IBA (10,000 mg/l) it will increase the formation of adventitious roots faster (10 -15 instead of 40-50 days) (Vargas-Santigo *et al.*, 2003). The cuttings should be watered regularly as per requirement but not excessive and after proper establishment they should be transplanted into the field.

Trellises and spacing: As dragon fruit plant is a climbing cactus and after planting in about 8 months it forms a thick dense mass of vines on top of the trellis which lies drooping to the ground. Therefore support is essential for their growth and development. So for providing support concrete, iron or wooden poles, fences, etc are required. The concrete or iron pillars are supported by a square structure on the top to train the vine for bearing purpose. At some places cycle tyres with their rims are used on the top to support the climbing cacti. On the basis of information obtained from various nursery growers and other studies 400 poles are required for one acre land at a spacing of 3×3m and approximately 1600 plants are planted having four plants on each pole. Proper spacing is needed for adequate air circulation and to check occurrence of diseases. Gunasena *et al*. (2006) suggested that the size of the pole should be 100-150 mm diameter and 2 m high and buried 40 cm in the soil.

Table 2: Common spacing of dragon fruit plants

Spacing (m)		Number of plants/ha
Between rows	**Within rows**	
3.0	3.0	1,100
4.0	3.0	833
4.9	3.0	680
3.7	3.7	730

Source: Gunasena *et al*. (2006)

Tree fences can also be used to overcome the expenses spend on formation of concrete trellises as dragon fruit crop do not require full sunlight. Farmers can take double benefit by cultivating dragon fruit crop in their fields with various fruit or other trees having low water requirement because high water can cause root rot in dragon fruit crop due to high moisture content in root zone.

Manure and Fertilizers: Dragon fruit crop requires judicious application of manure and fertilizers for higher yield although the recommendations of fertilizer rates vary from country to country. According to Tripathi *et al.* (2014) 10 to 15 kg of farm yard manure (FYM), 200 g nitrogen, 50 g phosphorus and 50 g of potash are required for 1 to 2 year old plants and the doses are applied every four months in a year. Twenty kg FYM, 500 g nitrogen, 750 g phosphorus and 300 g potash are applied in three or more year old plants in four equal doses every year i.e. after harvesting and during growth, before flowering and after fruit set (Table 3). Two kg N: P: K with ratio of 22:22:11, 50 g urea, 50 g super phosphate and 80 g potash can be applied. Although organic farming is preferred now a days so only FYM and poultry manure may be applied for supplementing nutrients to the crop.

Table 3: Manure and fertilizer doses per plant/year

Plant age (years)	FYM (kg)	Nitrogen (g)	Phosphorus (g)	Potassium (g)
1st year	15 kg	200	50	50
2nd year	15 kg	200	50	50
3rd year and above	20 kg	500	750	300

Source: Tripathi *et al.*, 2014

Irrigation method: Being cactus the crop requires less amount of water in comparison to other fruit crops, however water requirement is affected by various factors like type of soil, climatic conditions and various stages of the crop itself. Generally in pre bloom period the plants should be subjected to dry condition to produce more flowers while adequate moisture is required for flower and fruit development (Gunasena *et al*., 2006). If the rainfall is well distributed, irrigation may not be required, but when there is less rain or in summer season (dry days) frequent irrigation is required without flooding. Drip irrigation has been observed as an effective method for dragon fruit crop.

Weeds, pests and disease management:

Weed management is important as they compete with the crop for water and nutrients and act as a host for various pests which in turn damage the crop. Weeds can be controlled by the use of herbicides, mulching practices, tillage etc. Although dragon fruit is free of pests in comparison to other fruit crops but pests like ants, beetles, fruit flies, bats, borers, caterpillars, termites, mealy bugs, rats, etc. affect the crop. Ants feed on sap of fruits and may cause blemishes. Unwrapped and overripe fruits may be eaten by birds and bats if left un-harvested. Green beetle perforates the stem and causes necrosis while *leaf-footed bug* sucks the sap, leaving stains and some deformation. The crop should be monitored regularly to control pests when observed and proper management of weeds is required as they provide shelter to pests.

As far as the disease is concerned very few diseases have been reported in dragon fruit. A soft watery stem rot caused by *Xanthomonas compestris* which occurs due to high moisture. Anthracnose caused by *Colletotrichum gloesporioides* causes lesions on vine and also affects fruits which is prominent in rainy season and can be controlled by spraying fungicides. *Fusarium oxysporium* attacks the vine. *Botryoshaeria dothide* cause brown stem spot in which lesions occur of various sizes and can affect the entire stem if not controlled. The practice of wide spacing is suggested to enhance air circulation and light penetration which in turn will suppress disease problems. Pruners used for pruning should be sterilized to reduce the spreading of diseases from one plant to another.

Yield, harvesting and marketing: After plantation, it produces fruit in the second year and achieves its full production within four years and onward. Fruits are matured within 30-50 days after flowering and fruiting period continues up to 3-4 months. Outer cover of immature fruit is bright green in color which turns red when ripens and accurate time of harvesting is


Dragon fruit plant with white flowers and mature fruits

after four days of color changing. Harvesting may be done three to four times within this period. (Tripathi *et al.* 2014). In Port Blair, in an experiment conducted by Central Island Agricultural Research Institute, it was observed that flowering on red fleshed and white fleshed dragon fruits crop was initiated in nine months after planting in the month of March and fruits were ready to harvest within 25-35 days. The fruit weight ranges from 300-800 g and each plant produces 40 to 100 fruits per year. One plant normally yields 15 to 25 kg of fruits. The farm gate price rate is range between Rs. 125 to 200 per kg.

Conclusion:

The cultivation of dragon fruit crop has become beneficial with the point of nutrition and income generation. Only initial establishment cost is high due to the construction of trellises but once the crop is established, the fruits can be harvested continuously up to 20 years and only minimum expenses are required for management of the crop. It was found that in Indian market the fruits have good demand and imported fruits are marketed presently at the rate of Rs 200 to 250 per kilogram. Its cultivation in India can become a viable option for farmers and entrepreneurs of medium to large scale plantations. It is a potential fruit crop which provides early high retruns in the second year of planting. In this way the cultivation of dragon fruit will be fruitful to the region specific farmers in generating their income and in providing nutritional security to those who reside in dry and arid zone areas with supplementary irrigation facilities. With the help of horticulture experts and extension workers awareness related to farming of dragon fruit can be spread among the farmers.

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CROP RESIDUE BURNING: A THREAT TO SUSTAINABLE AGRICULTURE

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Abstract: To feed India's projected population of 1.35 billion in 2025, agricultural production especially staple food of India (rice and wheat) would have to increase by approximately 25%. Appearance of multi nutrient deficiencies, due to their over mining from the soil and poor management, low levels of soil organic matter and non recycling of crop residues, leading to their burning are some of the major factors for declining crop productivity, particularly in rice-wheat belt. Continuous removal and burning of crop residues lead to loss of vital components such as nitrogen, phosphorus, sulphur and potassium from the topsoil layer, making the land less fertile in short run and unviable for agriculture in the long run. Burning of agricultural biomass residue, or Crop Residue Burning (CRB) has been identified as a major health hazard, causing exposure to extremely high levels of Particulate Matter to people in the immediate vicinity. Recycling/retaining crop residue on the soil surface will improve nutrient cycling and ultimately, soil and environmental quality can be substantially improved.

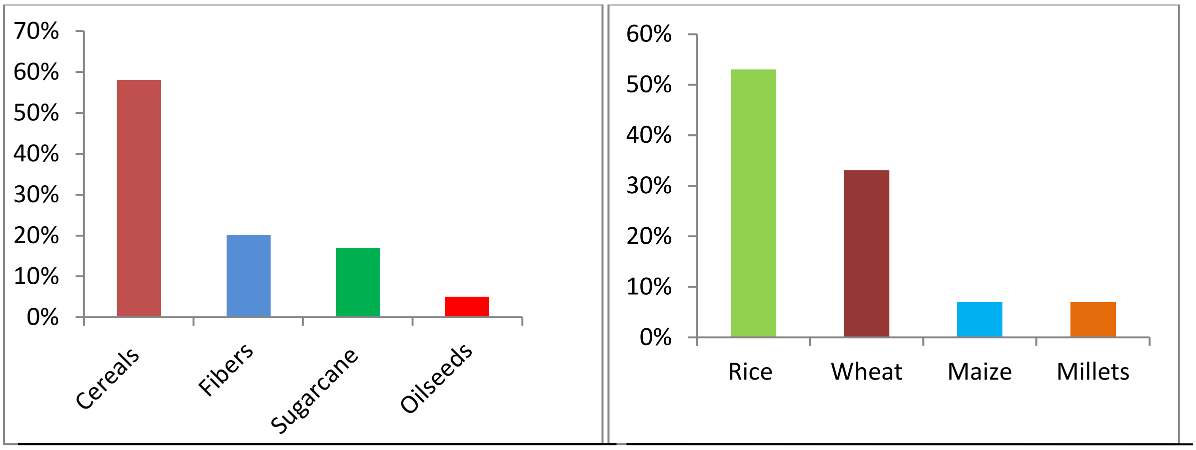
Keywords: Nutrient recycling, staple food, residue burning, microflora

Introduction

The Indo Gangetic Plains (IGP) is a very important agro eco-region in South-Asia, occupy nearly one-fifth of the total geographic area in the four countries (Pakistan, India, Nepal and Bangladesh) of the Indian subcontinent. In India it alone occupy 20% geographical area contributes 42% to the total food grains production and holds nearly 40% of the total population (Tripathi*et al*., 2007). In the IGPs region of India, 12 million hectares is occupied by rice-wheat belt and combine harvesting is very popular for harvesting of these crops with the farmers of Punjab, Haryana and western Uttar Pradesh which leaves large quantities of straw in the field (Badarinath*et al*., 2009). The crop residues are subjected to open burning on account of high labour wages and less available time in the sowing of next crop wheat (as crop residues interfere with tillage and seeding operations). It is estimated that, 686 Mt of gross crop residues are available in India on annually from the 39 crop residues generated by 26 crops (Hiloidhari*et al*., 2014). Annual national potential of surplus residue is 234 Mt/year i.e. 34% of gross residue generated in India. Cereal group (rice, wheat, maize, pearl millet, barley, small millet, sorghum) contribute the highest 386 Mt (54%) and 89 Mt followed by sugarcane 111 Mt (16%) and 56 Mt of gross and surplus residues, respectively, out of total amount annually. Rice contributes 154 Mt gross residues, highest, on individual crop basis followed by wheat (131 Mt) (Jat *et al*., 2014). Although rice produces the highest amount of gross residue among all the crops, its surplus residue production is less than sugarcane due to competing uses of its straw. Uttar Pradesh produces the highest amount of residue in the country has surplus availability of 33%, which is equal to national value but less than many other countries (Jat *et al*., 2014). In the states of Punjab, Haryana and Himachal Pradesh 80% of rice straw was burnt in situ followed by Karnataka (50%) and Uttar Pradesh (25%), which can be attributed to the mechanized harvesting with combine harvesters (Gupta *et al*., 2003). Rice and wheat constitutes nearly 85% out of 89 Mt of surplus residues which are burned on farm annually, out of the total crop residues burned globally, currently India contributes 33.6% (Jat *et al*., 2014). In Punjab alone, about 20 Mt of rice and wheat residues out of a total of 37 Mt of residues are being burned in situ annually, leading to a loss of about 8 Mt of C equivalent to a CO_2 load of 29 Mt per year and a loss of about 1×10^5 tonnes of N, in addition to loss of S and the destruction of beneficial microflora of the soil (Yadvinder-Singh *et al*., 2014). One tonne of crop residue burning releases 1515 kg CO_2, 92 kg CO, 3.83 kg NOx, 0.4 kg SO_2, 2.7 kg CH_4, and 15.7 kg non-methane volatile organic compounds (Andreae and Merlet, 2001). These gases and aerosols consist of particulate matter which has adverse impacts on human health in addition to contributing to global climate change. Besides, burning of crop residues lead to a loss of organic matter and precious nutrients (Up to 80% of N and S, and 10-20% of other plant nutrients). Many state governments in India have made it illegal to burn crop residues, but these laws have been difficult to enforce.

Causes and Scale

Rice and wheat crop in N-W India and many other regions is harvested by combines leaving considerable residue in the field. Rice straw considered as poor feed for animals whereas nearly 75% of wheat straw is collected as feed for animals, though this requires additional operation and investment. Because of very little turn-around time between rice harvesting and wheat sowing and lack of proper technology for recycling, management of rice straw, rather than wheat straw is a serious problem. Paddy, or rice, is a water-intensive crop, due to this, its cultivation has resulted in the central and various state governments restricting in the summer months, so, paddy cultivation can legally begin only around mid-June, when the monsoons typically arrive over North India. This further causes use of combine harvesters which leave 6-10 cm of paddy stalk on the field. The rise in incomes and the subsequent availability of mechanical implements in Punjab and Haryana lead to increased mechanisation of agriculture over the past 10-15 years.Farm labour in these states was in the form of seasonal, migrant workers from the states of Uttar Pradesh and Bihar. Currently, the demand for these workers saw a reduction, and accordingly, the availability of assured income from farm labour has declined and also, launching of NREGA type schemes further led to income opportunities in their home states. So, agricultural labour has become a scarce commodity in parts of Punjab and Haryana.The removal of the paddy stalk that remains on the field is a labour-intensive process. With less labour and time window for preparing the field for wheat cultivation, out of two options, either investing in expensive and rarely used agricultural implements, or burning the residue right on the field, the latter is both cheaper and requires less effort.According to estimates, Punjab produces nearly 19-20 million tonnes of paddy straw (of which 85-90% being burnt in the field) and about 20 million tonnes of wheat straw. Increasingly, wheat straw is also being burnt during the Rabi harvesting season. In Haryana, the problem of paddy straw (production is estimated at 2 million tonnes) burning also exists, although the scale is smaller than in Punjab.



(a) **(b)**

Fig. 1. (a) Contribution of different crops categories in residue generation. (b) Contribution of different cereal crops in residue generation (*Jain et al., 2014*).

In terms of efforts being made to reduce crop residue burning, the following approaches have been used by various state and central administrations and regulatory bodies so far:

1. ***Ban on Residue Burning***: Crop residue burning was notified as an offence under the Air Act of 1981, the Code of Criminal Procedure, 1973 and various appropriate Acts. In addition, a penalty is being imposed on any offending farmer. Village and block-level administrative officials are being used for enforcement.
2. ***Subsidy and innovation of agri-implements***: The state governments, in collaboration with the Centre, providing subsidy on mechanical implements that help tillage of soil, so that the crop residue can be retained in the soil, collection of crop residue for putting it to commercial usage or adding to its fertility, eg. happyseeder which can works upto 9 tonnes of crop residues/ha. However, the high cost of these implements means that in spite of subsidies, only a small number of farmers have access to these implements at the moment.
2. ***Detection and prevention***: A combination of remote sensing technology-use of satellite imagery and a team comprising local officials is being used to detect occurrences of crop residue burning in real-time and to prevent them from taking place.
3. ***Establishment of a marketplace for crop residue burning***: Alternate usage of paddy straw and other crop residue are being made to increase the avenues. For instance, as a fuel in biomass-based power plants, for the preparation of bio-fuels, organic fertilisers and in paper and cardboard making industries. The strategy, broadly, is to reveal a real economic and commercial value to the agricultural residue and making burning it an economic loss to the farmer.
6. ***Public awareness campaigns***: Efforts being made to highlight the health effects of crop residue burning. It produces extremely high levels of toxic particulates, which affect the health of the people in the direct vicinity of the burning.
7. ***Diversification of cropping system***: This is being attempted through cultivation of alternate crops (other than rice and wheat) that produce less crop residue and have greater gap periods between cropping cycles.

Conclusion: The major constraints of time and labour under intensive agriculture have led to the adoption of mechanised farming in rice based cropping system leaving large amount of crop residues in the fields. To avoid the losses due to late sowing of wheat (as crop residues interfere with tillage and seeding operations), farmers in north-west India as well as in many areas of eastern and southern India often prefer to burn surplus residues on farm after grain harvesting of rice. Adopting the principals of conservation agriculture together with best crop management practices would improve system productivity and overall resource use efficiency, resulting in higher profitability as well as long term sustainability of different crops and cropping system.

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A VERSATILE ORGANIC MANURE: PANCHAGAVYA

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Panchagavya is an important input in organic agriculture. In sanskrit, panchagavya means the mixture of five products obtained from cow. All these five products individually called ‘gavial’ and collectively called ‘panchagavya’. It contains ghee, milk, curd, dung and urine obtained from cow. Panchagavya has many beneficial implications in agriculture, organic farming as good quality natural manure and due to its medicinal property it fights against several diseases of animals and human beings. Panchagavya is a component of crop production and it plays a crucial role in each and every component of crop management like integrated soil fertility management, integrated disease management, integrated pest management and resulting in increase in overall yield. It also play an important role in quality of fruit and vegetables and enhancing the biological efficiency of crop plants. Panchagavya is cow based bio enhancer behave as yield promoter, growth promoter (75%) and immunity booster (25%) and exactly important component to sustain the organic farming.

The Panchagavya products also used as many other applications viz. excellent agricultural applications in the form of biofertilizers, vermicompost and biopesticides, which improves soil fertility and provide good quality non residue protected food free from the health hazards of using chemical fertilizers/pesticides.

Ingredients:


Cow dung


Cow urine

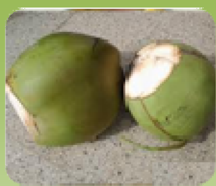

Cow ghee


Cow milk


Cow curd


Water


Jaggery


Tender Coconut


Well ripened Banana

Fresh cow’s dung - 5 kg	Cow’s milk - 2 lit	Tender coconut water - 3lit
Cow’s urine - 3 lit	Cow’s ghee - 500 gm	Ripe banana fruits - 12 numbers
Cow’s curd - 2 lit	Jaggery - 500 gm	Toddy (drink made from - 2 lit
Fermented sap of palm trees)		

- Alternative ingredient for jaggery is 3lit sugarcane juice.
- Alternative ingredient for toddy is 100gm yeast, 100 g jaggery with 2 liters of warm water or 2 liter of fermented (1 week) tender coconut water.

Sugarcane juice and coconut water are used to accelerate the fermentation which also help in minimizing the bad odour.

Preparation:

1. Take a wide mouthed mud pot, concrete tank (or) plastic cans (Avoid Metal containers because panchagavya is acidic).
2. Add cow's dung and cow's ghee in mud pot and stir the mixture well and leave it for 3 days.
3. On 4th day, add cow's urine, cow's milk and cow's curd and mix it well.
4. Then continue adding all remaining ingredients like add tender coconut water, toddy, mashed banana and add 500gm jaggery in 3lit of water.
5. Stir well the mixture and close the can tightly.
6. Stir twice daily for 15 days.
7. After 18 days Panchagavya will be ready with a good odour.

Composition:

pH	5.45
Total N (ppm)	229
Total P (ppm)	209
Total K (ppm)	232
Sodium	90
Calcium	25
IAA (ppm)	8.5
GA (ppm)	3.5
EC dSm2	10.22

Fungi	38800/ml
Bacteria	1880000/ml
Total anaerobes	10000/ml
Methanogen	250/ml
Acid formers	360/ml
Lactobacillus	2260000/ml

Panchagavya contains macronutrients like nitrogen, phosphorus, potassium and micronutrients also contains various amino acids, fats, carbohydrates, vitamins, growth regulators like auxins, gibberellins, kinetin and abscisic acid and also beneficial micro organisms like pseudosomonas azotobacter, azospirillum, phospho bacteria and Actinomycetes etc.

Recommended doses:

1. **Spray system:**

- 3% Panchagavya solution for all crops- The solution prepared by mixing 3 liters of Panchagavya with 100 liters of water.
- 2 % Panchagavya solution for crops like cucumber, mint, snake gourd, bottle gourd, - The panchagavya solution prepared by mixing 2 liters of Panchagavya with 100 liters of water.

2. **Flow system:** The 25 litres panchagavya solution mixed with irrigation water at 500 litres per acre in 15days/month either through drip irrigation or flow irrigation.

3. **Seed – seedling treatment**: 3% solution of Panchagavya used to soak the seeds or the seedlings for 30 min before planting.
4. **Seed storage:** 3 % Panchagavya solution to dip the seeds before drying and storing them.

Periodicity of application:

Pre flower phase	**Two sprays in 15 days interval depending upon duration of the crops**
Flowering and pod-setting stage	Two sprays in 10 days interval
Fruit / pod maturation stage	One spray during pod maturation

- For crops like Cereals, Pulses and Oil seed: One Spray in every 15days.
- For Green, Vegetables, and Flowers: One Spray in every week.

Effects of panchagavya in field crops:

Paddy:	**Sugarcane:**
• Increase tillering.	• Increases the girth and height.
• Absence of chaffy grains.	• Increases sugar content up to 15%.
• 300 grains/ear head.	• Increases the internodal distance.
• Good cooking quality.	• Increase the yield up to 90 tonnes/acre.
• Increase grain weight by 20%.	• Organic jaggery has good aroma, flavor and taste.
• Reduce quantity of broken rice during milling.	

Maize, Sorghum, Wheat and Pearlmillet:	**Sunflower, Groundnut and Mustard:**
• Increases the number, size, density and weight.	• Increases the oil content by 25%.
• Increase yield upto 20%.	• Increases the size and weight of the seeds by 20%.
• Increases the fibre content and nutrients.	• Enhance aroma, flavor and taste.
• Improve the taste and keeping quality of cooked food.	• Increases the shelf life of the oil by 6 months. and increases the harvest by 20%.

Mango:

- Increase keeping quality of mango by 12 days at room temperature.
- Stop the alternate bearing and tree continue to fruit regularly.
- Promote dense flowering with more female flowers.
- Flavor and aroma of the mango is excellent.

Guavava:

- Increase shelf life by 5 days.
- High T.S.S (Total soluble Solids) and brix ratio.

General Advantages of Panchagavya:

• Enhance soil fertility and soil health	• Fight against diseases of humans and animals
• Increase growth and productivity of crop plants	• Improve human health
• Used as fertilizers and biofertilizers	• Avoid use of chemicals like fertilizers, pesticides, fungicides etc.
• Provide resistance to insect and pest	• Simple to use or no techniques is required
• Eco-friendly approach	• Produce chemical residue free food
• Maintain sustainability for long term and Low cost of preparation	• Reduce the cost of cultivation by avoiding the use of chemicals

Panchagavya for animals:

When panchagavya taken orally by animals, it –

- Stimulates the immune system.
- Produces number of antibodies against the ingested microorganisms.
- Prevent illness and diseases.
- Slows down the ageing process.
- Improves appetite, assimilation, digestion and elimination of toxins in the body.
- Increases the blood circulation.
- Cures sterility.

Doses:

Cows:

100 ml panchagavya with feed or drinking water per cow per day. It increase the milk yield, fat content and SNF also increase the rate of conception.

Goats and Sheep:

10 ml to 20 ml Panchagavya mixed with water and feed per animal per day depending upon the age. It increases the weight in short period and animals become healthy and having shining hair.

Poultry:

1 ml mixed with feed or water per bird per day. The birds become disease free, lay bigger eggs for longer periods, improve the feed-to-weight conversion ratio by 5% to 10% and increase the weight of broiler chicken.

Fish:

Panchagaya given daily with fish feed. It increases the phytoplankton and zooplankton in the pond, food availability to fish, increases its immunity and weight in 9 months time each fish grows to a weight of 2 to 3 kg (common carp weight in 9 months is 3.850 kg) and reduces the death rate of small fingerlings.

Pigs:

10 ml to 50 ml per pig according to the age and weight. The pigs become healthy and disease free, increases the weight at a faster rate and increases feed-to-weight conversion ratio.

Problems, Constraints and Difficulties in Adopting Panchagavya:

- Lack of awareness and knowledge about its uses
- Non availability of its products in markets
- Slow action
- Sometimes during fermentation contamination occurs
- Lack of knowledge about its application
- It may reduce quality of the produce sometimes
- It encourages weed growth also as it is non selective
- Less usage by farmers

Conclusion:

Panchagavya play an important role in organic agriculture to maintain sustainability because of the excessive use of chemical results in adverse effect on soil microorganism and soil health and also on human health. So it is necessary to adopt products like Panchagavya to produce food free from chemicals and to maintain soil fertility and conserve soil flora and fauna.

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ECONOMIC ASPECTS OF ZERO BUDGET NATURAL FARMING IN INDIA

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Summary

Zero Budget Natural Farming is an impotent method of farming. Increase is economically viable by enhancing farm biodiversity and ecosystem service. ZBNF as an innovative model and said adopting this could help Indian farmers to double their income by 2022, which happens to be the 75th of Independence.

Introduction:-

Zero Budget Natural Farming, as the name implies, is a method of farming where the cost of growing and harvesting plants is zero. This means that farmers need not purchase fertilizers and pesticides in order to ensure the healthy growth of crops. ZBNF is a unique chemical-free method that relies on agro-ecology. It was originally promoted by noted agriculturist Subhash Palekar, who developed it in the mid-1990s. ZBNF promotes the application of *jeevamrutha* — a mixture of fresh cow-dung, urine of aged cows, jaggery, pulse flour, water and soil-on farmland.

Specific Features of ZBNF:-

- Zero budget natural farming requires only 10 per cent water and 10 per cent electricity than what is required under chemical and organic farming. ZBNF may improve the potential of crops to adapt to and be produced for evolving climatic conditions.
- It is, basically, a natural farming technique that uses biological pesticides instead of chemical-based fertilizers. Farmers use earthworms, cow dung, urine, plants, human excreta and such biological fertilizers for crop protection. It reduces farmers' investment. It also protects the soil from degradation.
- The ZBNF method also promotes soil aeration, minimal watering, inter-cropping, bunds and top soil mulching, and discourages intensive irrigation and deep ploughing. Since farmers are not required to buy any inputs, the cost of production in ZBNF is reportedly zero.

Benefits of Zero Budget Natural Farming (ZBNF):-

- As both a social and environmental programme, it aims to ensure that farming – particularly smallholder farming – is economically viable by enhancing farm biodiversity and ecosystem services.
- It reduces farmers' costs through eliminating external inputs and using in-situ resources to rejuvenate soils, whilst simultaneously increasing incomes, and restoring ecosystem health through diverse, multi-layered cropping systems.

- Cow dung from local cows has proven to be a miraculous cure to revive the fertility and nutrient value of soil. One gram of cow dung is believed to have anywhere between 300 to 500 crore beneficial micro-organisms. These micro-organisms decompose the dried biomass on the soil and convert it into ready-to-use nutrients for plants.
- Resilient food systems are the need of the day given the variability of the monsoons due to global warming and declining groundwater in large parts of India. The drought-prone regions in India are reportedly seeing promising changes already in farms with the ZBNF.

The four pillars of ZNBF:-

I. **Jivamrita/jeevamrutha-** is a fermented microbial culture. It provides nutrients, but most importantly, acts as a catalytic agent that promotes the activity of microorganisms in the soil, as well as increases earthworm activity; During the 48 hour fermentation process, the aerobic and anaerobic bacteria present in the cow dung and urine multiply as they eat up organic ingredients (like pulse flour). A handful of undisturbed soil is also added to the preparation, as inoculate of native species of microbes and organisms.
   - **Jeevamrutha Application-** Apply the jeevamrutha to the crops twice a month in the irrigation water or as a 10% foliar spray.

II. **Bijamrita/beejamrutha** is a treatment used for seeds, seedlings or any planting material. Bijamrita is effective in protecting young roots from fungus as well as from soil-borne and seed-borne diseases that commonly affect plants after the monsoon period. It is composed of similar ingredients as jeevamrutha - local cow dung, a powerful natural fungicide, and cow urine, a strong anti-bacterial liquid, lime, soil.

III. **Acchadana - Mulching.** According to Palekar, there are three types of mulching:
   - Soil Mulch: This protects topsoil during cultivation and does not destroy it by tilling.
   - Straw Mulch: Straw material usually refers to the dried biomass waste of previous crops, but as Palekar suggests, it can be composed of the dead material of any living being (plants, animals, etc)
   - Live Mulch (symbiotic intercrops and mixed crops)

IV. **Whapasa - moisture:** Palekar challenges the idea that plant roots need a lot of water, thus countering the over reliance on irrigation in green revolution farming. According to him, what roots need is water vapor. *Whapasa* is the condition where there are both air molecules and water molecules present in the soil, and he encourages reducing irrigation, irrigating only at noon, in alternate furrows ZBNF farmers report a significant decline in need for irrigation in ZBNF.

The four-wheels of zero budget natural farming require locally available materials:

i. Water vapor condensation for better soil moisture.
ii. Seed treatment with cow dung and urine-based formulations.
iii. Mulching and soil aeration for favorable soil conditions.
iv. Ensure soil fertility through cow dung and cow urine-based concoctions.

Government initiatives to support ZBNF:-

- Government of India has been promoting organic farming in the country through the dedicated schemes of Paramparagat Krishi Vikas Yojana (PKVY) since 2015-16 and also through Rashtriya Krishi Vikas Yojana (RKVY).In the revised guidelines of PKVY scheme during the year 2018, various organic farming models like Natural Farming, Rishi Farming, Vedic.
- Farming, Cow Farming, Homa Farming, Zero Budget Natural Farming (ZBNF) etc. have been included wherein flexibility is given to states to adopt any model of Organic Farming including ZBNF depending on farmer's choice.
- Under the RKVY scheme, organic farming/ natural farming project components are considered by the respective State Level Sanctioning Committee (SLSC) according to their priority/ choice.

Future Prospective:-

- In her maiden Union Budget speech in July last year, Finance Minister Nirmala Sitharaman hailed ZBNF as an innovative model and said adopting this could help Indian farmers to double their income by 2022, which happens to be the 75th of Independence.
- A new farmer pension scheme called Pradhan Mantri Kisan Pension Yojana worth Rs 900 crores was announced. To promote and deepen markets, creation of 10,000 new farmer producer organizations (FPOs) was envisaged, and passing reference was made to the role of e-NAM and APMC in that regard. Fishery sector was given a thrust as the speech proposed to create value-chains and infrastructure. Return to zero-budget traditional farming was emphasised.
- The population of India, which is currently 17.71 per cent of the total world population, is predicted to increase by 33 per cent from 1.2 billion in 2010 to 1.6 billion in 2050. Under 'business-as-usual' scenario, by 2050, 60 per cent of India's population, equivalent to over 10 per cent of the people on Earth, will experience severe deficiencies in calories, digestible protein and fat.
- One of the more progressive announcements were the cluster-based scheme SFURTI (Scheme of Fund for Up gradation and Regeneration of Traditional Industries). It is designed to promote bamboo, honey and khadi clusters. Hundred such clusters are envisaged under SFURTI for 2019-20.
- To meet increased demands for food on a shrinking area of agricultural land, efficiency of crop production must increase, but climate change, soil degradation and depopulation present further challenges to increasing the efficiency of Indian agriculture.

Conclusions:-

Zero budget natural farming started as a grassroots movement, aiming to provide multiple benefits, both to the environment and to farmers. However, there are conflicting opinions about how it should be developed for widespread use.

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A GENERAL INTRODUCTION OF ORGANIC FARMING

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Introduction

The concept of organic farming is not new to the Indian farming community as it is successfully practiced in diverse climates, particularly in rain fed, tribal, mountain and hill areas of the country. Much of the forest produce of economic importance, like herbs and medicinal plants, by default come under this category (Singh, 2007). India is the second most populous country in the world and with the increasing population; the cultivable land resource is shrinking day to day and therefore, to meet the food, fiber, fuel, fodder and other needs of the growing population, the productivity of agricultural land and soil health needs to be improved With agriculture as the backbone of the Indian economy supported by the fact that nearly 67% of our population and 55% of the total work force depending on agriculture and other allied activities, agriculture meets the threshold for satisfying the needs of India‘s enhancing population. It has been estimated that for India to achieve a double digit GDP growth rate, agricultural growth of around 4% or more is required. It is definitely true that India had witnessed a tremendous growth in agricultural production in the era of green revolution. The technologies involved during the inception of green revolution supported by policies and further propelled by agrochemicals, machinery and irrigation were the main driving forces for the enhanced agricultural production and productivity. With manufacturing of fertilizers and pesticides as the two major inputs of Green Revolution (GR) Green revolution technologies such as greater use of synthetic agrochemicals like fertilizers and pesticides, adoption of nutrient-responsive, high-yielding varieties of crops, greater exploitation of irrigation potentials etc. has boosted the production output in most cases. Therefore, for sustaining the productivity of the crop, maintaining the soil health and healthy ecosystem, there is need for adoption of an alternative farming system, may be the Organic Farming. India has converted 6.0 million ha of cultivated land into organic and another 1.17 million ha are under conversion (Yadav, 2012). Organic cultivation is particularly suitable for a country like India with a huge population of small farmers who still use traditional methods of farming with few agricultural inputs. In a Country like India it is important to note is that the first initiatives in organic cultivation were taken by farmers NGOs and the private sector agri-business players. A government institutional intervention largely followed to respond to the farmer’s and trade needs. Government interventions are mostly related to institutionalizing quality assurance mechanisms, however, the focus is also on supporting of farmland conversion to organic production and mandating/incorporating a comparative element in all related aspects the rough scientific to research (Anonymous, 2007). Organic farming, as an outcome of different assessments of economic, ecological and social goals, consequently, technique strategies such as integrated pest management of balanced nutrient supply might improve conventional agriculture to such as an extent that it may appear unnecessary to strictly ban pesticides and mineral fertilizers as required by organic standard. Organic farming is a method of farming system, which primarily aims at cultivating the land and raising crops in such a way, so as to keep the soil alive and in good health. In the Indian context organic farming is also termed as „Javik Krishi‟. The term organic is best thought of referring not to the type of inputs used, but to the concept of the farm as an organism, in which all the components likes, soil minerals, organic matters, microorganisms, insects, plants, animals and humans interact to create coherent, self regulating and stable whole. Reliance on external inputs, whether chemical or organic, is reduced as far as possible. Organic farming is holistic production system. However, as the process is slow and the output in normal course is very small, farmers have not been taking keen interest in this activity. Decomposing organic matter in soil gradually releases nitrogen. Earthworms, „the intestine of earth‟, are considered as agents to restore the soil fertility from the times of Aristotle. Earthworms are physically an aerator, crusher, mixer, a degrader and stimulator for decomposition of various organic wastes. This degradation of organic wastes by earthworm is known as vermin-composting. The potential of earthworms and vermiculture in India was realized in early 1980s. The vermi-compost is rich in micro and macronutrients, vital plant promoting substances, humus farming substances, nitrogen fixers and humus forming microorganisms (Bano *et al.*, 1987).

Importance of Organic Farming

The approach towards global food security has been a matter of grave concern around the world. To have a better, efficient and holistic approach towards the global food security, the concept of biosafety is being implemented at different levels. But, now-a-days, stress is being laid on the appearance and the quantity of food rather than the intrinsic quality and vitality of the food grains. Pesticides and other fertilizers that are being used at the time of crop development are being found in the food. In addition to this, the reduced quality of food has led into an increase in various diseases, mainly various forms of cancer and various diseases relating to weakened body immunity. As far as the impact of commercialization of agriculture on the environment is concerned, this commercialization. has been found to have a negative impact on the environment. The use of pesticides have led to a sort of enhanced biomagnified chemical build up in even our bodies starting from water, air, crop and animals as different levels of this biomagnification. An interesting fact is that the fertilizers have a short-term effect on productivity but on the contrary have a long-term negative effect on the environment where they remain for years after leaching and running off, contaminating ground water and water bodies. On the other hand, the use of hybrid seeds in addition to the practice of monoculture have led to a severe threat to local and indigenous varieties which are

Major Advantages of Organic Farming

Although, there are several advantages of switching over to organic farming from conventional farming techniques, yet all the advantages may not be feasible considering the Indian rural economy. Eventually, it is mandatory to throw some light on the advantages that are really feasible enough to be considered as advantages for Indian farming conditions. Here are some of the advantages that are relevant in this regard.

(i) High Premium (ii) Low Investment (iii) Less Dependence on Money Lenders (iv) Synergy with life forms (v) Traditional knowledge:

Conclusions

Organic farming perceptions are quite divergent. But there is a strong consensus on its eco-friendly nature and inherent ability to protect human health. Also, many studies have revealed that organic agriculture is productive and sustainable. Organic food production costs are higher in the developed countries as organic farming is labor intensive and labor is costly in these countries. But in a country like India, where labor is quite abundant and relatively cheap, organic farming is a great potential solution to the problem caused by the chemical farming method to the environment and the health of the mankind. Efforts have been made by the government of India on an overall basis to encourage organic farming. Even different organizations have been set up for the marketing of the produce of organic farming. The increasing demand for the organic food products in the developed countries as well as the policies adopted by the government of India to encourage the exports of the organic agri-products are the driving factors responsible for the uprising of the Indian organic food industries which have the potential to strengthen the Indian economy as well as the health standards of the Indian masses.

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