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1. SOIL SCIENCE

Soil Erosion and its Impact on Agriculture

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Introduction

Soil is the basis of production in agriculture activities. The combination of intensive farming activities, improper farming practices, rainfall regimes, and topography conditions that taken place in agricultural land lead to the soil erosion problem. Soil erosion is the major constraint to agriculture that affects the yield production and degraded environmental sustainability. Healthy soils increase the capacity of crops to withstand weather variability, including short term extreme precipitation events and intra-seasonal drought. Loss of organic matter will lead to an increase in input cost of nutrients applied as chemical fertilizer to mitigate or manage the loss of soil productivity. The loss of fertile soil makes land less productive for agriculture, creates new deserts, pollutes waterways and can alter how water flows through the landscape, potentially making flooding more common.

Soil Erosion

Soil erosion is the natural process in which the topsoil of a field is carried away by physical sources such as wind and water.

Erosion, whether it is by water, wind or tillage, involves three distinct actions –

- Soil detachment,
- Movement
- Deposition.

Types of Soil Erosion

- **Geological Erosion**-Weathering of parent rock and erosion are natural processes by agencies like water and wind. There is always equilibrium between the removal and formation of soil. There is not many harms done unless the equilibrium is disturbed by some outside agency.
- **Landside Erosion**-This is caused by the pressure of moisture going deep into the soil during heavy rains which being unable to go down further due to hard soil or rocky strata below, move down a big mass of overlying soil on the deep land. Such landslides are more common in ghat areas.
- **Accelerated Erosion** -The removal of the surface soil from areas denuded of their natural protective cover, grazing of grasses, excessively ploughed the land and expose it to nature accelerates erosion by removing top soil.
- **Wind** - It is caused by strong wind mainly in arid and desert areas. Wind erosion causes dust storm forms sanddunes and buries localities with deposition of sand. Thus fertile lands are rendered unfit for cultivation. It is more common in Rajasthan.
- **Water**- If the rain occurs in torrents there is not enough time for the water to soak through soil and it run off causing erosion.
    - Raindrop erosion
    - Rill erosion
    - Gully erosion
    - Bank erosion
    - Sheet erosion

Water and wind erosion in India extend over about 162.4 and 167.0 million tonnes hectares of area respectively

The effects of soil erosion on the main soil functions that enable ecosystem services provide by soil:

Eco system Service	Soil Functions	Effect of Erosion
Primary production	Medium for seed germination & root growth Supply of nutrients	Reduction of optimum rooting zone for extraction of

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	& water for plants	water and nutreient from soil
Nutrient cycling	Retention & release of nutrients on charged surfaces	Loss of charged organic materials from surface soil horizon
Water quality regulation	Retention,filtering &buffering of substances in soil water	Transfer of sediment and sediment-bound contaminants to water bodies
Water supply regulation	Regulation of water infiltration into soil and water flow within the soil	Decrease in surface infiltration and water holding capacity of soil
Air quality regulation	Regulation of particulate content of atmosphere	Transfer of particulate to atmosphere
Food,fibre and fuel supply	Providing water,nutrients &physical support for growth of plants for human & animal use	Degradation of water & nutrient supply and decrease of depth of suitable rooting medium
Climate regulation	Regulation of CO_2,N_2O&CH_4 emisions	Lateral transfer of soil organic carbon in landscabe &possible enhanced CO_2 emissions

Impacts of Soil Erosion in Cropping Lands

- Reduced ability of the soil to store water and nutrients
- Exposure of subsoil which often has poor physical and chemical properties
- Higher rates of runoff,shedding water and nutrients otherwise used for crop growth
- Loss of newly planted crops
- Deposits of silt in low-lying areas
- The annual loss in output of main crops in India because of soil erosion has been estimated to be 7.2 million tones which is about 4 to 6.3 percent of annual agricultural production of the country and ranges to a loss in terms of replacement cost from 1 to 1.7 percent of the GDP.As high as 74 million tonnes of major nutrients are lost to soil erosion in India per year

Soil Erosion Preventive Measures

To minimize the soil erosion following agronomic and mechanical measures are followed

1. **Agronomic Measures**
   a. **Strip Cropping:** This consists of growing erosion permitting crops and erosion resisting crops in alternate strip. The soil which flows from the strips growing erosion permitting crops is caught by the alternating strips of erosion resisting crops. Erosion permitting crops- cotton jowar, bajra, etc. The erosion resisting crops-groundnut, matki, hulga (Dolichos biflorus), soybean.
   b. **Mulching:** A mulch is natural or artificially applied layer of plant residues or other materials on the surface of the soil with the object of moisture conservation, reduction of runoff and erosion and soil losses e.g. jowar or bajra stubbles, paddystraw or husk, sawdust etc. The quantity of mulch use @ 5 tonnes per/ha.
   c. **Crop Rotation:** Rotation means growing a set off crops in a regular succession over the same field within a specified period of time. Continuous growing jowar or bajra crop causes more erosion, but if followed by a legume crop namely Hulga, Matki or Gram which covers the soil it causes less erosion.
   d. **Contour Cultivation:** Tillage operations viz. ploughing, harrowing, sowing and Inter Cultural should be done across the slope of land this will help creating obstruction to the flow of water at every furrow, which acts like a small bund and result in uniform distribution of water, less runoff and erosion.
   e. **Planting of Grasses for Stabilizing Bunds:** Grasses prevent soil erosion and improved soil structure. Several

grasses as well as legumes were tried on bunds should give maximum root growth and canopy coverage and stabilize bunds effectively e.g. anjan, marvel-8, rhodes, thin napier, blue panic, kusal.

f. **Planting of Trees and Afforestation:** Forests conserve soil and water quite effectively. They not only obstruct the flow of water, but the falling leaves provide organic matter, which increases the water holding capacity of soil.

2. **Mechanical Measures**

These measures require engineering techniques and structures.

Bunding- Graded bunding, contour bunding and block bunding.

Block Bunding: It was not uncommon to found tals i.e. big bunds across large blocks of sloping lands. These bunds are constructed of earth or stone or both to impound water and arrest soil washed from the fields lying above.

Contour Bunding

Terracing

It is suitable on bigger slope upto 10 p.c. and rainfall is higher than 1250mm. Terrace bunds consist of comparatively narrow embankments constructed at intervals across the slope and the vertical spacing between bunds may varied from 1 to 2 m., depending upon the slope, types of soil, rainfall etc. Bench terracing is done when gradient is stripper than 10 p.c. as in hilly ranges of Himalayas, Sahyadri etc. These terraces are like table tops slopping outwards and provided with stone waste weirs to drain away surface water.

Terrace Farming

Gully or Nala Control

The slopping sides are planted with grass and trees to prevent its extension and further destruction of cultivated lands and grassland. Small gully can be stabilized by converting them into paddy fields e.g. Check dams, Overflow dams and drop structures.

Control of Stream and River Banks

This should be protected by providing spurs, jetties, rivets and retaining walls. Adjoining areas should be stabilized under permanent vegetation.

2. AGRONOMY

Waste Decomposer: A way Forward to Organic Farming

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Introduction

India generated roughly 62 Million tonnes of Municipal solid waste (450 g/capita/day) in 2015 and it is rising with the population explosion. And also, India produces 500 Million tons of crop residues per year. Furthermore, approximately 92 million tons of crop waste is burned every year in India. The burning of crop residues has become a major environmental problem that causes health problems and also contributes to global warming. Composting is one of the effective sustainable techniques that could help to curtail these issues. So, Waste Decomposer could help in the reduction of a huge volume of organic waste by converting them into compost quicker than the conventional composting methods.

Drawback of Conventional Composting Methods

- Foul smell
- Matted leaves or grass clippings are not decomposting
- Stinks like rancid butter vinegar or rotten eggs
- Odor like ammonia
- Attracts insects
- Fire ant problem

History and Development of Waste Decomposer

Waste Decomposer is a product developed by the National Centre of Organic Farming (NCOF), Ghaziabad, Uttar Pradesh. It is a consortium of few beneficial microbes which is isolated by Krishan Chandra in 2004 from native cow dung. Besides, it is also validated by the Indian Council of Agricultural Research (ICAR).

Salient Features of Waste Decomposer

- Simple & Reliable
- Ready to use(within 5 days)
- Longer shelf -life(3 years)
- Recommended for all crops
- Better crop response
- Works as a great component for clean India movement (swachh bharat mission) by converting bio-waste into organic manure
- Low cost (only Rs.20/bottle)

Protocol for Mass Multiplication of Waste Decomposer

The Waste decomposer could be mass multiplied by a simple technique that is practically applicable to the farmers. This protocol is standardized by Krishan Chandra in 2015.

- Take 2 kg jaggery and mix it in a plastic drum containing 200 litres of water.
- Then take 1 bottle of decomposer (30 g) and pour all its contents in a plastic drum containing jaggery solution.
- Mix it properly with a wooden stick for uniform distribution of waste decomposer in the drum.
- Cover the drum with a paper or cardboard and stir it every day once or twice.
- After 5 days, the solution of the drum turns creamy.

The farmers could prepare the waste decomposer solution again and again from the above formed solution by the addition of 20 litres of waste decomposer solution into a drum with 2kg of jaggery and 200 litres of water. So, again it would be ready in 7 days.

Quick Composting using Waste Decomposer

The mass multiplied solution of waste decomposer could be used to decompose biowaste into organic manure.

- 18 – 20 cm thick layers of 1-ton bio-wastes such as agricultural wastes, kitchen wastes, cow dung, etc. are piled on the ground.
- Wet the waste with the solution of waste decomposer.

- Again another 18 – 20 cm thick layer of bio-waste is spread and again wet with waste decomposer solution.
- The above processes are repeated until the piling goes 30 – 45 cm higher.
- Turn the pile at every 7 days interval for uniform composting and add more solution at every turning.
- Maintain 60% moisture during the entire period of composting. If required again add a solution.
- The compost gets ready to use after 30 – 40 days. This tends to a healthy composting process and the high-quality compost could be obtained with high organic carbon and other nutrients.

Characteristics of the Compost

Compost which gets ready by using waste decomposer is dark brown in colour, no fuel smell, no warm, dry and very good in quality having high organic carbon content and other nutrient content. Waste decomposer application of 1000 litres per acre changes the biological and physical properties of all soil types (acidic and alkaline) within 21 days of application and helps to generate earthworm population in the soil up to 4 lakh in 1-acre soil within six months.

Role of Waste Decomposer in Other Area's of Agriculture

Waste decomposer works as biofertilizer, bio control and as well as soil health reviver.

The mass multiplied liquid waste decomposer culture is cultured in a ratio of 1:3 with water and applied as a foliar spray to control all types of soil borne, foliar diseases, insects and pests. The way it act as Bio-pesticides.

We can use the waste decomposer solution for treat the seeds before sowing. Spray the waste decomposer solution uniformly over any type of seeds. Leave the seeds under shade for 30 minutes. After 30 minutes, the seeds are ready for sowing. It controls the seed borne diseases.

Approximately, 200 litres of waste decomposer liquid could be used for 1 acre crop residue as in-situ composting.

Working mechanism

Waste decomposer micro organism produces primary metabolites that are a precursor of anti microbial compounds. It also produces a variety of anti microbial secondary metabolites including polyketides and alkanes. These antimicrobial metabolites facilitating in the field crop which controls the number of diseases. Besides this it also produce glucanase & β-1,3 glucanase enzymes which trigger defense mechanism of the plant.

Waste decomposer microorganism was demonstrated to be an excellent candidate for lignocelluloses degradation in this work, showed more robust growth, stronger spore production, faster secretion of lignocelluloses- decomposting enzymes and better pH tolerance.These features make this product unique to convert all types of waste into good compost

Waste Decomposer Contribution Chemical Farming

Incase of chemical farming, a farmer can save 60% of input cost by the usage of waste decomposer.The usage chemical fertilizers can be dropped down to 60% by the application of waste decomposer.That means waste decomposer is applied in the conventional fields, only 40% of urea,40% of DAP,40% of MOP of the earlier dose is required as waste decomposer decomposes the crop residue which results in the increase of organic carbon and it well known that presence of 0.1% of organic carbon would increase the 10% uptake of inputs.Hence fertilizer use efficiency (FUE) enhanced by 60% to 80%.

Conclusion

Conclusively, Waste Decomposer has an immense potential to undergo effective organic waste management, crop production, and soil health revival due to its beneficial multifunctions. It is an eco-friendly, cost-effective, and beneficial product that could work as a great component for Clean India Movement (Swachh Bharat Mission) by converting biowaste into organic manure. Hence, it could also give some additional revenue through the marketing of compost produced by the addition of the Waste Decomposer.

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3. SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Is Common salt a fertilizer?

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Sodium chloride, commonly referred as salt plays a vital role in our everyday food routine. There is a famous Tamil proverb that is "**Uppila pandam Kuppayilae**" which conveys the meaning that food without salt is equal to trash. From this, we can understand the importance of salt in food. Since it is having antimicrobial activity, they are used highly as a preservative for e.g.: Pickles and Pappads. This same common salt is also used as a fertilizer in agriculture as a traditional practice for pest and disease management as well as yield improvement. The following passages will give elaborate information about the use of this common salt as fertilizer.

Coconut- The Kalpavriksha

Coconut tree scientifically *Cocus nucifera* is referred as "**Kalpavriksha"** because all parts of plant is very much useful to human in our daily life. From coconut as an edible item, thatched coconut leaves as a roof for buildings, coir for wooden art crafts and very own coir pith for agricultural purpose, all the parts from the plant extends useful products to human kind. For this coconut crop, the common salt is used as a fertilizer.

Fig 1. Benefits obtained from Coconut tree

Why common Salt as a Fertilizer?

Application of Common salt either directly as a fertilizer or as a soil ameliorant is a very old and popular practice among the coconut growing farmers. Addition of sodium in the form of common salt in the basin of the coconut is a common practice. In lateritic soils, the common salt is added in the pits for planting seedlings is known to soften the laterite beds and help easily penetration of roots to the soil. It is also applied to the top of the palm along admixed with a little wood ash. In laterite areas 2 kg common salt per pit is applied for improving the physical condition of the soil.

This common salt application is highly preferred in the areas where soil is chlorine deficient. Coconut being a semi-halophyte can resist the action of common salt, but that does not mean that it requires salt. It is reported that sodium promotes early growth of seedlings, development of young palms, and enhances number of inflorescences; production of female flowers and setting of fruits. This sodium chloride acts as an excellent fertilizer to overcome the chlorine deficiency. Chlorine deficiency in coconut is widespread in most of the areas. Hence, in that concern, this sodium chloride will act as a cheapest and effective fertilizer for the coconut to tackle the chlorine deficiency

Application Methods

Salt can be applied to coconut in the following methods

- Broadcasting (in slopy areas)
- Broadcasting followed by digging at 2 to 3 inches' depth of soil (salt with nitrogenous fertilizers)
- Holing (for hilly-sloping areas distributed in 8-10 inches with 3-5 inches' depth around the base of the tree)

Fig.2. Salt application in coconut tree

Recommendation and Time of Application

At nursery stage (6-8 months), seedlings are supplied with 60 -70 g of NaCl per tree, 2 splits in a year at first half of start of rainy season and before ending of rainy season will results in the increase of plants girth and fresh weight, indicating that chlorine nutrition is important during nursery stage.

In general, 1.5 kg to 2 kg of NaCl per tree per year is considered to be most effective and economical to increase copra weight/nut and copra yield/tree. Split application is done at pre bearing stage (1-4 years old palm) which reduces loss of fertilizer thorough leaching and runoff

Generally, bearing palms are fertilized annually in areas with almost uniform rainfall distribution (Table 1). In areas with distinct wet and dry seasons with uneven rainfall distribution, and those with sandy soils, fertilizers are best applied every six months. Split application is done at the pre-bearing stage (one to four years) of palms. This practice helps reduce loss of fertilizer nutrients through leaching and run-off and make fertilizer use more effective.

Table 1. Recommended CS rates for different ages/stages of growth of coconut palms

Age/Stage of palms	Rate of NaCl/ Tree/ year
Nursery	50 g
Field planting	100 g
Six months after planting	150 g
One year after planting	500 g
Two years after planting	750 g
Three years after planting	1.10 kg
Four years after planting	1.30 kg
Five years and above	1.50 kg

Source: Techno Guide on Fertilization No. 02/2019

Uses

- Promotes crop growth and development
- Increases copra weight and number of nuts
- Reduce leaf spot damage
- Cheapest source

Problems

Since application of common salt as a fertilizer is a traditional practice among the farmers, still there are scientists who deny this fact. As salt contains sodium also, it is highly possible to increase the salinity of the soils. Application at one or two times or halophytic crops may not get affected but long-term application of this salt over a period of years will results in salt accumulation on the soil. This increase in salinity affects the soil quality results in crop failure. Hence scientists recommended that application of low quantity of common salt may be feasible as a fertilizer and use of vermicompost, phosphate rich organic fertilizers are highly advisable.

Reference

Common Salt Fertilization on Coconuts, Techno Guide on Fertilization No. 02/2019

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4. ENTOMOLOGY

Algae as a Bio Fertilizer for Sustainable Agriculture

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Biofertilizers are natural fertilizes which uses living microbial inoculants of bacteria, algae, fungi alone or in combination for enhancing the availability of nutrients to plants. Bio-fertilizer application is a sustainable agricultural practice that increases soil nutrient content resulting in higher productivity. With respect to algae, the majority of cyanobacteria can fixes atmospheric nitrogen and species including *Anabaena* sp., *Nostoc* sp., and *Oscillatoria angustissima* were known to be effective cyanobacterial based bio fertilizers., *Chlorella vulgaris, Spirulina platensis, Acutodesmus dimorphus, Scenedesmus dimorphus, Anabaena azolla and Nostoc* sp. are some of the green microalgae and cyanobacteria species that have been successfully used as bio fertilizers to boost crop growth. Particularly *Chlorella vulgaris* is one of the most commonly used microalgae in bio fertilizer (Ammar *et al.,* 2022).

Effects of algal bio-fertilizer on plants growth and soil quality

Crop	Algal species	Impact
Rice	*Chlorella vulgaris Spirulina platensis*	(1) Improvesrice yield and productivity. (2) Improves the physical, biological and chemical properties of the soil.
Wheat	*Chlorellavulgaris*	Algal biomass supports agriculture by supplying nutrients to marginal soils.
Corn seed and plant	*Chlorella* sp.	(1) Increases the corn seed germination rate and shortens germination period. (2) Promotes the growth of roots and leaves and enhances photosynthesis.

(Nosheen *et al.,* 2021)

Microalgae as bio-fertilizers

Crop	Species	Impact
Rice	Cyanobacterial inoculum composed by *Aulosira fertilissima, Anabaena sphaerica, Nostochatei, Cylindrospermum majus and Westiellopsis prolifica*	Increase in nitrogen availability in the soil and increase in grain and straw yield
Wheat	*Anabaena torulosa biofilm*	

Macroalgae as bio-fertilizers

Seaweeds known as macro-algae, they are used as a soil conditioner, fertilizer, animal feed, biofuel, integrated aquaculture, and waste

treatment. Major sea weeds used in crop and their impacts are given in table.

Commercial seaweed (macro algae) products are used in agriculture

Application	Seaweed	Product name
Plant growth stimulant	*Ascophyllum nodosum Ascophyllum*	Acadian
	Nodosum Macrocystis pyrifera	Agri-Gro Ultra
	Ascophyllum nodosum	AgroKelp
Bio fertilizer	*Ecklonia maxima*	Fartum
Biostimulant	*Durvillea potatorum*	Sea Winner

(Nabti *et al.* 2016)

Benefits

- Biofertilizers act as supplements to chemical fertilisers.
- Biofertilizers are cost-friendly and can aid to decrease consumption of chemical fertilisers.
- It fixes atmospheric nitrogen to soil which supplies nitrogen directly to plants.
- Enhanced the seed germination and improves average crop yield by 10–20 per cent
- Reduce salt stress during seed germination and increases the grains and fruit quality
- Its help in the multiplication and survival of beneficial micro-organisms in the root region (rhizospheric bacteria).
- Control and inhibit pathogenic soil bacteria.
- Enhance soil texture by increasing amount of humus and maintain soil fertility.
- Improves soil health by enhancing beneficial microbs in the soil

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5. AGRICULTURE

Quantitative Triat Loci for Yellow Mosaic Virus Disease Resistance in Blackgram and Greengram

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DNA./Gene/ Chromosome

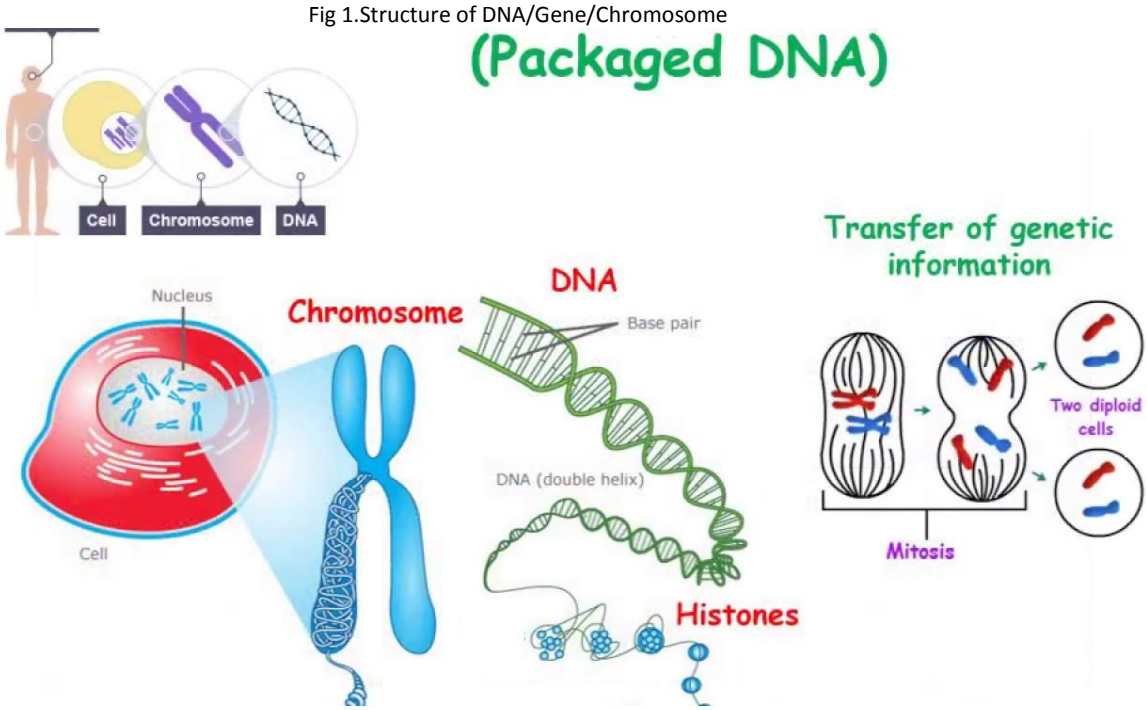
In the nucleus of each cell, the DNA molecule is packaged into thread-like structures called chromosomes. Each chromosome is made up of DNA tightly coiled many times around proteins called histones that support its structure.

Chromosomes are not visible in the cell's nucleus—not even under a microscope—when the cell is not dividing. However, the DNA that makes up chromosomes becomes more tightly packed during cell division and is then visible under a microscope. Most of what researchers know about chromosomes was learned by observing chromosomes during cell division.

Each chromosome has a constriction point called the centromere, which divides the chromosome into two sections, or "arms." The short arm of the chromosome is labeled the "p arm." The long arm of the chromosome is labeled the "q arm." The location of the centromere on each chromosome gives the

chromosome its characteristic shape, and can be used to help describe the location of specific genes.

Fig 1.Structure of DNA/Gene/Chromosome



Centimorgan (cM): A unit of measure of genetic recombination frequency. One cM is equal to a 1% chance that a marker at one genetic locus will be separated from a marker at another locus due to crossing over in a single generation. In humans, 1 cM is equivalent, on average, to 1 million base pairs.

The distance between two markers is measured by centimorgan. The 5 Cm is used for selection of markers

The centimorgan is named after the pioneering (and Nobel Prize winning) geneticist Thomas Hunt Morgan

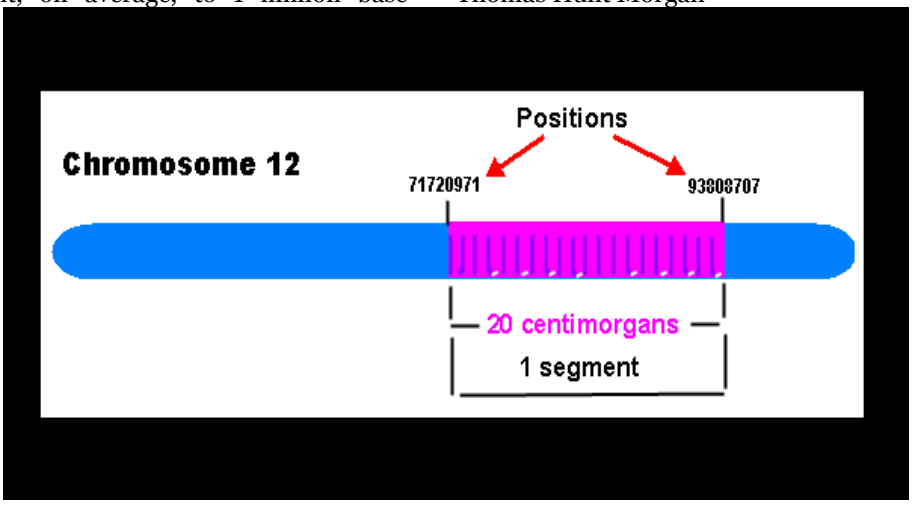


Fig 2: Centimorgan (cM)

Flanking markers

Using MAS to select individuals with disease resistance involves identifying a marker allele that is linked with disease resistance rather than the level of disease resistance. The assumption is that the marker associates at high frequency with the gene or quantitative trait locus (QTL) of interest, due to genetic linkage (close proximity, on the chromosome, of the marker locus and the disease resistance-determining locus).

The QLT is flanked by two markers

MAS can be useful to select for traits that are difficult or expensive to measure, exhibit low heritability and/or are expressed late in development. At certain points in the breeding process the specimens are examined to ensure that they express the desired trait.

Quantitative trait locus

A quantitative trait locus (QTL) is a locus (section of DNA) that correlates with variation of a quantitative trait in the phenotype of a population of organisms.[1] QTLs are mapped by identifying which molecular markers (such as SNPs or AFLPs) correlate with an observed trait. This is often an early step in identifying and sequencing the actual genes that cause the trait variation.

A quantitative trait locus (QTL) is a region of DNA which is associated with a particular phenotypic trait, which varies in degree and which can be attributed to polygenic effects, i.e., the product of two or more genes, and their environment.[2] These QTLs are often found on different chromosomes. The number of QTLs which explain variation in the phenotypic trait indicates the genetic architecture of a trait. It may indicate that plant height is controlled by many genes of small effect, or by a few genes of large effect.

Typically, QTLs underlie continuous traits (those traits which vary continuously, e.g. height) as opposed to discrete traits (traits that have two or several character values, e.g. red hair in humans, a recessive trait, or smooth vs. wrinkled peas used by Mendel in his experiments).

Moreover, a single phenotypic trait is usually determined by many genes. Consequently, many QTLs are associated with a single trait. Another use of QTLs is to identify candidate genes underlying a trait. Once a region of DNA is identified as contributing to a phenotype, it can be sequenced. The DNA sequence of any genes in this region can then be compared to a database of DNA for genes whose function is already known, being this task fundamental for marker-assisted crop improvement.[3][4]

Fig 1. QTL maping

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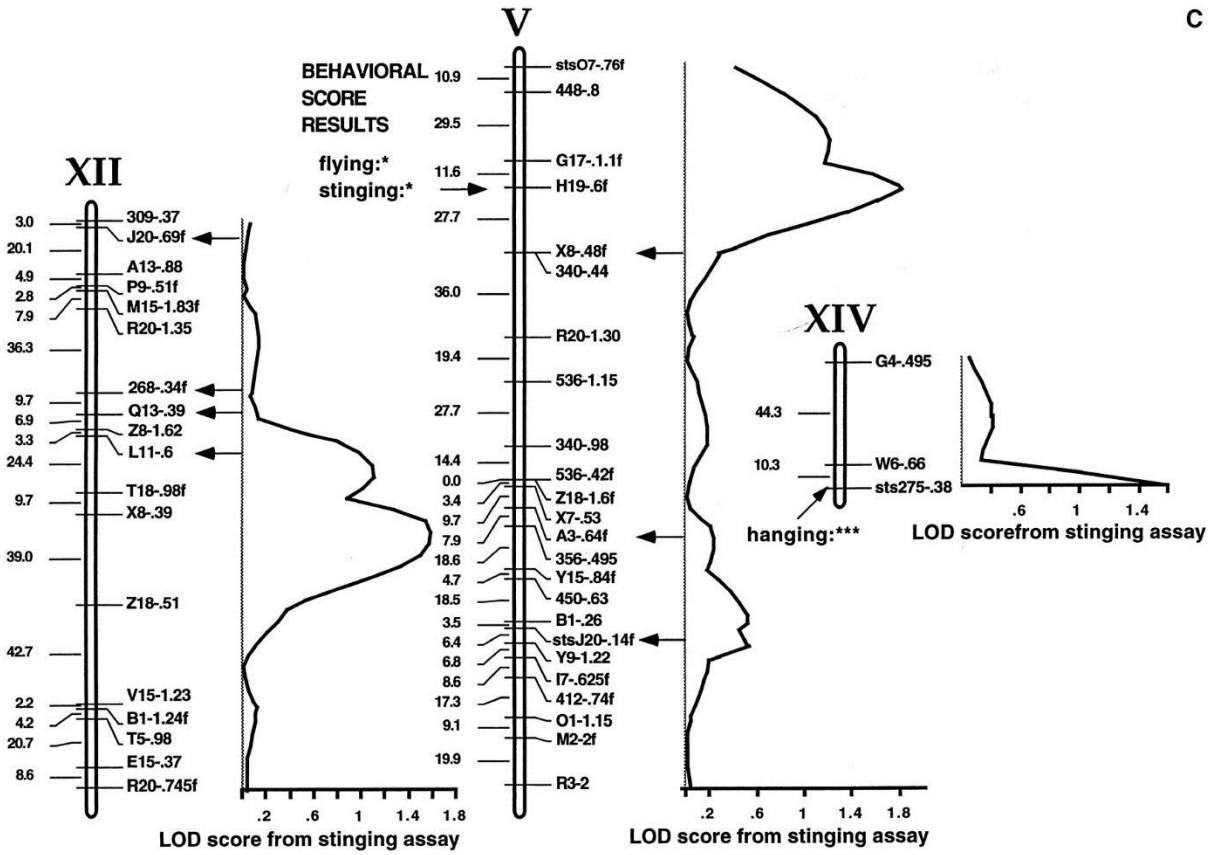


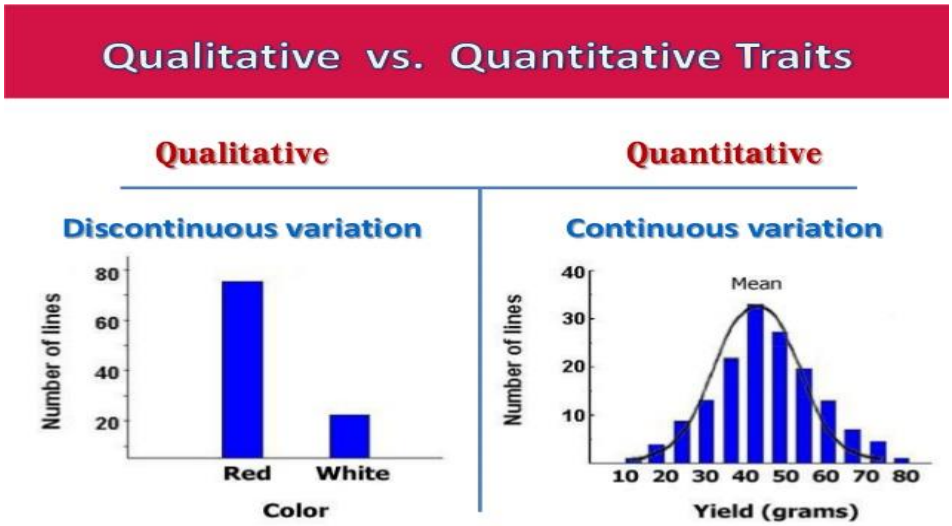
Quantitative and Qualitative characters

Qualitative Traits

A qualitative trait is a trait that fits into discrete categories. This means that you can neatly categorize a trait. For example, if a species of plant had either red leaves or yellow leaves, and nothing in between, this would be a discrete trait. "Yes or no" traits, traits where an organism either has the trait or doesn't, also fit into this category. Usually, a single gene or small group of genes control qualitative traits.

Quantitative Traits

Quantitative traits occur as a continuous range of variation. This means that these traits occur over a range. To picture this, imagine the length of a lizard's tail. The length can vary, and does not fit into natural categories. Generally, a larger group of genes control qualitative traits. When multiple genes influence a trait, you can also describe it as a "polygenic trait."



Phenotypic variation explained (PVE)

Genetic effects and phenotypic variation explained (PVE) by genetic components for traits related to flag leaf morphology of main shoots in wheat RIL population across four environments. Different lowercase letters indicate significant differences ($P < 0.05$) between genetic components for each trait.

The phenotypic variability explained (PVE) by QTL detected in the across environments analysis ranged from 4.9 to 12.4 % for biomass yield and 5.1 to 12.0 % for plant height. Overall, 11 genomic regions were identified that were important in controlling biomass yield and/or plant height in cereals.

QTL in Yellow mosaic disease in blackgram gram

Yellow mosaic virus (YMV) disease is a serious disease which affects the black gram productivity. In this study, 10 molecular markers reported to be linked to YMV resistance in black gram and mungbean were validated on 19 diverse black gram genotypes for their utility in marker assisted selection. Three molecular markers (ISSR8111357, YMV1-FR and CEDG180) differentiated the YMV resistant and susceptible black gram genotypes. Other seven molecular markers were either monomorphic or failed to amplify the marker fragment in black gram genotypes. Inter Simple Sequence Repeat (ISSR) marker ISSR8111357 and its derived Sequence Characterized Amplified Region (SCAR) marker YMV1-FR amplified the respective marker fragments in all YMV resistant genotypes except DPU 88-31, IPU 02-43, IPU 94-1 and IPU 07-3. A 136-bp allele of Simple Sequence Repeat (SSR) marker CEDG180 linked to YMV resistance was amplified in the aforementioned four genotypes in addition to PU 31. ISSR8111357 and CEDG180 are located on different linkage groups in the black gram genetic linkage map, suggesting that two independent resistance genes may be governing resistance to YMV in Indian black gram cultivars with marker ISSR8111357 linked to one resistance gene and marker CEDG180 linked to other resistance gene. Therefore, both markers can be used for marker assisted selection of YMV resistance. Among the resistant genotypes, PU 31 was the only genotype where both markers were amplified suggesting that PU 31 might be carrying both YMV resistance genes. Therefore, genotype PU 31 would be a valuable donor of YMV resistance and should be actively used in black gram breeding programs for incorporating YMV resistance.

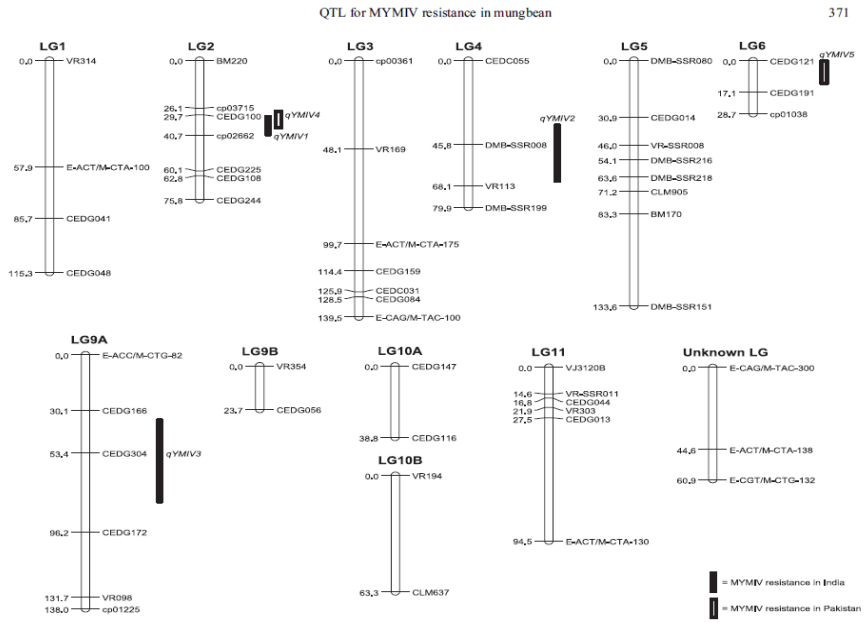


Fig. 2. An SSR-based linkage map of the mungbean RIL population derived from the cross KPS2 × NM10-12-1 and position of the QTLs conditioning yellow mosaic India virus resistance, as detected by composite interval mapping.

Fig1: QTL map in Blackgram for YMV resistence

QTL in Greengram for yellow mosaic disease

Mungbean (Vigna radiata) and ricebean (V. umbellata) were utilized to obtain an inter-specific recombinant inbred line (RIL) population with the objective of detecting quantitative trait loci (QTL) associated with mungbean yellow mosaic virus (MYMV) resistance. To precisely map QTLs, accurate genetic linkage maps are essential. In the present study, genotyping-by-sequencing (GBS) platform was utilized to develop the genetic linkage map. The map contained 538 single nucleotide polymorphism (SNP) markers, consisted of 11 linkage groups and spanned for 1291.7 cM with an average marker distance of 2.40 cM. The individual linkage group ranged from 90.2 to 149.1 cM in length, and the SNP markers were evenly distributed in the genetic linkage map, with 30–79 SNP markers per chromosome. The QTL analysis using the genetic map and 2 years (2015 and 2016) of phenotyping data identified five QTLs with phenotypic variation explained (PVE) from 10.11 to 20.04%. Of these, a QTL on chromosome 4, designated as qMYMV4-1, was major and stably detected in the same marker interval in both years. This QTL region harbours possible candidate genes for controlling MYMVresistance. The linkage map and QTL/gene (s) for MYMVresistance identified in this study should be useful for QTL fine mapping and cloning for further studies

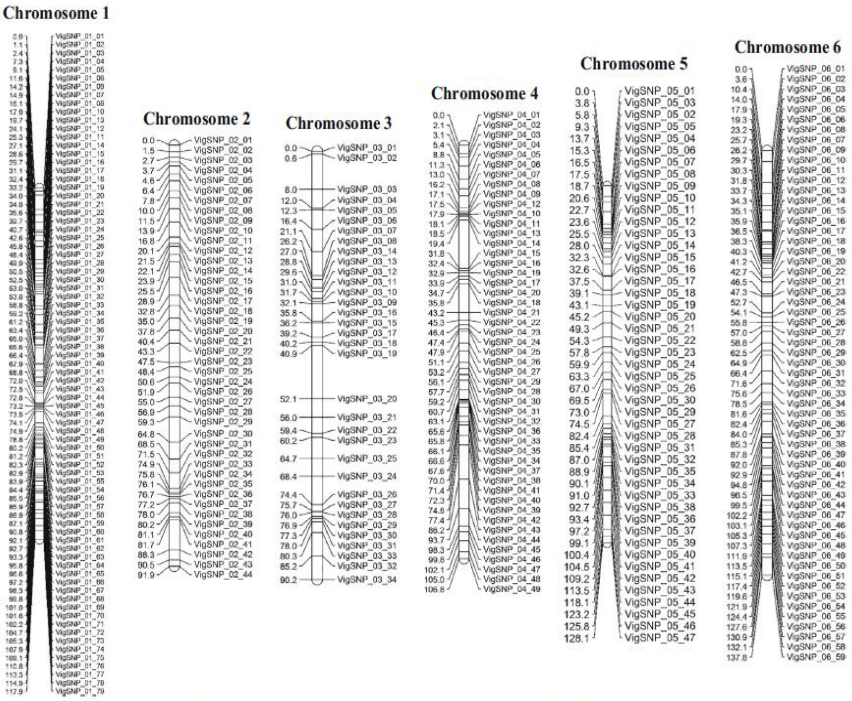


Fig. 4 Distribution of markers in 11 linkage groups (LGs) that represent 11 chromosomes of the F_9 RIL population derived from the cross between VRM (Gg) 1 and TNAU RED

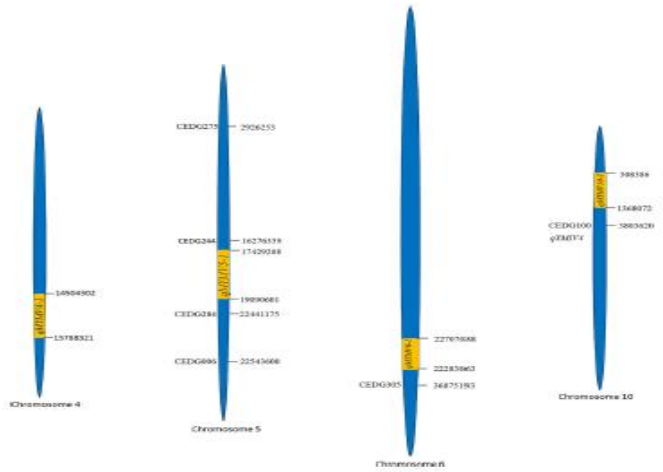


Fig1: QTL map in Greengram for YMV resistence

Advantages of QTL , Mapping

1. However, most of these markers were identified using specific mapping populations and therefore, there is a need to validate these markers in different black gram genotypes before applying these markers for marker assisted selection (MAS) of YMV resistance in black gram. In this study, we used 10 molecular markers reported to be linked to YMV resistance in black gram and mungbean for validation on different black gram genotypes

for their usefulness in MAS of YMV resistance in black gram breeding programs

2. Molecular markers and genetic linkage maps are pre- requisites for molecular breeding in any crop.

   Such tools would speed up the process of introgression of beneficial traits into preferred varieties

3. During pyramiding of resistance genes, it is difficult to select plants with multiple resistance genes based on phenotype alone as the action of one gene may mask the action of another. In such situations, the molecular markers help in identifying individual genes that could be used in gene pyramiding without pathogen inoculation and/or progeny testing.

6. PLANT PATHOLOGY

Fusarium Wilt of Castor and its Management: An Overview

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Abstract

Castor is important non edible oil which was found across all tropical and sub-tropical regions of the world can also grow in arid and semi-arid conditions. India dominates the world market for castor oil and ranks first in both the area and production of castor. Biotic stressors brought on by insects and pathogens are the main factors limiting castor yield. Among these diseases, vascular wilt caused by Fusarium oxysporum f. sp. ricini (Nanda and Prasad) is the most important soil and seed borne disease of castor causing significant yield losses up to 39-77%. The disease affects all crop growth phases throughout the year; however it is most noticeable during the flowering, spike production, and capsule maturity stages. Leaf blight symptoms and the development of dark stripes on the entire stem up to the afflicted leaves precede wilting. Both macro and micro conidia are produced by the fungus. The fungus also produces terminal and intercalary chlamydospores. The optimum condition for pathogen to infect the plant is at 13–15 °C and the symptoms to appear in their full form are at 22–25 °C. The fungi cause vascular infection, hence, chemical control is not much effective but integrated disease management will be effective and viable approach to manage the disease.

Introduction

Castor belonging to family Euphorbiaceae is found across all tropical and sub-tropical regions of the world, can also grow in arid and semi-arid conditions (Weiss, 2000).Its oil is an important raw material for several industrial products such as lubricants, soaps, hydraulic brake fluids, surfactants, surface coatings, varnishes, nylon fibers, polymers, dyes, and cosmetic and pharmaceutical preparations (Ogunniyi. 2006).India, Mozambique, China, and Brazil are major castor growing countries, accounting for 90% of the world's production. India ranks first in the area and production of castor and plays a significant role in the international castor oil market (FAOSTAT. 2019).In India, Gujarat is leading castor growing state, contributing around 82 % of total production in the country and has established a virtual monopolistic grip on the international market.

Castor production is predominantly constrained by biotic stresses caused by insects and diseases. Castor is known to be attacked by more than 150 pathogens, including fungi, bacteria, and nematodes (DOR 2003). Among these diseases, vascular wilt caused by *Fusarium oxysporum* f. sp. *ricini* (Nanda and Prasad) is the most important soil and seed borne disease of castor causing significant yield losses. Fusarium wilt in castor was first reported in 1937 from Brazil and in India from Udaipur, Rajasthan in 1974 (Nanda and Prasad, 1974). The wilt disease is an important seed and soil-borne disease of castor which appears at all crop growth stages and it is more prominent during flowering and spike formation stage. The extent of yield loss

depends on the stage at which plant wilts with the losses ranging from 77% at flowering, 63% at 90 days and 39% in later stages on secondary branches (Pushpawathi *et al*., 1998). The reduction due to wilt is 10 to 40% in yield, 8–14% in seed weight and 1–2% in seed oil content (Lakshminarayana and Raoof, 2006).

Symptomology

The disease occurs throughout the year in patches at all crop growth stages but it is more prominent at flowering, spike formation and capsule maturation stages. Seedling infection was common in wilt endemic areas. Young seedlings at 2–3 leaf stage exhibit discoloration of hypocotyl, loss of turgidity with/without change in leaf color. Wilting is preceded by production of leaf blight symptoms and formation of dark stripes on the entire stem up to the infected leaves. Drooping of plants with few top leaves after drying and dropping of all the affected lower leaves is a characteristic symptom and ultimately plants die (fig. 1). On the stem, clusters of purple colored sporodochia develop under humid weather conditions. Brownish discoloration and white cottony mycelial growth is also seen in the pith region if the stem is split open. Transverse and longitudinal sections of the affected roots reveal the presence of the fungus in vascular tissue. The infected stem tissue show intercellular mycelium in vessels and hypertrophy of xylem parenchymateous cells. Sick plants either do not bear capsules or produce dull colored wrinkled seeds. Seed borne nature of the wilt fungus has been reported and the extent of seed transmission was recorded up to 20%.

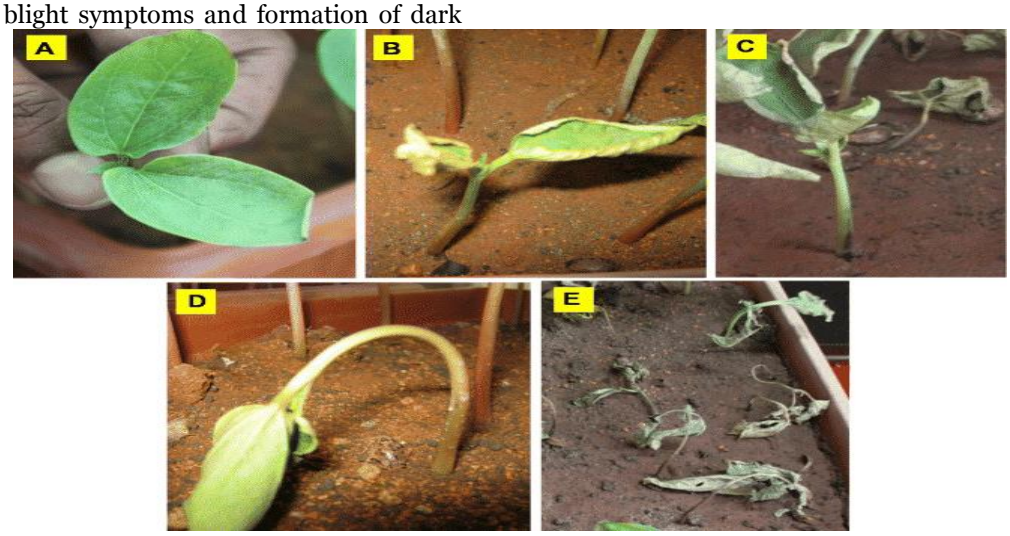

Fig.1 Symptoms of *Fusarium oxysporum* f.sp. *ricini* infection in castor (**a** Necrosis, **b** Discouloration and drying of leaf, **c** Black streak from color region, **d** Drooping of seedling, **e** Death of seedling)

Etiology

Fusarium oxysporum f. sp. *ricini*, Nanda & Prasad causes wilt disease. White fluffy mycelial growth of fungus observed on potato dextrose agar medium,that changes to pinkish when incubated under fuorescent light. The fungus produces both macro and micro conidia. The microconidia are single or two celled, round to ovoid, hyaline, many in number which measures 6.31–15.29×3.66–3.76 µ in size. Macroconidia are straight, spindle and sickle shaped, few in number, 2–6 septate (mostly 3) and measure 17.50–70.00×3.50–5.25 µ (Desai *et al.* 2003). Both terminal and intercalary chlamydospores appear which measures 8.7×4.44 µ. Generally, sporodochia develops in two-weekold cultures.

Disease Cycle

The pathogen is mainly seed and soil borne. The fungus found to be externally as well as internally seed borne to an extent of 10–20% (Raoof *et al.* 2003). In wilted castor plants, seeds carry inoculum at the micropylar end and seed infection generally confined to testa, tegmen and

endosperm (Naik 1994). The fungus survives in the infected crop debris for long periods in the form of chlamydospores as thick walled resting structures. Chlamydospores germinate under favourable conditions to produce mycelia with micro and macro-conidia. Under moist conditions, the spores germinate in soil and when they come into contact with the roots they infect the plants. Generally these spores enter the older roots and root tips through nematode feeding punctures, any other abrasions or natural wounds. The mycelium grows through the root cortex intercellularly inside the plant and invades the vascular vessels through the xylem's pits when it reaches the xylem. The mycelium remains in the vessels at this point, then it progress upwards through the stem later to crown of the plant. Microconidia are produced abundantly and carried upward within the vessel through the plants sap stream as the mycelium grows. The pathogen also advances laterally as the mycelium penetrates the adjacent xylem vessels through the xylem pits. As the fungi grow into xylem tissue after penetration, it invades diferent tissues of the plant, produces typical wilted symptoms by plugging up the vessels (Moshkin 1986).

Epidemiology

Plants are susceptible at all growth stages, but the disease generally appears in months of October–November when the crop is about 3–4 months old and becomes more prominent during February- March when the crop is in seed formation stage (Nanda and Prasad 1974). The optimum condition for pathogen to infect the plant is at 13–15 °C and the symptoms to appear in their full form are at 22–25 °C (Andreeva 1979). In the perpetuation and spread of the pathogen infected seeds play an important role upto a depth of 60 cm (Sviridov 1988). The inoculum potential found to be highest in arable layer. They enter the root tips and older roots through natural wounds, nematode feeding punctures, and other abrasions. Mono-cropping continuously for several seasons results in the wilt sick endemic areas.

Integrated disease Management:

- Cultivation of crop in low lying and ill drained conditions should be avoided
- Regular removal of diseased plant/plant parts from field reduces inoculum build up and spread
- Crop rotation for 2-3 years with non-host plants like pearl millet, ragi or other cereals play an important role in minimizing the disease intensity
- Seed treatment with thiram @ 3g/kg or bavistin @ 2g/kg of seed
- Grow resistant varieties viz., Haritha, DCS-9, DCH-32, DCH-177, 48-1, GCH-4 etc.
- Seed (10 g/kg) and soil application (1kg/100 kg FYM) of *Trichoderma viride* will reduce the wilt incidence
- Apply more quantity of FYM to the wilt affected plots
- Nematodes – predisposes the plants to wilt – manage nematodes

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7. POST HARVEST TECHNOLOGY

Inhibition of Enzymatic Browning in Postharvest Processing

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Introduction

Fruits, vegetables, and beverages browning is a major problem in the food industry and is believed to be one of the main causes of quality loss during postharvest handling and processing. Browning is categorized as enzymatic and non enzymatic (Walker, 1977). Nonenzymatic browning results from polymerization of endogenous phenolic compounds, as well as from the Maillard reaction that occurs when mixtures of amino acids and reducing sugars are heated where as enzymatic is by enzymes. This article focuses on inhibition of enzymatic browning in postharvest processing (Arthur *et al.,* 2018).

Enzymatic browning is the result of PPO catalyzed oxidation of mono- and diphenols to o-quinones. PPO is a mixed function oxidase that catalyzes both the hydroxylation of monophenols to diphenols (cresolase activity) and the subsequent oxidation to o-quinones (catecholase activity). The most effective method for controlling enzymatic browning in canned or frozen fruits and vegetables is to inactivate the PPO by heat treatment, such as by steam blanching (not for fresh foods), exclusion of oxygen (by the process of immersion in deoxygenated water, syrup, brine, or by vacuum deoxygenation, or coating of the food with surfactants)(Obrero *et al.,*1987). act primarily on the enzyme or react with the substrates and/or products of enzymatic catalysis in a manner that inhibits pigment formation. The use of antibrowning agents in the food industry is constrained by considerations such as toxicity, effects on taste, flavour, colour, texture, and cost. The most widespread methodology used in the food and beverage industries for control of browning is the addition of sulfiting agents. Sulfites are currently used to inhibit melanosis (blackspot) in shrimp, browning of potatoes, mushrooms, apples, and other fruits and vegetables.

Inhibitors of Enzymatic Browning

1. **Reducing Agents**: Reducing agents or antioxidants in the prevention of browning is their ability to chemically reduce the enzymatically formed or endogenous o-quinones to the colourless diphenols, or react irreversibly with the o-quinones to form stable colorless products analogous to the action of sulfites. The effect of reducing agents can be considered temporary because these compounds are oxidized irreversibly by reaction with pigment intermediates, endogenous enzymes, and metals such as copper. Thus, reducing agents are effective for the time period determined by their rate of consumption. The non specificity of reducing agents can also result in products with off-flavours and/or off-colours.
    a. Ascorbic acid and ascorbyl derivatives (ascorbic acid and erythorbic acid), ascorbyl phosphate esters, ascorbyl fatty acid esters, L-5,6-o-isopropylidene- 2-(9 methylcarbo:methyl ascorbic -acid and ascorbic acid vic-glycols, produced by reaction of dioxalan-based compounds with organic acids such as acetic acid.
    b. Sulfhydryl Compounds **(**p-mercaptoethanol, dithiothreitol**)**

2. **Chelating Agents**: Polyphenol oxydase contains copper in its active site. In the context of PPO catalyzed browning, chelating agents are believed to either bind to the active site copper of PPO or reduce the level of copper available for incorporation into the holoenzyme.
    a. Ethylenediaminetetraacetic acid or sodium salt
    b. Phosphate-based Compounds (Sodium acid pyrophosphate, polyphosphate or metaphosphate)
3. **Acidulants**

The pH optimum of polyphenol oxidase activity varies with the source of the enzyme and the particular substrate but in most cases it has an optimum pH in the range of pH 6 to 7. PPO preparations from several sources are reported to be inactivated below pH 4.O. By lowering the pH of the media below 3, the enzyme is effectively inhibited. Hence, the role of acidulants is to maintain the pH well below that necessary for optimal catalytic activity.

    a. Citric Acid and other acidulants
4. **PPO Inhibitors**: there are numerous reports on specific PPO inhibitors
    a. Substituted Resorcinols
    b. Aromatic Carboxylic Acids
    c. Aliphatic Alcohols
    d. Amino Acids, Peptides, and Proteins
    e. Anions
    f. Kojic Acid
5. **Complexing Agents**
    a. Cyclodextrins
    b. Chitosan
6. Enzyme Treatments
    a. Ring-cleaving Oxygenases
    b. o-Methyl Transferase
    c. Proteases

Conclusion

Development of anti-browning agents in the food industry is critical to maintain the quality of fruits and vegetables products. Traditionally, effectiveness and cost-efficiency are important factors to be considered for developing anti-browning agents. However, current trends in anti-browning agents need to meet consumer needs that demand attention to natural sources, health benefits, and sustainability. Enzymatic browning is a major factor contributing to quality loss of fruits, vegetables and processed foods. Moreover, there are efforts underway to elucidate the anti-browning inhibition in research wing.

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8. COMMUNICATION

Impact of Media and Social Media on Youth

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In today's wold, media became an integral part of our life and development of nation seems impossible without the use of these platforms. Media is influencing every aspect of the society either directly or indirectly. In 19th century, media passes through a number of phases and with these changes, there is relaxation by government in the regulation of media and people accepted it as a platform for marketing. As a result, there is immense increase in number of private news channels running across the day. With the development in information and technology, social media also penetrated every single aspect of life and a large number of people are directly or indirectly influenced by the media/ social media. We can call it media revolution or commercialization of media. Media has a huge market and now governs the political and economic world. With the development of media

there comes the development in education, health, sports, science, employment, religion, news and entertainment etc. everything is now available at a single click. But everything comes at cost and there are some positive and negative impacts of media/social media that are discussed as:

Positive Impact

- People are more connected to their family, friends and relatives.
- Media keeps us updated about the things that are happening across the world.
- Better expression of capabilities through social media, which makes the people feel better and confident.
- Better interaction or expression of emotions with peers as compared to face to face talking.
- Media is a suitable place for marketing and one can have a reach to a large number of customers for marketing of their goods.
- Media is a great source of advanced and indigenous knowledge to solve the issues faced in day to day life.
- Media is an excellent tool to save lives during the time of any emergence either by issuing advisory or warning related to event.
- Students around the world have easy access to the resources that are online and gain all the information.
- Social media enables the students to communicate easily with their teachers even during the pandemic that saved the time and carrier of the students.
- Media is one of the best way to connect with the peoples around the world to find new business ideas and to find jobs worldwide.

Negative impact:

- Youth today is giving utmost importance to the social media and is less concerned about the professional goals, family, sports and national or international issues.
- Virtual side of social media is having an ill impact on the youth of society and they try to mimic the behaviour of influencer at any cost without considering the difference in the economic and social status.
- People now a days have the habit of bullying their elders and when it comes to cyberbullying, it affects a lot to other elders as this can go viral easily.
- Social media is addictive and is responsible to side track the youth from it's priorities.
- Media sometime is influenced by political and economic sound people and can easily be used for their personal benefits.
- Lack of regulation on social media sometimes resulted in disturbed communal harmony of the nation.
- Social media lacks privacy and youth today get too open on social platform and share their personal information for virtual hipe.
- Social media is a tool for negative minded individuals for bullying and to create trauma or to create false propaganda against someone.

So, using media and social media in a responsible and productive way is the key to harvest maximum constructive from this revolution. We have to emphasise the positive impact and should try to elimination the negative impact so that we can harvest the maximum constructive. Because if the youths do so, this platform is blessing for mankind.

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9. SEED SCIENCE

Novel Seed Sowing Technique; the Seed Tape Technology

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Introduction

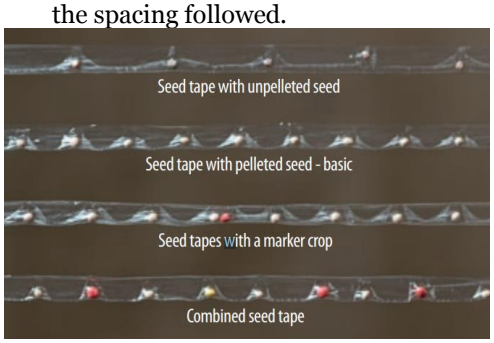
Seed is the primary input for agriculture. There are many constraints faced by farmers due to the smaller size of seeds, low seed weight like the proper spacing cannot be maintained, improper germination, washing away of seeds while irrigation, tough weeding operations, ants and birds attacking the seeds, etc. the new developing technology of seed tape is a solution for all these constraints. Seed tape was discovered by Schindler George Antony. Seed tape is a pre-sowing technique where seeds are laid in the tissue layer or water soluble film or degradable layer at proper spacing for proper growth and development of the crop.

Seed tape allows simple fast and very effective planting by maintaining accurate spacing for the optimum population. Even spacing maintained in the tap prevents oversowing of seeds by broadcasting. The method also reduces cultural operations like thinning and gap filling to maintain the population in the field. Researchers on seed tape technology focus on the aspects like the exploration of agronomic requirements for seed tape seeding, the research on seed tape manufacturing, and seed tape laying. The application research of crop seed tape sowing technology and equipment, including the agronomic technology, key technology and equipment of seed tape manufacturing and laying is finding more focus in precision agriculture.

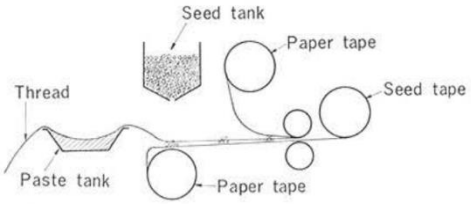
Types of Seed Tapes

The seed tape will be 5 to 10m long containing pelleted or unpelleted seeds on the transparent film based on which the tapes are divided into 3 types

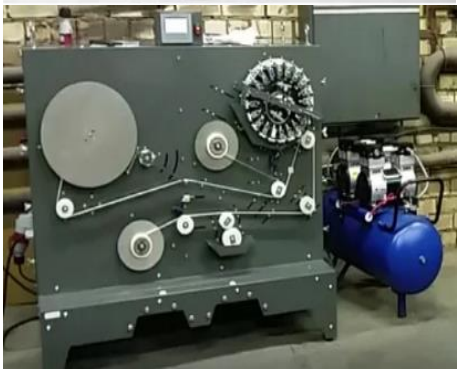
1. Seed tape with unpelleted seed: High vigour seeds unpelleted used in the tape.
2. Seed tape with pelleted seed: High vigour seeds pelleted used in the tape.
3. Seed tape with marker crop: A marker seed with distinct character added in the tape which has faster germination than the main crop for easy differentiation of the rows and the spacing followed.



Manufacturing of Seed Tape



The manufacturing of seed tape includes the placing of seeds into the seed tape material which is a water-soluble material with a metering device. The material used for seed tape technology is biodegradable cellulose or water-soluble tissue paper. The suitable material for seed tape manufacturing has caused many discussions among researchers. The concept of water-soluble material arose due to the difficulties faced to remove the plastic layer after the cultivation of the crop and the pollution and environmental effect caused by its usage.



The technology used in attaining the seed tape includes a seed wrapping system. The seed tape-making system contains (1) Seed tank, (2) two paper reels, (3) a cotton thread reel and (4) a motor.

The seeds are placed on one film and the other is used to cover it meanwhile the cotton thread is dipped in a paste tank containing adhesive materials like glutinous rice or maida solution which binds the two thin films together. The cotton thread gives the tensile strength for the tape for pulling and usage without damaging the seeds within. The seeds are placed on the spots according to the required spacing. The seeds are placed in convenience to the growth and cultural practises to be done for crop.

Tape Seeder Machine

The machine which is used for the establishment of seed tape on the field is the tape seeder machine. It consists of (1) float shoes (2) rollers and (3) tape reels. The machine is manually operated suitable for small and even large fields. The seeder machine makes furrows approximately 2cm deep the tape is placed in the furrow simultaneously. Hence the seeds are seeded and covered with soil ensuring proper germination. When the seeds are not covered by the soil the germinated stems basal part will be covered simultaneously.

Advantages of Seed Tape Technology

- Reduction in wastage of seeds.

- Reduction in requirement of labours for cultural practises like thinning and gap filling.
- Proper germination and establishment of the seedlings.
- Preventing the consumption of seeds by birds, ants or other insects.
- Maintenance of adequate spacing and proper resource utilization
- The tape is biodegradable or water-soluble causing no harmful environmental effects.

Disadvantages of Seed Tape Technology

- There is a high cost of establishment.
- The high rate of seed tapes than the normal pelleted seeds.
- There is a reduction in the quality of seeds.
- The less availability of seed tapes and its equipments.

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10. PLANT BREEDING

Speed Breeding and Its Implications in Crop Improvement

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Introduction

In the present scenario of global climate change, the increase in food production levels are not in pace to meet the hunger needs of the ever rising population. Agricultural scientists and plant breeders are under perpetual pressure to equip the present crop varieties for crop resilience to reap higher yields. Through their efforts by applying a surfeit of conventional and modern techniques, breeders are able to push up the yield bar. Though plant breeders are successful in designing varieties for climate change, the major limiting factor that hinders the progress of plant breeding is the time consumed in designing a variety. In the present scenario where, immediate attention has to be given for accelerated improvement, combining conventional methods with will underpin efforts to meet the challenge of feeding population of nearly 10 billion. Speed breeding involves the manipulation of environmental conditions under which crop genotypes are grown, aiming to accelerate flowering and seed set, for rapid advancement of generations that saves a lot of time and resources. Various breeding methods can be easily complemented with speed breeding, such as the single seed descent (SSD), single pod descent (SPD), single plant selection (SPS), clonal selection, marker-assisted selection (MAS), genomic selection. Therefore, speed breeding offers opportunities to rapidly develop stable varieties and to facilitate rapid generation advancement there by accelerating the breeding program. Also, speed breeding technology fits well with MAS and high-throughput phenotyping methodologies for multiple trait selection.

Limitation

- Needs expertise and technical skill to carry out a speed breeding program
- Require proper infrastructure, plant phenomics lab facility.
- Establishment needs long term financial funding and support
- Response of different plant species vary to extended photoperiods, especially the case with day-neutral plants, in which flowering will occur regardless of the photoperiod.
- In crops where photoperiod response is unknown or complex in nature, prior experimentation is required to standardise the protocol.
- Establishment of greenhouse with all the lighting and temperature requirements is a costly affair.

Conclusion

Speed breeding can effectively and efficiently accelerate the breeding cycle and aids in rapid development of improved cultivars to cater the emerging needs of ever rising population. Recent advancements in breeding techniques like genetic engineering, genomic selection and doubled-haploid technology have shortened breeding cycles and enhanced genetic gain rates. Speed breeding strategies are highly amenable with other breeding methods. When these technologies are paired with speed breeding techniques can enhance effectiveness of breeding programs. However, speed breeding is not widely adopted by many developing countries because of its high demanding nature for infrastructural facilities, trained breeders and financial needs. Financial aids/ backup for speed breeding programs in public plant breeding institutes would aid in sustaining the method usage and accelerating the pace of breeding accomplishments for ensuring food security.

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11. ENTOMOLOGY

Honey Bees in Crop Production

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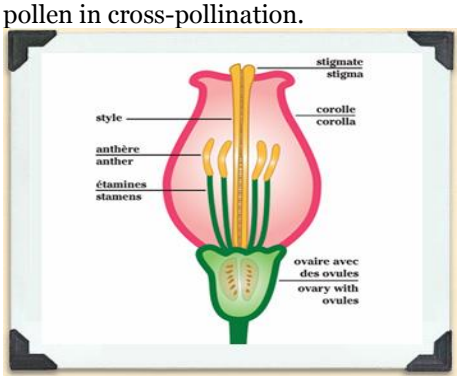
Introduction

Pollination plays a significant role in the agriculture sector and serves as a basic pillar for crop production. Plants depend on vectors to move pollen, which can include water, wind, and animal pollinators like bats, moths, hoverflies, birds, bees, butterflies, wasps, thrips, and beetles. Cultivated plants are typically pollinated by animals. Animal-based pollination contributes to 30% of global food production, and bee-pollinated crops contribute to approximately one-third of the total human dietary supply. Bees are considered significant pollinators due to their effectiveness and wide availability. Bee pollination provides excellent value to crop quality and quantity, improving global economic and dietary outcomes.

Pollination

Pollination is defined as the process by which pollen moves from the male anthers to the female stigmata, either within the same flower (self-pollination) or between plants (cross-pollination) . Pollinators are the key players of the crop yield process since plants completely rely on vectors to transfer their pollen in cross-pollination.



The Importance of Bees in Pollination

The most important thing that bees do is pollinate. Pollination is needed for plants to reproduce, and so many plants depend on bees or other insects as pollinators. When a bee collects nectar and pollen from the flower of a plant (some pollen from the stamens), the male reproductive organ of the flower-sticks to the hairs of her body. When she visits the next flower, some of this pollen is rubbed off onto the stigma, or tip of the pistil-the female reproductive organ of the flower. When this happens, fertilization is possible, and a fruit, carrying seeds, can develop.

Qualities of honeybees which make them good pollinators

1. Body covered with hairs and has structural adaptation for carrying nectar and pollen.
2. Bees - Not injurious to plants
3. Adult and larva feed on nectar and pollen - Available in plenty
4. Superior pollinators - Since store pollen and nectar for future use
5. No diapause - Need pollen throughout year
6. Body size and probascis length - Suitable for many crops
7. Pollinate wide variety of crops
8. Forage in extreme conditions also (weather)

Cooperation between farmers and Bees

In the recent years, there has been an increasing amount of data concerning the harvest of seeds in bee-pollinated crops. Some crop failures may be incorrectly blamed on poor soil, pests or drought, when in fact the real cause is lack of bees in sufficient numbers to pollinate the crop.Knowledge of the bee pollination can be so small that farmers try to get rid of useful bees by using smoke.

Challenges of honey bee pollination services

Honey bees have been in crisis since 2006, when bee keepers first reported the sudden disappearances of entire colonies.This phenomenon is known as colony collapse disoreder, but the causes behind it still are not understood.

The primary suspects are,

- **Neonicotinoids** are a group of pesticides common in the agricultural industry.They also alter bee behavior, limiting their ability to harvest nectar,and weaken bees'immune systems.
- The **varroa mite**, is a parasite that attacks honey bees, weakening individual bees and infesting

hives.Within one to two years, varroa mites can wipe out a colony of honey bees.Tracheal mites reduce honey production and eventually cause bees to die off.

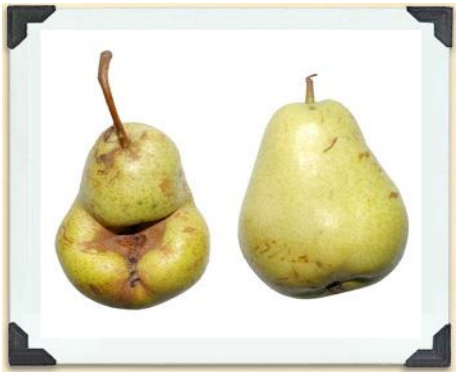
- Habiitat loss is another big threat to bee populations.

How to improve the population

- Avoid food grown using pesticides containing Neonicotinoids.
- Increase bee's natural habitat by planting a garden

Effect of bee pollination on crop

- Pollinators, primarily bees,are essential to agriculture,providing a significant yield benefit in over 60% of crop yield.
- It improves quality of fruits and seeds
- Bee pollination increases oil content of seeds in sunflower
- Bee pollination is a must in some self incompatible crops for seed set
- Flowers that are visited more often by bees will produce larger and more uniform fruit than those visited less often. This beneficial effect of pollination is most obvious in tree fruit.
- If a fruit tree's flowers are not sufficiently pollinated,its fruit can be misshapen



Conclusion

Pollination is an important ecosystem services and honeybee is valuable pollinator.One can utilize better agricultural technology like high quality seed,high-yielding varieties,and high quality agronomic techniques like timely irrigation and fertilizers.Still,without pollination,no fruitor seed will be produced.Almost all the food that we consume results from the pollination activity done by insects, especially honey bees. The formation of seed is the essential and crucial step for the new life. Honey bee accomplishes this activity throughout their life.

12. HORTICULTURE

Lettuce – Cultivation Techniques

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Introduction

Lettuce (*Lactuca sativa* L.) a member of family Asteraceae is one of the important salad crop. It occupies the largest area under protected structures among salad crops in the world. It is most often grown as a leaf vegetable. In many countries, it is typically eaten cold, raw, in salads, sandwiches, hamburgers, tacos and in many other dishes.

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Soil and Climate: It prefers light loam or sandy loam, fertile well drained, soils with pH of 6-8. Lettuce is a cool season crop and optimum mean temperature range for excellent growth and good quality of lettuce is 15-25°C and temperature above 25°C accelerates seed stalk and reduces the quality of leaves and may develop a high incidence of tip burn, bolting and may vary from loose heads. In addition, high temperatures may induce an irreversible flowering stage.

Types of Lettuce

Lettuce was cultivated as early as 4500 BC in the Mediterranean for the oil extracted from the seeds. Since then, production of the annual plant has spread worldwide. Lettuce can be split into two main groups:

1. **Head lettuce** (*Lactuca sativa* var. *captain*), which includes iceberg, crisp head and butter head lettuce.
2. **Leaf lettuce** (*Lactuca sativa* var. *longifolia* and *L. sativa* var. *crispa*), which includes romaine, green leaf and red leaf lettuce.
    - Only butter head lettuce is grown in green houses.
    - A good source of vitamin A, E and folacin, lettuce is considered a healthy food and its popularity is on the rise as consumers make more healthy food choices.

Cultivars

There are 6 commonly recognized cultivar groups of lettuce:

1. **Butter head** (*Lactuca sativa* var. *capitata*) forms loose heads. Its leaves have a buttery texture. Popular varieties include Boston, Bibb, Butter crunch, Tom Thumb.
2. **Crisp head** (*L. sativa* var. *capitata*) also called as Iceberg, forms tight, dense head that resembles cabbage. They are generally the mildest of the lettuces, values more for their crunchy texture than for flavour.
3. **Summer crisp**: Also called Batavian, forms moderately dense heads with a crunchy texture. This type is intermediate between iceberg and loose leaf types.
4. **Chinese lettuce** (*L. sativa* var. *asparagina*) types generally have long, sword-shaped, non head forming leaves.
5. **Loose leaf** (*L. sativa* var. *crispa*) has tender, delicate and mildly flavoured leaves. This group includes oak leaf, revolution, dark ruby red etc.
6. **Romaine** (*L. sativa* var. *romana*) also called Cos, grows in a long head of sturdy leaves with a firm rib down the center. Unlike most lettuce, it is tolerant of heat. Some of the cultivars are- Green Romaine.

Sowing time

Lettuce is a cool season crop and recommended growing time in mid hills is September to November but under Telangana condition it can be grown from November to January where the temperature is very low.

Seed rate

Seed rate varies from 350 to 500 gm per hectare depending upon the types of cultivar for transplanting crop.

Nursery Raising

Seedlings are raised in Nursery by the use of Polypropylene trays such as pro-trays or plug trays provided with holes at bottom. Portrays of 98 cells are used for raising of seedlings. These trays are filled with coco-peat. Seeds are sown @ one/cell and again covered with coco peat. After sowing, 8-10 trays are kept one above the other and covered with plastic sheet to create humidity and facilitates early germination.

Soon after germination, trays are shifted to poly or net houses and are placed in plastic sheet spread on nursery beds. These trays are irrigated with the help of rosecan. Seedlings are ready for transplanting after 20-30 days of sowing in trays. Seedlings are lifted from tray along the base bole of sowing media.

Planting

Double row planting is more convenient than single row. In general it is transplanted at a distance of 45 cm x 30 cm or 30 cm x 15 cm distance depending on the varieties or types.

Irrigation Requirements

Lettuce plants have a relatively shallow root system making them susceptible to moisture deficiency and excess. Optimum growth of lettuce occurs if moisture supply is uniform and close to

field capacity throughout season. Under polyhouse conditions drip irrigation is frequently done to improve water use efficiency.

Manures and Fertilizers

Lettuce does not normally demand a high uptake of nutrients. Approximately 80% lettuce growth occurs during the 3-4 weeks before harvest. Hence adequate nutrient availability during this period is critical.

Lettuce shows a favorable response to application of animal manures. Hence application of adequate quantity of well decomposed FYM @ 30 t/ha or vermicompost @ 10 t/ha along with 100:60:60 kg NPK/ha is recommended. Half dose of fertilizers are applied as basal, remaining half dose of fertilizers are applied 45 days after transplanting as top dressing.

Harvesting

In case of heading or crisp type, maturity is judged on the basis of head compactness. Compact head which can be compressed with moderate hand pressure is considered ideal maturity stage for harvest.

- • In romaine or Cos type, lettuce maturity is judged on the basis of number of leaves and head development. Heads that are slightly immature (less than 30 leaves before trimming) or just (having about 35 leaves) are ideal in terms of flavour due to more sweetness.

Post harvest handling and storage

- Lettuce should be quickly cooled after harvest to retain high quality and enhance shelf life.
- Hydro-cooling is effective for non-heading lettuce but is not used for heading lettuce.
- Lettuce held at temperature 0-2°C and high relative humidity more than 95% can be maintained in good condition for 2-3 weeks.

Yield: 25-30 t/ha

Physiological Disorders

Tip burn

Caused due to the prevalence of high temperature, light intensity and long duration, excess of nitrogen, soil moisture content and high endogenous level of IAA. This is common in glasshouse grown crop than field crop.

- **Control**: Increase the dark period and RH, spray the crop with $CaCl_2$ @ 0.5%

Insect-pest

- **Aphids (*Aphis gossypii*):** Suck cell sap resulting in reduced plant growth and quality.
- **Control**: Spray Dimecron (0.05%) and malathion (0.05%)

Diseases

Fungal: Damping off, Downey mildew, Grey mould

Bacterial: Bacterial rot

Viral: Lettuce mosaic, Big vein

13. AGRICULTURAL ECONOMICS

Post-Harvest Losses of Fruits and Vegetables: Impact and Mitigation Approaches

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Introduction

Post-harvest loss refers to measurable quantitative and qualitative food loss along the supply chain, starting at the time of harvest till its consumption or other end uses (Hodges *et al.,* 2011). India is one of the leading producers of food in the world. The country produces more than a billion tons of agricultural produce. Cereals account for 55 per cent of the net sown area while horticulture covers 16 per cent. Horticulture utilizes around 25 million hectares of area, however it contributes 38 per cent (which is highest) to the agricultural GDP.

The Government has got a study done on

"Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops and Commodities in India" by ICAR - Central Institute of Post-Harvest Engineering and Technology (CIPHET), Ludhiana. The study was commissioned in 2012 and the final report submitted on 31.03.2015. The study has estimated that annual value of harvest and post- harvest losses of major agricultural produces at national level was of the order of Rs. 92,651 crore calculated using production data of 2012-13 at 2014 wholesale prices. Among the total agricultural products, post harvest losses for fruits and vegetables accounts for about 5 to 16 percent.

India is the second largest producer of fruits and vegetables in the world. India produced 95 million metric tonnes of fruits (12.4 %) and 181 million metric tonnes of vegetables (13.3 %). The area under cultivation of fruits stood at 6.7 million hectares, while vegetables were cultivated at 10.3 million hectares (2019-20).

The post-harvest losses in fruits and vegetables are quite high due to their perishable nature and lengthy marketing channels. Post-harvest losses results in low per capita availability and huge monetary losses. There exist a huge gap between per capita demand and supply due to enormous waste during post-harvest activities caused by improper storage facilities, unavailability of cold chain facilities in various parts of country for preserving the produce, along with significant processing of the agricultural produce which results in immense loss to the nation.

The post-harvest losses increase cost on transport and marketing. This affects both the producer (reduction in share in consumer's price) and consumer (reduced availability and higher prices.)

Impact of post-harvest losses:

Post-harvest losses of horticultural crops affect both the nutritious status of the population and economy of the country.

1. **Nutrition:** Fruits and vegetables are rich source of vitamins and minerals essential for human nutrition. These are wasted in transit from producer to consumer represent a loss in the quantity of a valuable food. This is important not only in quantitative terms, but also from the point of view of quality nutrition.
2. **Economy:** Careless harvesting and rough handling of perishable fruits and vegetables bruise and scar their skin, thus reducing quality and market price. Such damaged product also fails to attract national and international buyers. This ultimately results in huge losses to economy.

Agribusiness Approach to mitigate the risk of post - harvest losses

The possible causes of post-harvest losses can be related to all the steps of supply chain and can be minimized by improving the efficiency of supply chain. It calls for the fact that an Agribusiness approach is the need of the hour to mitigate the post-harvest losses.

Agribusiness is the sum total of all operations that begin from input supply to consumption (production, storage, processing, marketing and distribution), and also includes all institutional arrangements (Banks, NGO's, SHGs, Government organizations) within.

The term coined by Goldberg and Davis (1957). They emphasized that various sub sectors of a production chain are interdependent and ignoring one while emphasizing another, may only lead to disruptions in long run resulting in broken production and supply chains. Eg: producing without knowing demand or market could be disastrous.

Broken Links in Agri-Supply Chain in India (Singh and Khanna, 2019):

Production: Poor extension, Quality inputs, Low productivity, Deficient and inefficient production management, Non demand linked production and Improper post-harvest management resulting in poor quality.

Supply Chain: Lack of storage, Poor transportation, High wastages, Multiple intermediaries, Fresh produce transported to mandis in open baskets or gunny bags stacked on top of one another, Cold chain absent or broken and Food safety is major concern: hygiene and MRL's not monitored.

Processing: Low processing, Lack of quality, Poor returns and Low capacity utilisation.

Marketing: Poor infrastructure, Lack of

grading, No linkages, Non-transparency in prices and Long delays from producer to retailer.

Agri logistics is the most important aspect to make sure that the farmer is able to find the favorable market for his produce. Farmers need cold chain set up to decide the time for perishables, or a proper storage for grains. They also need a near farm processing unit to change the form of the produce, which will help to reduce post-harvest losses to a good extent. Furthermore, the value chain needs to be integrated both forward and backward, wherein the information shall flow from consumers to farmers and from input suppliers to farmers as well. An integrated value chain will help in reducing post-harvest losses.

Technologies for minimizing post-harvest losses:

1. **Waxing:** It is used as protective coating for fruits and vegetables to reduce loss in moisture and rate of respiration and ultimately results in prolonged storage life.
2. **Evaporation cool storage:** It is the best short-term storage of fruits and vegetables at farm level. It helps the farmers to get better returns for their produce. It reduces shrivelling and extends the storage life.
3. **Pre-packaging:** This technology controls the rate of transpiration and respiration and hence keeps the commodity in fresh condition both at ambient and low temperature. It is able to bring revolutionary progress in our trade practice and also benefits both the consumer and producer because of its low cost and ready availability.
4. **Cold storage:** These structures are extensively used to store fruits and vegetables for a long period and employ the principle of maintaining a low temperature, which reduces the rate of respiration and thus delays ripening.
5. **Modified Atmosphere Packaging (MAP):** These packaging modify the atmosphere composition inside the package by respiration. This technology is successful to extend the shelf life of different fruits and vegetables.
6. **Controlled Atmosphere (CA) storage:** It is based on the principle of maintaining an artificial atmosphere in storage room, which has higher concentration of Co_2 and lower concentration of O_2 than normal atmosphere. This reduces the rate of respiration and thus delays ageing.
7. **Irradiation:** It is used during storage to reduce post-harvest losses and extend storage life of fruits and vegetable. When fruits and vegetables expose to ionizing radiation such as gamma-rays at optimum dosage delays ripening minimizes insect infestation, retards microbial spoilages, control sprouting and rotting during storage.
8. **Edible coatings:** These are prepared from edible materials such as proteins, polysaccharides and lipids. An edible coating improves structural integrity and mechanical handling so that, they help to maintain quality and inhibit microbial growth.

Conclusion

As per the report on Global Hunger Index 2021 India ranks 101st among 116 countries. It clearly shows our vulnerability and inability to address the postharvest losses, which otherwise could feed a huge undernourished or 'hungry' people. Inspite of being World's second largest food producer, India ranks second highest in under nourished population in the world. More than 80 per cent of India's farmers operate on marginal and small land holdings practicing almost subsistence kind of agriculture, and are victim of low production- low price cycle year on year. Their incomes are low and for most of them, the future generations disagree to take up their farming forward. How could this issue of persistent hunger and poverty be resolved? Is increasing productivity, as we have been emphasizing for long, the only solution? No, not exactly. Mere producing more does not ensure the accessibility of food to everyone; does not ensure food and nutritional security. We have been producing enough, however we have been unsuccessful utilizing resources efficiently, and in moving the produce right along the value chain, with minimal losses at every step.

Agribusiness approach to the problem seems a feasible and sustainable solution in long run. It is required that timely interventions are done at every stage of supply

chain which can reduce the losses significantly, making food easily accessible by everyone in terms of quality and quantity as well.

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14. FRUIT SCIENCE

Plasticulture in Fruit Crops

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Introduction

India is the second largest producer of fruits after China contributing 16% of the world population with 2.4% land resources and 4% of water resources. India contributes 11.7 MT/ha of fruit productivity which is very much lower when compared to other countries like Indonesia, USA, Brazil, Philippines, Italy, Turkey, Mexico etc. There are many reasons for low productivity, the major one is being non adoption of high tech horticulture. High tech horticulture includes the use of plastic from production till protection and packaging. In order to improve the productivity and also quality of the produce there is an urgent need of adoption of high tech horticulture which ensures sustainable resources utilization, affordable and also cost effective for small and marginal farmers. High tech horticulture includes use of plastic which is used in fruits crop for raising the seedlings in nursery (polybags), polycaps for grafted and budded plants, mulching the soil (strawberry), pipes used for drip and sprinkler irrigation which are also made up of plastic, fruit bagging, propagation structures, plant protection nets, fruit wrapping materials and also fruit carry bags.

Plasticulture

The use of plastics in horticulture has made considerable headway during the last decade. We are aware that plastics contribute from planting to post harvest handling and processing in many fruit crops. Plastic is used at each and every stage of horticultural life cycle right from seeds packaging, planting, propagation, mulching, irrigation, harvesting, fruit packing and preservation. The application of plastics in agriculture sector is popularly known as Plasticulture. India produces about 5 million tones of plastics annually and use about 0.35 million tons in agriculture. Plastics are used in greenhouses to promote growth and production, mulching to suppress weeds and maintain soil temperature and moisture as well as in containers for seedling and soil solarization to reduce pest and diseases.

Properties of Plastics

- Superior thermal insulation properties.
- Excellent Corrosion resistance.
- Superior flexibility.
- Excellent moisture barrier properties
- Excellent light transmissibility
- Impermeability to water, gas, etc.
- Resistance to chemicals.
- Less friction due to smoother surface.

Fruits Under Plasticulture:

- **Tropical fruits** - Mango, banana, papaya, guava.
- **Subtropical fruits**- Citrus, litchi, grape, pomegranate.
- **Temperate fruits**- Apple, pear, plum, peach, strawberry, raspberry, blackberry and cherries.

Major Applications in Fruit Crops:

- Controlled environment: Polyhouses, plastic tunnels, photo-selective nets and plant protection nets.
- Surface cover cultivation: Soil solarization covers, plastic mulching
- Nursery management: Shade-net houses, plastic bags, plastic pots, root trainers, polycaps, portrays
- Water management: Drip irrigation, sprinkler irrigation
- Packaging materials: Leno bags, plastic punnets, shrink wrapping

Greenhouse:

A greenhouse is a framed structure covered with transparent/translucent cladding material in which crops may be grown under modified environment. Depending on transparency, the greenhouse cover allows solar radiation to pass through but traps thermal radiation emitted by the objects within, thus increasing the inside temperature which is called as Greenhouse effect.

Polyhouse:

A polyhouse is a framed structure covered with transparent material in which crops may be grown under modified environment. Polyhouse production practices could be characterized as a farming process wherein the microclimatic conditions around the plant body are regulated partially or entirely according to the prerequisite of plants grown amid their time of growth in their natural habitat. In temperate regions, it is not favorable to grow crops in summer in tropical regions. Polyhouse brought a revolution in the agriculture sector to produce vegetables, fruits, grains, herbs and flowers in the off-season.

Plastic Tunnels:

A poly tunnel or plastic tunnel is a elongated semi- circular or square tunnel. It is most often constructed using steel and covered in polythene. Poly tunnels come in a range of sizes and are used to keep plants, vegetables and fruits warm enough to grow in temperate regions. It can also enable to grow fruits, vegetables and plants out of season.

Within the polythene tunnel, the temperature and humidity are higher. Crops and plants are also covered which means they are not exposed to heat, cold, rain, wind and strong sunlight therefore, they will continue to flourish even during adverse weather conditions.

Shade NET House:

Shade net house is a framed structure made of materials such as GI pipes, angle iron, wood or bamboo. It is covered with plastics net (net made of 100% Polyethylene thread with specialized UV treatment) having different shade percentages. It provides partially controlled atmosphere heat during day time to crops grown under it. Hence round the year seasonal and off-season cultivation is possible.

Shade nets are available in different shade percentages or shade factor i.e 15%, 35%, 40%, 50%, 75%, and 90% (for example 35% shade factor means- the net will cut 35% of light intensity and would allow only 65% of light intensity to pass through the net).

Plant Protection Nets:

Plant protection nets are the nets which protect the plants or crops from insects, birds, strong wind and other adverse climatic condition. These are available in different forms like

- Windshield nets
- Anti-bird nets
- Anti-hail nets

Plastic Mulching:

A protective covering (as of plastic film) spread or left on the ground to reduce evaporation, maintain even soil temperature, prevent erosion, control weeds, enrich the soil and keep fruit clean. Covering the soil around the plant with plastics which prevents the loss of moisture and acts as a barrier between the soil and atmosphere. It helps in moderating the soil temperature & micro-climate in the plant root zone, which helps to increase yield and early maturity of crops. LDPE and LLDPE plastic films commonly used.

Black mulches:

Black mulch does not allow sunlight to pass through onto the soil thus photosynthesis does not take place in soil in absence of sunlight below the black film. Hence, it arrests weed growth completely. The black plastic mulch is helpful in conserving moisture and

controlling weed growth. However, it may increase the soil temperature.

Clear or transparent mulches:

The transparent film is quite successful as soil solarization film for disinfecting the soil in order to reduce soil borne diseases and some weeds. This application is quite successful in nursery raising by solarising the beds before sowing seeds for nursery raising, which gives near 100% seed germination & disease free nursery. The transparent film is effective in hilly areas for raising soil temperature in cold climatic conditions during winter.

Two-side color mulches:

Available in yellow/black, white/black, red/black and silver/black colors. These are also called as wavelength selective or photo selective films. These are designed to absorb specific wavelength of solar radiation. It reduces the insect damage. Eg: Yellow mulch repels white fly.

Soil Solarization

Covering soil with a transparent polyethylene cover, to trap solar energy for controlling soil borne plant pathogens including fungi, bacteria, nematodes, insect and mite pests along with weed seeds. 25 micron transparent polyethylene film is used. Soil solarization is normally done during summer months when the air temperature more than 35°C.

Soil Solarisation

Nursery Management:

Plastic structures used for raising seedlings, storage of budded and grafted planting materials like shade net houses, poly bags, pots, polycaps, etc. Protection from biotic and abiotic stresses like wind, hail, rain, frost etc and also hardening of seedlings.

Protrays, plastic pots, polybags are made up of plastic which are used for raising the quality planting materials. The rose cans which are made up of plastic are used for irrigating the nursery plants instead of direct irrigating the plants. Polytapes for sealing the grafting and budded parts and also the pipes used for drip and sprinkler irrigation are made up of plastic.

In the propagation plastics are generally used in layering and grafting. In grafting polythene strips are used to tie stock and scion. Different colours of poly-wrappers used in layering. Red, blue and black poly-wrappers having higher success in rooting and survival by increasing physiological activities (etiolation effect) which is essential for cell division and cell enlargement. In nursery plastics are used in form of nursery bag, plug tray, crate and hanging basket. It is easy to handle, planting, transplant and transport. This plastic nursery bags can be used in different size and thickness depend on crop.

Water Management:

Plastic emitters and pipes are used in drip and sprinkler systems making water conveyance and application effective. Regulated application of irrigation water at low pressure and frequent intervals into the root zone of plant with the help of close network of pipes is known as drip irrigation system. Water saving up to 40% - 70% . The most important feature of plastics in drip irrigation system is the unit made by plastics are rust proof. The other quality like resistant to UV radiation, wide pressure compensation range, easy fitting to accessories, crack resistant and easy to roll back. This system is mostly made up of HDPE plastics.

Fruit Bagging:

Fruit bagging is the practice of putting bags over fruit to protect them from pests, elements and diseases. The practice is associated with organic farming as an alternative to pesticides. Bags are typically applied when fruit first appears and are kept on until harvest. Fruit bagging acts as a barrier between fruit and insects.

Fruit Bagging in Pomegranate

Packaging

Packaging is one of the most critical areas in the distribution and marketing of agricultural produce. More than 30% of agricultural produce is lost between the chain of farm and consumer.

The packaging must stand up to long distance transportation, climate, storage condition, multiple handling during distribution and marketing of agricultural produce. Traditional packaging techniques such as wooden crates and jute bags have many disadvantages like untreated wood can easily become contaminated with fungi and bacteria, material may be too hard or rough for produce like soft fruits, need of disposal of the crates after use so not reusable and ultimately cost of such material is more. Generally LDPE (Low Density Polyethylene), PVC (Polyvinyl Chloride), PP (Polypropylene), LLDPE (Linear low density polyethylene), HDPE (High Density Polyethylene) and PA (Polyamide) are used as plastic material in fruit packaging. Plastic packaging is very important because plastics are flexible, light weight, cost effective, hygienic, transparent so product visible from outside, easy printable, reusable, increases shelf-life of the produce. It provides invaluable support during processing, used in making of different packaging materials like flexible plastic films, tray with over wrap, punnets, net bag, foam sleeve, crates and also used in storing, preserving and transporting of fresh as well as processed fruits.

Conclusion

Plasticulture - benefit horticulture by its wide applications. It can be used to tackle region wise problems. It ensure efficiency and sustainability of agriculture practices .Use of mulching, cladding materials for protective structures, nets, pressurized irrigation, soil solarization, plastic wrapping, sleeving and packaging not only increase production but also minimize the pest, diseases and weed population and extend shelf life of fruits as well as saving fertilizers. Thus use of Plasticulture, which is in its infancy in India, can significantly benefit agriculture by its wide applications ensure efficiency and sustainability of agriculture produce. Scope and growth will not only depend upon availability and affordability but also the awareness of its advantages.

15. AGRICULTURE

Nano Bubbles in Agriculture

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Nanobubbles are nanoscopic gaseous (typically air) cavities in aqueous solutions that have the ability to change the normal characteristics of water. Ordinary bubbles have a diameter which range from 1 µm and larger. These quickly rise to the surface of a liquid and collapse. Nanobubbles which are <100 nm in diameter will randomly drift owing to what is termed, Brownian Motion and can remain in liquids for an extended period of time.

The small size of nanobubbles gives them much more interesting properties than larger bubbles, due to their high specific area and high stagnation features in the liquid phase.

Free-radical generation occurs when micro- and nano-sized bubbles collapse due to the high density of ions at the gas-liquid interface that develops prior to the collapse. It has been shown that nano-bubbles cannot remain in a stable state under atmospheric pressure due to extremely high internal pressure. Following a number of experiments, it has been suggested that the typical lifespan for a gas bubble with 100nm radius would be around 100 μs.

In saturated liquids, these nano-bubbles are extremely stable due to the absorption of ions on their surface. The gas molecules inside the nanobubbles do not come in contact with the bulk liquid, allowing the nanobubbles to last for a much longer time. Larger bubbles have air that is above atmospheric pressure, but nanobubbles contain internal pressures of tens or even hundreds of atmospheres. Under such high pressures, it has been proven that the liquid absorbs the gas inside the nanobubbles.

Applications of Nanobubbles

Nanobubbles have an extensive range of applications such as in drinking water and wastewater treatment, including decontamination of groundwater; decontamination of sediments and soils; biomedical engineering; and other industrial applications such as agriculture, fishery, and food.

One of the best uses of nanobubbles is the treatment of wastewater and drinking water that have been recently developed due to their ability to generate highly reactive free radicals. Hu and Xia (2018) showed the feasibility of remediating groundwater using ozone micro- and nanobubbles.

A new technology to decontaminate sediments using ultrasound with ozone nanobubbles uses three innovative technologies, namely, ultrasound, ozone, and nanobubbles, to provide a cost effective and environmentally sustainable onsite treatment of sediments with lower total cost over a shorter time span. It also has minimal adverse impact on the environment and the socioeconomic growth of the region. The ultrasound energy provides agitation and sediment decontamination. The ozone reacts with desorbed contaminants for removal from water. The nanobubbles help the dissolution of ozone gas in water (Meegoda and Batagoda, 2016; Meegoda *et al.*, 2017).

There are many biomedical applications of nanobubbles. One of them is the delivery of cancer drugs, where nanobubbles are placed in the body and are given the ability to identify tumor cells. The bubbles are blown up when they approach tumor cells, destroying the cancer (NHI, 2017). Nanobubbles have also been used in emergency procedure, where nano oxygen bubbles are injected directly into the bloodstream allowing people who are suffocating an extra 15 min during transportation to hospitals. While this is not a long time but it does allow for higher survival rate (Narayan, 2017).

There are many industrial applications of nanobubbles. Nanobubbles have shown the ability to create reactive oxygen species which contribute to seed germination. This increase in reactive oxygen species has the same effect as adding H_2O_2, resulting in higher germination rates. Also they used in sparkling water and sports drinks. With the addition of nanobubbles, the water can potentially keep gases for a longer time period (Bauer Nanobubbles, 2017). Nanobubbles also have application in paints. Due to the presence of nanobubbles, paint dries faster and also resists mold. In addition, there is an increase in brightness due to the nanobubbles (Bauer, 2014). They are also used as artificial flotation in water. This is accomplished by altering the ionic equilibria of dissolved ions in solutions and by changing the net charge on particle surfaces.

Nanobubbles are also used in food industry. Nanobubbles are used to regulate pH levels in liquids utilizing carbon dioxide (CO_2). This is achieved by adding nano CO_2 bubbles, which are suspended in the water for a long time regulating solution pH. Nanobubbles are also used in fish farming. Studies have shown that a decrease of oxygen leads to decreased respiration and feeding activity that slows growth rate of fish. However, with nano air bubbles, oxygen levels in water are maintained leading to high fish survival rates (Moleaer, 2017).

Nanobubbles have significant potential as a new environmentally friendly method to remove organic compounds through their small size and existence of a surface charge, which

effectively improve the air flotation process to separate suspensions; the large specific surface area and durability of nanobubbles allow the enhancement of the oxygen mass transfer efficiency to promote aeration for aerobic microorganisms to biodegrade organics and decrease the production of excess sludge in the activated sludge process, and alleviate fouling on the membrane of MBRs; moreover, the ability to generate free radicals with considerable oxidation function promotes the degradation of organic compounds. In this regard, this technology has significant value for treating wastewater containing organic pollutants.

Most offensive odours produced in wastewater are the gaseous by-product of decomposed organic matter. The most common of these is hydrogen sulphide, commonly referred to by its chemical formula H_2S, which is formed from the anaerobic degradation of organic matter containing sulphur or from mineral sulphates and sulphites. Hydrogen sulphide is known for its rotten egg smell and can adversely impact human health at levels above 10 ppm. Odour in sewer lines, collection points, treatment plants, and ponds can lead to public complaints and reduces aesthetic value. One means of treating odours, including H2S, is to prevent the water from going anaerobic by increasing dissolved oxygen (DO) or oxidation reduction potential (ORP) using air, oxygen or other oxidants. Nanobubbles effective gas-injection technology delivers a high volume of air or oxygen nanobubbles, efficiently maintaining DO and preventing the anaerobic conditions that lead to odorous compound formation.

Nano bubbles have been applied for the prevention and removal of proteins adsorbed onto solid surfaces. It has been shown that adsorption of proteins onto various surfaces could be inhibited by NBs, thus preventing the surfaces from fouling. For example, NBs can block adsorption of bovine serum albumin on mica surface, while NBs also helps remove organic contaminants from pyrolytic graphite and gold surfaces (Liu et al., 2008). Recently, similar defouling effect of NBs was also observed on stainless steel surface.

It is reasonable to consider that MBs and NBs would have wide applications where materials come into contact with biological media, such as medical equipment, membrane cleaning, ship and filter regeneration. MBs and NBs may provide a promising path for a convenient, clean, cheap and environmental friendly technique suitable for cleaning of conducting surfaces. Hence, it can be concluded that the use of MBs and NBs in developing new technology is still ahead to be explored.

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