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Agriculture Science: Research and Review Volume IX

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PREFACE

We are delighted to publish our book entitled ***"Agricultural Science: Research and Reviews Volume IX".*** *This book is the compilation of esteemed articles of acknowledged experts in the fields of basic and applied agricultural science.*

The Indian as well as world population is ever increasing. Hence, it is imperative to boost up agriculture production. This problem can be turned into opportunity by developing skilled manpower to utilize the available resources for food security. Agricultural research can meet this challenge. New technologies have to be evolved and taken from lab to land for sustained yield. The present book on agriculture is to serve as a source of information covering maximum aspects, which can help understand the topics with eagerness to study further research. We developed this digital book with the goal of helping people achieve that feeling of accomplishment.

The articles in the book have been contributed by eminent scientists, academicians. Our special thanks and appreciation goes to experts and research workers whose contributions have enriched this book. We thank our publisher Bhumi Publishing, India for taking pains in bringing out the book.

Finally, we will always remain a debtor to all our well-wishers for their blessings, without which this book would not have come into existence.

Editors

CONTENT

TRANSFORMATION AND MOBILITY OF MAJOR MICRONUTRIENTS IN SOIL

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Abstract:

Plant need certain nutrients other than the macronutrients, but in small quantities, these nutrients are called as micronutrients which are also essential for plant growth, development and disease resistance. A deficiency of one or more of these micronutrients can lead to severe depression in growth, yield and crop quality**.** Biogeochemical cycling of these micronutrients play an important role in availability of these nutrients in soil from unavailable to available form through various transformation processes such as mineralization/ immobilization and microbial oxidation/reduction reactions. Various factors such as soil pH, organic matter content, temperature and microbial activity influence the availability of these micronutrients in soil. Mobility of micronutrients in soil through different methods describes their availability and deficiency in soil. Therefore knowledge about their transformation and mobility of the micronutrients will help in correct placement and increasing their availability in soil for long term use.

Keywords: Micronutrients, Deficiency, Transformation, Mobility, Fertilizers

Introduction:

Plant nutrition and other ecosystem functions are influenced by a number of chemical elements which are divided into macro nutrients (those absorbed in large amounts from soil and fertilizers) and micro nutrients (those absorbed in lesser quantities from soil and fertilizers). Eight elements such as (iron, manganese, zinc, copper, boron, molybdenum, nickel, and chlorine) are essential micro nutrients that are required for plant growth, but required in such small quantities (0.01-1000ppm) and generally (less than 1ppm) that they are also called trace elements, oligo elements and spurn elements. Despite of their less requirement, too little or too much of one or more of the micronutrients can stimulate dramatic effects in plant growth. Biogeochemical cycling of each of these elements plays an important role where these nutrient elements are converted from unavailable to available forms through a wide variety of transformation processes that include immobilization/mineralization and microbial oxidation/reduction reactions. The mobility of nutrients is also one of the important factors in knowing the availability and deficiency of the nutrients and is the over-all process whereby nutrient ions reach sorbing root surfaces, thereby making possible their sorption into the plant. Modern agriculture practices have led to increase in demand of micronutrients by the high yielding crop cultivars (especially rice and wheat) due to the crop yields which require large amount of these nutrients followed by long-time cropping which has removed measurable amounts of these nutrients. It is therefore, an urgent need to pay more attention to the adequacy of micronutrients in crop production.

Available and Critical Level of Micronutrients in Indian Soils

Table 1: Total and available micronutrient content of Indian Soils (Source: Reddy *et al.*, 2017)

Micronutrients	Total content (mg kg-1)	Available content (mg kg-1)		
	Range	Mean	Range	Mean
Zn	20 - 97	55	0.12 – 2.80	0.54
Fe	13000 - 80000	33000	3.40 – 68.1	20.5
Mn	38 – 1941	537	4.00 – 102.0	26.0
Cu	11 – 141	41	0.15 – 5.33	1.7
B	2.8 – 630	-	0.04 – 7.40	1.7
Mo	Traces – 12.3	-	Traces – 2.80	-

Variability in the total micronutrient contents of Indian soils is a mirror of the diversity of the parent materials (Rocks and Minerals) from which these have originated and the available nutrient content at a given time is only a very small fraction of the total amount present.

Table 2 : Critical Levels of Micronutrients in Indian soils (Source: Reddy *et al.*, 2017)

Nutrient	Extractant	Critical level (mg kg-^{1})
Zn	DTPA	0.4-1.2 (0.6)
Fe	DTPA	2.5-4.5
	Ammonium acetate	2.0
Cu	DTPA or Ammonium acetate	0.2
Mn	DTPA	2.0
B	Hot water	0.5
Mo	Ammonium oxalate	0.2

Elucidation of critical levels of micronutrients describes the deficiency, optimum and toxic range and is considered to be important with respect to fertilizers application. As the critical levels are found to vary with the soil fertility status and the crop and the cultivator levels.

Mobility of micronutrients in soils and plants

The most useful concept of plant nutrition for diagnosing nutrient deficiency and their availability is the principle of nutrient mobility in plants. Nutrients must reach the root surface before uptake by the plant.

The three methods by which nutrients reach the root surface are

1) Root interception
2) Mass flow
3) Diffusion.

Importance

- The relative importance of these methods can provide guidance for the most efficient method of application of each micronutrient.
- A dominant method for a nutrient to reach a root surface is most important when it is deficient because this can guide correct placement.

1) Root Interception

Root interception is the growth of the root into contact with ions that are held on the exchange complex of clays and organic matter. Copper and iron are usually held on the exchange complex. This also applies to some extent for zinc.

2) Mass Flow

Mass flow (or convection) given by Munch is the transpiration induced convective flow and is defined as the movement of dissolved nutrients along with water to the plant root which the plant roots absorb for transpiration. Mass flow provides an over abundance of Cl, B and Mo to the annual crops.

3) Diffusion

Diffusion is the movement of ions from a higher concentration to one of lower concentration. Diffusive movement of ions does not necessarily involve water movement. Whether nutrients arrive at the root surface by root interception or mass flow and are taken up by the plant, the concentration of those nutrients is lowered and diffusion can occur. Uptake of manganese, zinc, and to some extent iron and molybdenum if limiting has been shown to be related to movement by diffusion in the soil.

- Mobility of micronutrients in soil is known to depend on their availability in three forms which are
  1. Mobile micro nutrients which are highly soluble and are not adsorbed on clay complex. Eg: $B0_3^-$ Cl^-, Mn^{2+},
  2. Less mobile micro nutrients which are also soluble but they are adsorbed on clay complex so their mobility is reduced. Eg: Cu^{2+}, iii) Immobile micronutrient ions which are highly reactive and get fixed in the soil. Eg: Zn^{2+}

Micronutrients Transformation in Soil

Zinc Cycle

Zinc exists in the soil as zinc cations in soil solution **,** soluble zinc and OM complexes known as chelates**,** Zinc is retained by soil particles on the cation exchange sites**,** Primary and secondary zinc containing minerals. Zinc bearing minerals can dissolve and supply zinc to the soil solution. Once in the soil solution, zinc can be immobilized , taken up by plants, retained by soil particles or chelated with soluble OM. OM zinc must undergo mineralization before it becomes available for plant uptake.

Iron Cycle

Iron exits in soil as both mineral and organic forms. Iron may exist in the soil solution and includes soluble iron and OM complexes in the form of chelates, as primary minerals , as precipitated minerals and on cation exchange sites of soil particles. Fe containing minerals may dissolve to replenish the soil solution as iron is removed by plants. Little iron is retained by the cation exchange sites of soil particles as compared to base and acid cations.Organic cycling is an important process that ensures iron availability through the process of mineralization and immobilization.

Copper Cycle

Copper exists in the soil as solution copper and includes soluble copper and OM complexes known as chelates , Exchangeable copper on the cation exchange sites of soil particles, Primary and secondary copper minerals. Copper may be occluded or buried within the structures of various minerals such as iron and aluminium oxides. Organic copper is more tightly bound to OM than the other micronutrients, Copper deficiencies can occur in organic soils. Copper containing minerals can dissolve and supply Zn to the soil solution. Like Zinc, copper can be immobilized by microorganisms, taken up by plants or exchanged on soil particle surfaces. Copper may also form chelates with soluble OM. Organic copper must be mineralized before it is available for plant uptake.

Manganese Cycle

Manganese exists in soil as manganese cations in soil solution and includes soluble manganese and OM complexes known as chelates**,** exchangeable manganese on soil solution (cation exchange sites)**,** primary and secondary manganese containing minerals. Manganese is retained by the cation exchange sites of soil particles. Manganese may undergo precipitation/dissolution/sorption/desorption on the cation exchange sites and mineralization and immobilization of OM may also provide Mn in soil solution.

Boron Cycle

Boron exists in the soils as soil solution boron, exchangeable boron on the anion exchange capacity sites**,** primary and secondary boron minerals**,** boron and OM complexes**.** H_3B0_3 is the most common form of boron in soils that have a pH between 5 and 9. The exchangeable boron buffers changes in the boron levels of the soil solution. OM supplies plant available boron.

Molybdenum Cycle

Unlike other micronutrients molybdenum exists as an anion in the soil solution. The molybdenum exists in soil as soil solution molybdenum, exchangeable molybdenum on the anion exchange sites, primary and secondary minerals, organic matter .Instead of being held onto the CEC molybdenum is held to soil particles with an anion exchange capacity including amorphous materials, iron oxides, acidic kaolin clays. Organic molybdenum undergoes mineralization and immobilization.

Chlorine Cycle

Nearly all of the chloride in soil exists in the soil solution. The mineral and organic fractions contain only small quantities of Cl^-. Cl^- adsorption to clay or oxide surfaces is negligible. Because of its high solubility and mobility in soils, appreciable Cl^- leaching can occur under conditions of high water transport through soil.

Micronutrients Transformations influenced by pH in soil solution

Iron

- **Mineral Fe**: Most of the soil Fe is found in primary minerals, clays, oxides and hydroxides. The solubility of the common Fe minerals in soil is very low , only 10^{-6} to 10^{-24} M Fe^{3+} in solution depending on pH.
- **Soil Solution Fe**: Compared with other cations in soil, the Fe^{3+} concentration in solution is very low. In well drained oxidized soils , the solution Fe^{2+} concentration is

less than that of Fe^{3+} species in solution .Soluble Fe^{2+} increases significantly when soils become waterlogged. For every unit increase in pH Fe^{3+} concentration decreases 1000 fold. In contrast Fe^{2+} decreases 100 fold for each unit increase in pH.

$$Fe(OH)_3\ (soil) + 3\ H^+ \longrightarrow Fe^{3+} + 3H_2O$$

Manganese

- **Soil Solution Mn**: The principal species in solution is Mn^{2+}, which decreases 100 fold for each unit increase in pH. The concentration of Mn^{2+} in solution is predominantly controlled by MnO_2. Mn in the soil solution is greatly increased under acidic, low redox conditions.
- The frequent occurrence of Mn deficiency in poorly drained mineral and organic soils is often attributed to low Mn levels resulting from leaching of Mn^{2+}
- Because of its mobility Mn^{2+} can leach from soils, particularly from acidic podzols.

Zinc

- **Soil Solution Zn**: Zinc in the soil solution is very low with more than half of the Zn^{2+} in solution complexed by OM. Above pH 7.7, $ZnOH^+$ becomes the most abundant species . Zinc solubility is higly pH dependent and decreases 100 fold for each unit increase in pH.

$$Soil\text{-}Zn + 2H^+ \longrightarrow Zn^{2+}$$

- Soil solution concentration and plant available Zn are governed predominantly by solution pH and Zn adsorbed on clay and organic surfaces in soils.

Copper

- **Soil Solution Cu^{2+}:** The Cu concentration in soil solution is usually very low. The dominant solution species are Cu^{2+} at pH <7 and $Cu(OH)_2$ at pH >7 as described below.
- **Adsorbed Cu**: Cu^{2+} is specifically or chemically adsorbed by layer silicate clays, OM and Fe, Al or Mn oxides through formation of Cu-O-Al or Cu-O-Fe surface bonds.
- **Occluded and Coprecipitated Cu**: A significant fraction of Cu is occluded or buried in various mineral structures such as clay minerals and Fe, Al and Mn oxides.

Boron

- **Soil Solution B**: Undissociated H_3BO_3 is the predominant species expected in soil solution at pH values ranging from 5 to 9. At pH >9.2 $H_2BO_3^-$ can hydrolyze to

$H_4BO_4^-$. B can be transported from the soil solution to the absorbing roots by both mass flow and diffusion.

- **Adsorbed B**: B desorption and adsorption can buffer solution B which helps to reduce B leaching losses. Increasing pH, clay content and OM favor $H_4BO_4^-$ adsorption.

Molybdenum

- **Soil Solution Mo**: Mo in solution occurs predominantly as MoO_4^{2-}, $HMoO_4^-$ and H_2MoO_4. Concentration of MoO_4^{2-} and $HMoO_4^-$ increases dramatically with increasing soil pH described below. The extremely low concentration of Mo in soil solution is reflected in the low Mo content of plant material.

Factors affecting the availability of micronutrients

The effects of soil environment on micronutrient cations are different from those of micronutrient anions. Fe, Mn, Cu, Zn, Ni are called micronutrient cations as these carry positive charges. B, Mo and Cl occurs as anions and carry negative charges.

Effect on cations

Certain soil factors tend to exert a similar effect on the availability of all the micronutrient cations.

1. Soil pH:

It is the most important factor which regulates the solubility and availability of micronutrients in soil. If the pH of the soil is higher than 7.0, the micronutrient cations get precipitated as insoluble hydroxides. Eg:

Soluble ion		**Insoluble compound**
$Fe^{3+} + 3OH^-$	→	$Fe(OH)_3$
$Cu^{2+} + 2OH^-$	→	$Cu(OH)_2$
$Mn^{2+} + 2OH^-$	→	$Mn(OH)_2$
$Zn^{2+} + 2OH^-$	→	$Zn(OH)_2$

Solubility and bioavailability of a micronutrient cations decreases above pH 6.0, thus necessitating the maintenance of soil pH around 6.0 for keeping the micronutrient cations in adequate amount in soil solution.

2. Oxidation state of micronutrient cations:

Reduced states of Fe, Mn and Cu are more soluble than oxidized states at the normal pH range of soils. The reduced states are encouraged by poor oxygen supply under submerged conditions. In well-drained aerated calcareous soils, micronutrient cations exist in oxidized state and their availability becomes very low, and therefore plants suffer from micronutrients deficiency, although the total content of all the micronutrients may be very high.

3. Interaction of micronutrient cations with other soil constituents:

The availability of micronutrient cations in soil is highly affected by inorganic ions in soil solution, soil solid constituents, especially free oxides of iron and aluminium, soil organic matter, fertilizers and amendments applied to soil. Silicate clays contain micronutrient cations, particularly Zn, Fe and Mn in the octahedral layer especially in 2: 1 type of clay minerals. Fixation by soil clays may cause serious problems for Zn and Cu and is less significant for Fe and Mn because of their high total content in soils. The presence of carbonate and bicarbonate ions in soil due to sodicity or overliming reduces the availability of micronutrient cations to field as well as orchard crops which suffer most from iron deficiency.

4. Soil temperature:

Low temperature also interferes with the availability of micronutrient cations in soil. When the soil temperature goes down due to freezing, zinc deficiency appears in the crop. This deficiency of micronutrient cations in soil at low temperature is mainly caused by the decreased solubility of native micronutrient cations. Wet soil conditions at low temperature further aggravate the situation in terms of decreased availability of micronutrient cations.

5. Soil organic matter:

The ability of soil organic matter to hold micronutrient cations in stable combinations is well established. Copper is retained very strongly in organic soils and such insoluble complexes are responsible for low availability of copper in organic soils. The zinc availability is also low in organic soils for similar reasons. But some organic ligands can keep micronutrient cations as chelates and these are plant available.

6. Microbial Activity:

Microorganisms also assimilate these micronutrients cations as they require these metal ions for many microbial transformation reactions and temporarily immobilize the micronutrients in their body. Later on, these immobilized micronutrients are released in soil after the death of microorganisms through mineralization process.

Effects on Anion

B, Mo occurs as anion in soils and these do not show any similarity in their behaviour in soils.

1. Soil pH:

Boron availability decreases as pH increases. Unlike the other micronutrients the availability of molybdenum increases with increasing pH.

2. Soil Moisture:

Dry environments reduce the availability of boron

3. Interaction with other nutrients:

Crops are less sensitive to boron when there is ample amount of calcium because calcium acts to reduce boron availability. Molydenum is strongly held onto the surface of aluminium and iron oxides, which reduces its availability.

Conclusion:

Micronutrients are the nutrients which are needed in small amounts and when they are needed, very small applications of micronutrients are known to produce striking results. 'Micronutrient availability' in soil (i.e., all the soluble forms that can be taken up by plants) depends on their solubility in soil. Transformation processes such as immobilization/mineralization and microbial oxidation/reduction reactions play an important role where these nutrient elements are converted from unavailable to available forms and increase their solubility in soil. There are many soil factors influencing micronutrient solubility and availability for plants such as pH, organic matter content, temperature, interaction with other nutrients etc. Understanding the factors controlling trace element solubility allows the selection of soil amendments that promote or reduce their availability in soil.

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LASER AND ITS APPLICATION TO AGRICULTURE FIELD

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Introduction of LASER:

The word LASER is short form of Light Amplification by Stimulated Emission of Radiation. In fact laser is a resource of light or radiation having a special set of characteristics. Laser light has amazing properties which are not generally found in the ordinary light sources. An important invention of the 20^{th} century of science, the laser holds pivotal position due to broad range of applications in various fields. Because of the striking special feature LASER radiation it is becoming most popular tool amongst all electromagnetic radiation in all walks of life. The attributable to the following striking special features are: 1) high directionality 2) high intensity 3) extraordinary monochromaticity 4) high degree of coherence and 5) wide range of wavelength.

Nowadays laser and laser systems are widely used in the field of communication, industry, medicine, military operation, scientific research, agriculture, etc.

Historical background of laser

Einstein in 1917 proposed a theory on electromagnetic (EM) radiation based on stimulated emission of photon, absorption of photon and spontaneous emission of photon. Einstein suggested that stimulated emission must exist as the balance between emission and absorption. Einstein's theory of radiation was not technically successful until mid-fifties of the last century. First successful result of stimulated emission was obtained in microwave region by C. H. Townes in USA in 1954. Independently and simultaneously similar outcomes were obtained by Charies Townes, Nicolay Basov and Aleksander Prokhorov in the field of quantum electronics. This was used to design oscillators and amplifiers using the maser –laser principle.

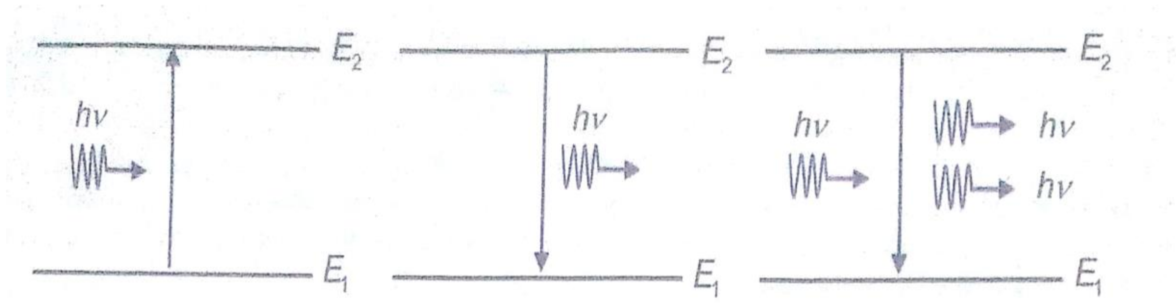
First successful implementation of stimulated emission in visible and infrared radiation was carried out in ruby laser in 1960 by T. H. Maiman of Hughes research laboratory, in California. In the same year major breakthrough was obtained in laser field in the form of gaseous discharge of He-Ne which was demonstrated by Javan A. et al. Laser plays an important role in current fundamental research. Till date 31 scientists have shared prestigious Nobel Prize on 14 different occasions in laser technology and applications (Raghu, 2017).

Table 1: Nobel award in the laser and it's application field

Sr. No.	Year	Nobel laureates	Work
1	1964	Charles Townes, Nicolay Basov and Aleksander Prokhorov	Fundamental work in the field of quantum electronics, which has used to the construction of amplifiers and oscillators based on the maser-laser principle.
2	1966	Alfred Kastler	Optical pumping
3	1971	Dennis Gabor	Holography
4	1981	Nicolas Bloembergen, Arthur Schawlow	Nonlinear optics and laser spectroscopy
5	1989	Norman F. Ramsey	Maser and atomic clocks
6	1997	Steven Chu, Claude Cohen-Tannoudji, William D. Phillips	Methods of cooling and trapping of atoms by use of laser light
7	1999	Ahmed H. Zewail (chemistry)	Study of chemical reactions by use of femtosecond laser pulses
8	2000	Zhores Alferov, Herbert Kroemer	Semiconductor heterostructures based on lasers of high speed opto-electronics
9	2001	Wolfgang Ketterle, Eric Cornell, Carl Wieman	Experimental realization of Bose Einstein condensation.
10	2002	John B. Fenn, Koichi Tanaka (chemistry)	Mass spectroscopic analysis of biomolecules by use of laser desorption
11	2005	Roy J. Glauber, Theodor W. Hansch, John L. Hall	Theory of coherence and optical frequency analyzer.
12	2009	Charles K. Kao. Willard S. Boyle, George E. Smith	Ground breaking achievements concerning the transmission of light in fibers of optical communications invention of an imaging semiconductor circuit-the CCD sensor.
13	2014	Stefan W. Hell, Eric Betzig and William E. Moerner (chemistry)	Development of super resolved fluorescence microscopy
14	2017	R. Weiss, B. C. Barish and K. S. Thorne	The crucial contributions to the LIGO detector and the observation of gravitational waves.

Principle of Laser Action:

Quantum theory states that there are discrete energy levels. The light interacts with the matter with by absorption, stimulated emission and spontaneous emission. These processes can be explained with a simple two discrete level model of an atom. The tendency of an atom is to remain in the lowest energy state. When light falls on the matter, atoms get excited to one of the higher energy levels. The process is called as absorption. The atoms cannot remain in exited state, once the incident light is stopped it will return into ground state in 10^{-8} seconds by emitting photon of energy E_2-E_1=hν, which is spontaneous emission. The atom in an excited state interacts with external incident photon of a certain definite frequency. The same atom drops to a lower energy level by emitting photon with same frequency, phase and polarization of incident photons. This process is called as stimulated emission.



(a) absorption **(b) spontaneous emission** **(c) stimulated emission**

Figure 1: Process of Laser action

Amplification and Population Inversion:

The productive conditions are framed by the stimulated emission; more atoms are forced release photons. This will trigger a chain reaction and will release huge amount of energy, which will be a monochromatic light travelling coherently in a precise fixed direction. This procedure is called as amplification by stimulated emission.

The population means the number of atoms or molecules in any energy level or state at a given instance of time. Usually lower energy level or state (ground state) has more population of the atoms than that of the upper energy level. For the Laser action pumping process should keep a higher population of atoms in the upper energy level compared to lower energy level. The condition in which population of atoms in upper energy level is more than that of the lower energy level, which is a reverse of the normal occupancy, is known as population inversion. For the process of stimulated emission, it is essential that atoms that are in the upper energy level or meta-stable state should have long life time i.e. the atoms may stay at the meta-stable state for long time.

Characteristics of laser:

The characteristics which distinguish lasers from other known light sources are

I) Directionality

II) High intensity

III) Extra ordinary monochromaticity and

IV) High degree of coherence

I) Directionality: The Laser sources emit light only in one particular direction. The directionality of laser beams is termed as full angle beam divergence, which is double the angle that the outer edge of the beam makes with the axis of the beam. The outer edge of the beam is determined as a point at which the strength of the beam has decreased to 1/e times its value at the centre. A beam with planar wavefront radiates from an aperture of diameter (d), then the beam propagates as a parallel beam for a distance about d^2/λ.

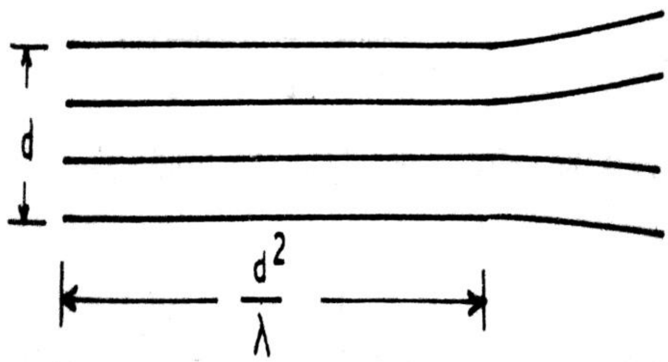


Figure 2: Divergence of Laser beam

The angular spread $\Delta\theta$ of the far field beam is related to the aperture diameter d by

$\Delta\theta=\lambda/d$

For a typical laser beam divergence is less than 0.01 miliradian. (The beam spreads less than 0.01mm. for every meter.)

II) Intensity: The narrow beam of laser light has concentrated energy in a small region. This concentration of energy has both spectrally and spatially. Due to this laser beam has greater intensity.

III) Monochromaticity: The monochromaticity is the Greek words, mono means single and chroma means colour. Monochromatic light have single colour or single wavelength. Laser light is greatly more monochromatic than that of any conventional monochromatic source.

IV) Coherence: Two light rays are perfectly coherent if they have a constant phase difference, identical frequency and same waveform. Laser light has a high degree of coherence. Laser light emits high coherence light it makes probable to realize a wonderful spatial coherence of light power, such as 10^{13}w in a gap with linear dimensions of only 1µm.

Types of Laser:

The numerous types of laser may be broadly classified according to their production techniques. They are following types

I) Solid-state lasers

II) Dye lasers

III) Semiconductor lasers

IV) Free Electron lasers

V) Chemical lasers

VI) Gas lasers

I) Solid-state lasers:

In solid-state lasers, solid substances are used in Laser devices. The active material is used in laser is less than one percent. The bulk material does not participate in the laser action, it acts as a host. Some examples of solid-state lasers are as follows. Ruby laser, rare earth ion lasers, Nd: Glass lasers, tunable laser etc.

II) Dye Laser:

The important and useful types of liquid lasers are organic dye lasers. These lasers have played very prominent role in atomics and molecular spectroscopy. In this laser an organic dye dissolved in a suitable liquid such as ethyl alcohol, benzene, methyl alcohol, acetone, water etc. used as the active medium. These lasers were first invented by Sorokin et al. Example of dye laser are as rhodamine 6 G (Xanthene dye).

III) Semiconductor Laser:

Semiconductor lasers are of smallest size of all Lasers. The semiconductor Laser consists of a semiconducting material, such as lead selenide, gallium arsenide etc. These lasers have partially reflecting mirrors at the ends of parallel faces. Semiconductor lasers are known as junction lasers because they produce laser energy at the junction of two types of impurities in a semiconductor. Semiconductor lasers are simple and light in weight with compact unit. Semiconductor lasers are not suitable for high powers applications. It emits wavelength 0.7 to 1.8 microns (1 micron=10^{-4}Cm). Semiconductor lasers are mainly used in the area of communication through low-loss optical fiber. They have large market as reading devices for compact dice players.

IV) Free Electron Lasers:

Free electron lasers are different from any other types of lasers. In this laser, the radiation is not obtained by discreet transitions in atoms or molecules of a material. High energy electrons are passing through a varying magnetic field that causes the electrons to oscillate to and fro in a perpendicular direction to the direction of their beam. These oscillations cause the electrons to radiate the oscillating frequency and stimulate other electrons also to oscillate and emits at the alike frequency and same phase with the original oscillating electrons. It emits an intense beam of light emerging from one end of the device. These lasers radiate any wavelength from the ultraviolet to infrared regions. A great benefit of this laser is a high output power in the range of kilowatts. These lasers have applications mainly in the medical field.

V) Chemical Lasers:

Chemical lasers produce a high energy light in the reaction of two or more chemicals. The light sources of intense light produced by chemicals may be used for laser excitation. Chemical laser produces radiation in the region of 3.4-4.1μm. Chemical laser have more efficiency and extremely powerful beam of light, which are being developed for star war programme by United State to destroy the enemy missiles in space.

VI) Gas Lasers:

Gas lasers have a combination of gases or a gas as their light-amplifying substance. Electrical pumping is used by applying a high voltage between electrodes placed within the gaseous medium to accelerate the required high energy level. These lasers are of continuous wave types and high coherence. They are significantly less powerful as compared to solid state lasers. Some examples of gas lasers are Helium-Neon laser, Co_2 laser, Copper vapour laser, Argon Ion laser, He-Cd laser, He-Se laser etc.

Laser Treatments in Agriculture:

Last 50 years, various chemical are used for fertilizing crops and controlling pests helping to expand highly successful farm system ensuring more food production. The applications chemical fertilizer results into contamination of foodstuff with toxins it also decrease soil yielding capacity (Aladjadjiyan *et al.,* 2007). It is necessary to find best quality of seed which will help the farmer to avoid above mention draw back help them to have maximum crop production. Such seeds of best quality will produce quick and uniform seedling which will result into good quality product. Germination of seeds depends on its quality, environment, seed born pathogen and superiority of soil. To increase germination percentage by using medicine and chemical fertilizer is harmful for environment and society.

Light plays an important role in growing plant. The germination process and plant growth depends on how much period it is exposed to light (Behzadi *et al.*, 2012). The peculiar characteristics of Laser radiation, its coherence, high density, polarization, monochromaticity is not only used in engineering field but it also find in important in medical and plant biology The uniqueness of the laser radiation, such as monochromatic, coherence, polarization and high density, can be used not only in area of engineering but also in medical and plant biology (Dinoev *et al.*, 2004; Aladjadjiyan *et al.*, 2007). It is demand of time to search new technique for increasing agro product because the demand for food is increasing day by day (Aladjadjiyan *et al.*, 2007; Yasemin *et al.*, 2013; Yasser *et al.*, 2009). Scientist proposed the use of LED light, micro-wave and laser light for accelerating plant growth, to increase disease resisting enzymatic activities. These methods are also useful to concentrate chlorophyll in the seeds (Soltani *et al.*, 2006; Durkova *et al.*, 1993; Gladyszewska *et al.*, 2006; Hernandez *et al.*, 2005).

J. Podlesny (2002) has conducted experiment in Pulawy. The objective of the study was to evaluate physiological and biochemical changes in faba bean (Vicia faba minor) seeds. He irradiate faba bean (Vicia faba minor) with Laser for different irradiation dose such as 1) no irradiation–D_0, 2) single irradiation– D_1, 3) Double irradiation–D_3 , 4) three-fold irradiation– D_4, 5) four-fold irradiation– D_5 and 6) five-fold irradiation–D_6. A single dose was equal to 4·10 –3 $J \cdot cm^{-2} \cdot s^{-1}$. The results show that the activity of amylolitic enzymes increases with time, reaching its maximum value between 24 and 72 h after sowing. Irradiated seeds show significant change in enzyme activity, particularly at the initial stage of their germination. The three-fold and the five-fold treated seeds give similar results. Treated seeds increase in the amylolitic enzymes activity for three-fold and five-fold doses after 12, 24, 48, 72, 96, 120 and 144 h after sowing by: 18.1, 77.4, 114.0, 90.2, 40.0, 16.6, 21.2%, respectively. The rate of germination is found to be different when harvest time for treated and untreated seeds. Significant result was obtained after 12 and 24 h after sowing. The number of germinated seeds is found to be more as compare to lower dose of irradiation than that of higher dose. All the seeds were germinated after 144 h. The seeds grown started to emerge after 17 days of sowing. Irradiated seeds influenced the rate of the occurrence of the first plants. The plants grown for three- fold and five-fold irradiated seeds did not differ significantly with regard to the time of germination. Treated seeds germinated about 2–3 days earlier than the untreated seeds. Differences were observed in plants growth and development between treated and untreated seeds. Plants obtained from treated seeds were earlier and higher to flower about 3–4 days than the plants from untreated seeds. The pre-sowing treated seeds accelerated the rate of dry matter accumulation of particular plant parts. It is observed that there is more influence on the yield of dray matter during germination and flowering stage. Laser light influenced the increase in the dry matter yield of particular plant parts roots, leaves and stems.

Yi-Ping Chen *et al.* (2004) studied the influence of He-He laser irradiation on seeds thermodynamic parameters and seedlings growth of Isatis indogotica. They studied physiological characters (net photosynthetic rate, stomatal conductance, water utilization efficiency and concentration of chlorophyll). Biochemical characters (soluble saccharides, soluble protein, pyruvic acid) and growth parameters of seedlings (biomass and leaf area) they found significant increase in all the above three characters when the seedlings were pre treated with He-Ne laser. This study suggested that pre-treated of seedlings with He-Ne laser has short term as well as long term effect. They stated that laser irradiation are chiefly of light effect, temperature effect, pressure effect and electromagnetism effect. The low power laser is emits little heat and pressure effect. During the germination process the enthalpy change (ΔH) was higher in pretreated seeds with laser than the control seeds. The change of enthalpy referred to heat content, which is related to internal energy. The change of enthalpy was causes change of entropy, which was involved in temperature change. The laser treatment has induced enzymatic activities, change in thermodynamic parameters, change in biochemical metabolism, which accelerated and enhanced the physiological growth of seedlings.

St. Dinoev *et al.* (2004) studied effect of laser irradiation on wheat and maize. They observed that laser irradiation can have beneficial effect in maize and wheat growing. It increased crop yield. The results show that irradiation with 1min. gives significant germination. The amount of chlorophyll per unit of an area in the sixth leaf was increased 7-8% in plants from laser irradiated seeds. The photosynthesis intensity received after the laser irradiation showed that in 34^{th} and 41^{st} day was increase intensity. The effect of laser irradiation on the leaf mass and density was increased significantly. There was increase in the crops average day growth rate and the accumulated dry substance. This shows that the laser irradiation leads to change in the growth and development of the crop.

Noha S Khalifa *et al.* (2011) have studied on the effect of pre-sowing laser (Nd-Yag) source at wave length λ= 532nm treatment on soybean seeds. Laser irradiation dose was 5, 10, 30, 60 and 120 minutes on uniform soybean seeds. In this study, they investigated protein banding patterns of the leaf pools at the molecular level of the irradiated and non-irradiated control plants. The results obtained clearly indicated that the vegetative growth of soybean seedlings (4- week- old) was significantly enhanced due to Nd-Yag laser treatment. The magnitude of seedling growth was increased with the exposure time of laser treatment. The investigation in molecular mechanism by which laser induces growth and development in higher plants, the seedling leaves were extracted and then separated using the SDS-PAGE electrophoresis method. An achieving significant result was noted with the linearly increased level of a ~ 55 KD protein concomitant with the increased dose of irradiation time. They stated that pre sowing laser treatments of seeds led to increased concentration of the Rubis CO large subunit. It enhanced growth and productivity of soybean plants. Due to increase in the large subunit concentration of the enzyme in the chloroplast that act as a positive feedback signal therefore the expression level of other RBCs genes in the nucleus increases. They concluded that the laser irradiation on seeds was enhance the formation of more active Rubis CO, more CO_2 fixation and accelerated plant growth.

H. R. behzadi *et al.* (2012) studied influence of LED laser on Basil seeds before sowing. They treated Basil seeds by the LED lamp with wavelength of 620-625 nm from a distance of 1 cm. The seeds were divided into four groups. 1st group was the control group and received no radiation. 2nd, 3rd and 4th groups were irradiated 6, 12, 24 hours. After 50 hours, they examined the following parameters:

1) Average number of fertilized seeds in each group,
2) Average height of plants in each group,
3) Average number of new leaves in plants,
4) Growth rate of groups and
5) Uniformity of growth in each group.

They noted that after six day the irradiated seeds which have exposed for 24h showing enhancement in germination up to 85% and controlled was 50%. The 24 hours irradiation seeds were found to be more than the average height and they are grown almost linearly. We define growing rate as the speed of extra new leaf of plant. This growing rate had more informality for 24 hour exposed seeds. The samples with more radiation have more uniform growth characteristics. Furthermore, the amount of chlorophyll is greater in the plants from more irradiated time seeds. The seeds that irradiated with LED light were noted longer and more roots. They concluded that increasing internal energy of seeds due to irradiation of photons of LED light, germination percentage increases, growth rate, chlorophyll content and biological parameters also increases.

Yasemin Z. Rassam *et al.* (2013) conducted a study on Laser treatment on hard wheat seeds and observe growth and fungal infection. They used He-Ne (λ=632.8nm), Diode lasers (λ=650nm) and Nd-YAG laser with wavelength 532nm. as irradiation tool. The seeds were divided into two groups. Both the groups were irradiated in different conditions, one in dray condition and second in wet condition. Again these two groups were divided into five subgroups. Dose of irradiation were 1) control (no irradiation), 2)1 minute, 3) 5 minutes, 4)10 minutes and 5)15 minutes to He-Ne laser. The same condition and same dose for other groups of seeds were irradiated with Diode laser and SHG Nd-YAG laser. First group of seeds was irradiated in dry condition and second group was irradiated in wet condition after soaking water for 24 hours. The percentage of seed germination was noted after He-Ne, diode laser and Nd-YAG laser treatment in dry and wet conditions. The He-Ne and diode laser enhanced the germination percentage of wheat cultivars. The maximum percentage of germination was 95% recorded after two days with He-Ne irradiation for 5 min in wet condition and 93% of germination by diode laser for 5min. The Nd-YAG laser significantly enhanced the germination percentage of wheat after 3 days to reach maximum of 93% with 5minutes irradiation in wet condition. The percentage of germination was low for 5minutes irradiation in dry condition was 83%, 82% and 85% for He-Ne, diode laser and Nd-YAG laser treatment respectively. There was no significant effect on germinations with 10 minutes irradiation, while 15 minutes irradiation caused an inhibition in germination percentage. He-Ne and Diode lasers exposing on the hard wheat seeds were considerable improvement in the growth and early development of the plant. When treated in wet condition the hard wheat seeds show improvement in growth and resistance to fungal infection. The irradiation on seeds was causing cell pumping and enzymatic stimulation. There are many enzymes that control the plant growth and development. The laser treatment can be an alternative method to control seed infection by fungi.

Huize Chen and Rong Han (2014) studied the effect of irradiation of He-Ne laser and UV-B radiation on wheat seedlings. Treatment with a He-Ne laser (wavelength: 632nm, flux rate: 5.0mW mm^{-2}) with dose 1) control, 2)1 min, 3) 2 min, 4) 3 min, 5) 4 min and 6) 5 min. were applied. They have sowed 30 seeds on wet filter paper per petri dish and grow at 25 °C and 60% relative humidity and sprayed water daily. They examined the effects of He-Ne laser treatment on wheat seed the photosynthesis of wheat seedlings exposed to He-Ne laser by measuring parameters in wheat such as root length, seedling height, and MDA, soluble protein and sugar contents. They observed that 2 minutes exposure of He-Ne laser will result maximum root length, plant height, more soluble protein and soluble sugar. They stated that low dose (2 min at 5 mW mm^{-2}.) treatment have positive effects on wheat plant height, root length, and soluble sugar and soluble protein levels. However, with increasing irradiation time, He-Ne laser inhibited wheat growth and damaged wheat seedlings at the physiological level. They observed that exposure to UV-B radiation had deleterious effects on wheat photosynthesis parameters. Photosynthesis process is one of the most sensitive metabolic processes in plants. Photosynthesis is directly linked to biomass production and yield. He-Ne laser irradiation stimulated the activities of key enzymes and improving seedling photosynthesis.

Marcela Krawiec *et al.* (2016) studied on seed germination and root yield of Scorzonera hispanica L. They were used He-Ne laser with wavelength of 632.4nm and power density –6 and 8mWcm^{-2}. Seeds were irradiated with a two doses of He-Ne laser beam of 1, 3 and 5 times. The duration of each irradiation treatment was ca. 0.1 s. The results of 2-year study shows that the irradiation He-Ne laser on scorzonera seeds had a positive effect on the germination capacity, emergence and root yield relative to the control. The most positive effects were observed after the 5-time irradiation of the seeds. Depending on the irradiation dose applied on the seeds, the germination capacity of the seeds enhances and increased by 1.5-13.2%. The irradiated seeds had longer radical and greater dry weight compared to those non-irradiated seeds. The emergence and the yield of roots also were dependent on weather condition. In the experiment the weather conditions proved to be a highly significant role. The root yield increased by 1.2-13.5% depending on the laser light dose applied. The root yield was increase due to increased field emergence. They concluded that laser irradiation can be used for the improvement of the quality of scorzonera seeds. They also stated that the use of laser irradiation is safe for the environment; it can be applied in organic farming.

Conclusion:

The laser holds pivotal position due to broad range of applications in various fields. The growing need for agriculture product with the increased demand of food production as well as industry imposes the necessity for searching new safer technique. Laser irradiation can be used for the improvement of the quality of seeds. The use of laser irradiation is safe for the environment; it can be applied in organic farming or raising the agricultural production yield, high quality of seeds and without contamination of toxins.

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DEVELOPMENT OF SUGARCANE JUICE: IMPERATIVE ASPECT IN ENERGY DRINK

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Abstract:

Sugarcane juice is a proven health-benefiting drink having considerable amount of antioxidants, polyphenols, and functional nutrients which is known to prevent several ailments. Maintenance of adequate nutrition and positive health benefit of population through assured nutrient intake continues to be national preference for nation to become productive, strong and healthy. It is a crucial commodity in the universal market as it provides massive health benefits. In the health-conscious consumer-oriented market, sugarcane juice competes with other soft drinks available. This paper represents preparation of health drink by using sugarcane juice blending with spinach and lime juice with the objective to evaluate the sensory acceptability of the product. The beverage formulations were prepared by blending sugarcane juice, spinach juice and lime juice in the ratio: (100:00:00) % (v/v); (80:15:05) % (v/v); (70:20:10) % (v/v) and (60:25:15) % (v/v) as T_0, T_1, T_2, and T_3 respectively. Each and every treatment was replicated five times. Sensory assessment of all the products was carried out under the criteria of 9 point Hedonic Scale. All the control and experimental treatments were chemically analyzed using AOAC method. On the basis of analysis, it was conducted that T_2 (70% sugarcane juice, 20% spinach juice and 10% lime juice) was found fit in case of overall acceptability of the product.

Keywords: Health-benefiting drink, Sugarcane juice, Spinach juice, Lime juice.

Introduction:

Juice is a liquid substance, naturally contained in fruits and vegetables. 100% fruit juices added value to any well-adjusted diet, that provide micro-nutrients: vitamins and minerals like folate, calcium, iron, potassium, vitamin C, etc. At times more than two juices are mixed together to yield a well-balanced, appropriately flavored, extremely palatable reviving and refreshing drink. Fruit beverages are highly refreshing, digestible, appetizing, thirst quenching, and nutritionally far superior to many other synthetic and aerated drinks available in the market (Sidappa *et al.*, 1986).

Juice is made from pressing or extraction of natural liquid composed in fruit and vegetables and is commonly consumed as a beverage or used as a flavoring substance or as an ingredient in foods or different beverages, as smoothies. Juice came out as popular beverage choices after the development of pasteurization methods which facilitate its preservation without fermentation (Ward, 2015). The largest country among the fruit juice consumers are New Zealand (nearly a cup, or 8 ounces, each day) and Colombia (more than three quarters of a cup each day). Fruit juice consumption on average enlarges with country's income levels (Stephen *et al.,* 2017).

Sugarcane *(Saccharum officinarum L.)* is a tropical perennial grass of the genus *Saccharum* that forms lateral shoots at the bottom to give rise to multiple stems, generally three to four meters high and around five cm in diameter. The stems develop into cane stalk, which when mature comprises approximately 75% of the entire plant. The important product of sugarcane is sucrose, which assembles in the stalk internodes which is used as a raw material for sugar production or is fermented to produce ethanol (FAO, 2010). In the ancient Indian Ayurveda, sugarcane is procured as a singular medicine as well as a combination drug with other plants and herbs (Anis *et al.,* 1986).

Sugarcane juice is extracted from pressed sugarcane and is largely consumed as a beverage in many places, basically where sugarcane is commercially grown like South Asia, Southeast Asia, Brazil and Latin America. Sugarcane juice is alkaline in nature because of the high concentration of calcium, magnesium, potassium, iron and manganese (nutritional composition of sugarcane is listed on the Table 1). The juice accommodates phytonutrients, polyphenols, antioxidants, and fibers which offer enormous healthsupporting benefits. Because of the low glycemic index of sugarcane juice, in the range of 30–40, its average intake by diabetic patients is acceptable (Khare *et al.,* 2012).

Table 1: Nutritional Composition of Sugarcane (Source (FAO, 2010)

Constituent	Per 100 gm
Water	63-73%
Fiber	11-16%
Magnesium	2%
Soluble Sugar	12-16%

Spinach (*Spinacia oleracea*) is a green leafy flowering plant indigenous to Western and Central Asia. Spinach leaves are common edible vegetables which are eaten either fresh or after storage using different preservation techniques such as freezing, canning, or dehydration. It can be consumed raw or cooked and vary in taste considerably. The high oxalate assemblage of the spinach may be reduced by steaming. World production of spinach was 26.3 million tons with China only accounting for 90% of the total production in 2018 (Food and Agriculture Organisation, 2018).

The nutritional value of spinach and other green leafy vegetables is much greater than the nutritional food value of nearly all other food items. It contains lots of vitamins and nutrients such as vitamin K, A, C, B2, B6, B1, B3, manganese, folate, magnesium, iron, calcium, potassium, tryptophan, dietary fiber, copper, phosphorus, zinc, etc. (Mandle *et al.*, 2013). These vitamins and nutrients can help body in a lot of different ways (nutritional composition of spinach is listed on the Table-2). It can help in building stronger bones, improve cardiovascular system, gastrointestinal system, help improve mental function, eyesight and provide body with iron which gives energy (Dande, 2016).

Lime (*Citrus aurantifolia*) is a genus of flowering plants in the family *Rutaceae* (orange family) has been proven to have both medicinal and cosmetic values. Lime juice carries high quantity of citric acid providing them distinctive sharp (tart) flavor. Citrus fruits are important for their fragrance, particularly due to limonoids and flavonoids contained in the skin and most are juice-laden (Colker, 1999).

Limes are great source of magnesium and potassium that helps to improve digestion, lower blood pressure, fights infection, prevent cancer, helps with weight loss and decrease inflammation (nutritional composition of lime is listed on the table 2). Lime juice consists of organic acid which is particularly citric acid that can act as natural preservative, good antimicrobial agents and can be gotten from major citrus family such as lime, lemon, orange and other genus in the group (Ezeigbo *et al.*, 2015).

Table 2: Nutritional Composition of Spinach and Lime (Source- USDA)

Components	**Spinach (per 100gm serving)**	**Lime (per 100g serving)**
Water	91%	88%
Carbohydrates	3.6g	11g
Proteins	2.9g	-
Iron	2.7mg	3%
Fiber	2.2g	2.8g
Vitamin C	-	48%

Materials and Methods:

Fresh and fully harvested sugarcane stalks and vegetables such as spinach and limes were procured from local markets of Prayagraj city. Experiments were carried out in two parts i.e.

- Preparation of control using only sugarcane juice and experimental energy drink by using sugarcane juice, spinach juice and lime juice having varied concentrations; and
- Evaluation of the control and experimental for overall acceptability of the product which includes: organoleptic properties and chemical analysis of the energy drink.

Method of preparation of sugarcane juice:

Sugarcane
↓
Washing
↓
Peeling
↓
Milling
↓
Filtration/Straining
↓
Sugarcane juice

Extraction of Sugarcane juice is done by washing and peeling the harvested sugarcane. Then, in the milling process, sugarcane is chopped and passed through crushers to extract juice. This juice is then, clarified through filtration or straining.

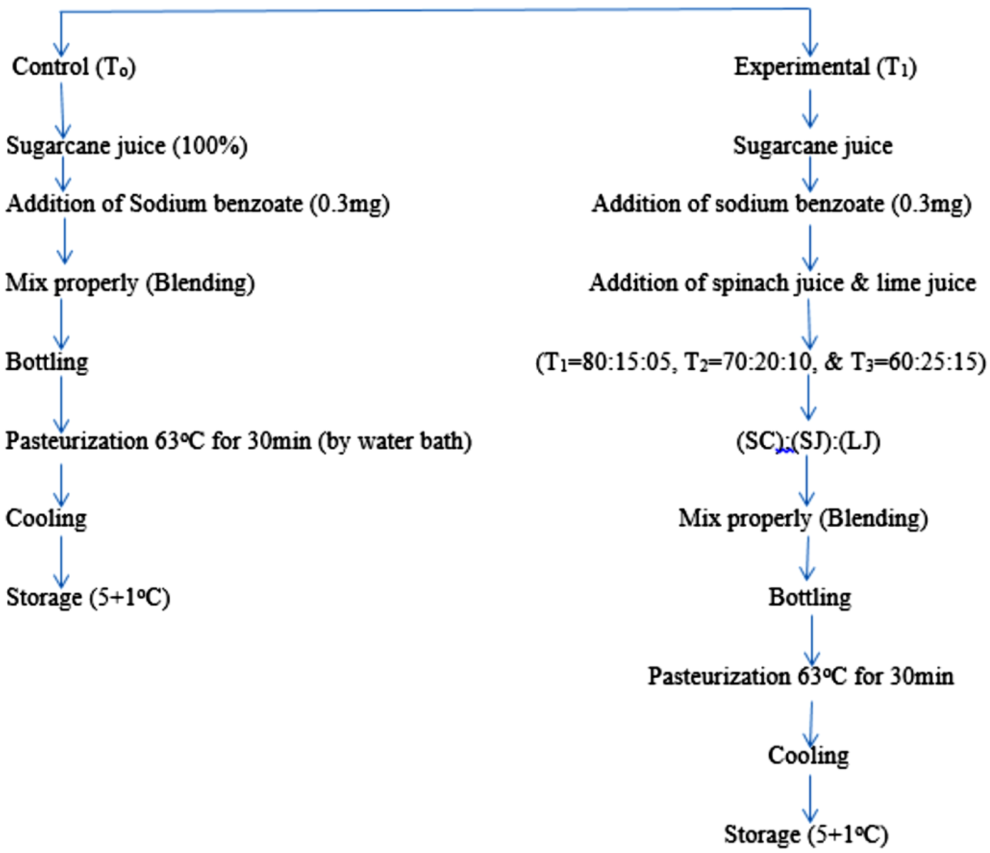
Method of preparation of spinach juice:

Spinach leaves
↓
Washing
↓
Cutting
↓
Grinding
↓
Pulping
↓
Filtration/Straining
↓
Spinach juice

Table 3: Treatment combinations

Treatments	Sugarcane juice (SC)	Spinach juice (SJ)	Lime juice (LJ)
T_0	100	00	00
T_1	80	15	05
T_2	70	20	10
T_3	60	25	15

Flow chart for the preparation of control and experimental energy drink:



For the preparation of control (T_0):

100% Sugarcane juice is mixed or blended with Sodium benzoate (0.3mg).Then, filling the juice in sterilized glass bottle under aseptic conditions and packed air tight. Allowed for In-bottle pasteurization (63°C/30 min) followed by cooling to room temperature and then keeping in refrigerator for storage.

For the preparation of experimental (T_1, T_2 and T_3):

Sugarcane juice is mixed with sodium benzoate (0.3mg). Then, it is mixed with spinach juice and lime juice. The beverage formulations were prepared by blending sugarcane juice, spinach juice and lime juice in the ratio: (80:15:05) % (v/v); (70:20:10) % (v/v) and (60:25:15) % (v/v) as T_1, T_2, and T_3 respectively. Then, filling the juice in sterilized glass bottle under aseptic conditions and packed air tight. Allowed for In-bottle pasteurization (63°C/30 min) followed by cooling to room temperature and then keeping in refrigerator for storage.

Results:

The results of sensory evaluation obtained from the analysis are listed in (Table 4). According to the result, the experimental T_2 (70% sugarcane juice, 20% spinach juice and 10% lime juice) showed the highest overall acceptability attributes i.e. 7.85 and the score was fall in the range of like very much, whereas T_3 sample shows the lowest acceptability score i.e. 6.37, followed by T_1 and control samples. The proximate composition of control and experimental energy drinks, were presented in Table 5.

Table 4: Organoleptic score of energy drinks

Parameters	T_0	T_1	T_2	T_3
Colour	7.40	7.83	7.62	6.80
Flavour	7.62	8.20	8.40	6.30
Consistency	6.30	5.60	7.40	5.86
Taste	6.52	7.26	8.00	6.53
Overall acceptability	6.96	7.22	7.85	6.37

Table 5: Physico-chemical analysis of energy drinks

Parameters	T_0	T_1	T_2	T_3
Moisture %	85.54	87.16	87.56	87.08
Protein (g)	0.16	0.87	1.65	1.40
Fat (g)	0.40	0.42	0.48	0.47
Carbohydrate (g)	13.11	12.55	13.44	12.38
Fiber %	0.56	1.02	1.28	1.47
Ash %	0.23	0.52	0.59	0.61
Total Soluble Solid %	18.5	19.00	19.50	20.00
Acidity %	0.95	0.33	0.28	0.25
pH	5.0	4.9	4.7	4.5
Total ascorbic acid %	6.73	12.14	13.18	15.36
Energy (kcal)	56.68	57.46	64.47	59.35

Conclusion and Summary:

From the results, it represents sugarcane juice developed by blending with spinach and lime juice was having appealing colour, flavor, consistency and overall sensory acceptability of the product. It can be concluded that good quality juice can be prepared by blending 70% sugarcane juice, 20% spinach juice and 10% lime juice i.e. treatment T_2 having points (7.85). The good quality sugarcane juice is acceptable and thus, it helps in utilization of the sugarcane. Indian food technologist should consider scope for expanded sugarcane processing as highly promising. These drinks are consumed less as a food than for their medicinal effects, also it will provide instant source of energy.

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A CASE STUDY OF RAITHU HITHA FARMER PRODUCER COMPANY LTD., GARLADINNE MANDAL

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Abstract:

Farmer producer organisations are crucial for both improving livelihoods of small farmers and increasing the supply of diverse, nutritious foods that are increasingly in demand across India. By joining together in FPOs farmers work to jointly reduce costs and improve market access, helping to drive higher agricultural productivity, enhanced food security, and livelihood development. The main goal of FPO is to enhance farmer's competitiveness and increase their advantage in emerging market opportunities. This study has been devised with the objectives of studying the functioning of RHFPC and analysing the constraints faced by the members in the RHFPC. The present study was conducted in Anantapur district in which RHFPC was selected randomly. The primary data required for the study were collected from 30 member farmers of RHFPC through a questionnaire and also collected from the officials of promoting organisation. The results revealed that the RHFPC was favoured to have been supported by promoting institution. In case of constraints lack of infrastructural facilities, price fluctuations and lack of developed storage facilities were the major problems faced by the member farmers of RHFPC.

Keywords: FPO, Organizational Structure, SWOC Analysis, Garrett Ranking

Introduction:

Agriculture is crucial not only from an economic perspective but also from the social, political, and cultural perspectives. First prime minister of India, Jawahar Lal Nehru, had said that "agriculture needed top most priority because the government and the nation would both fail to succeed if agriculture could not be successful" (GoI, 1951). Indian agriculture is predominantly characterized by large number of dispersed and fragmented small holdings. Around 85 percent of the land holdings belong to small and marginal farmers and being unorganized, these farmers are unable to realize good value for their produce. In India, almost 62 percent of the farmers are marginal farmers, thus attention needs to be paid to the small and marginal farmers so that they can climb up the ladder and be on equal level with the big farmers. To save small farmers from the ill effects of globalization, there is a need to integrate them into the modern competitive markets (Small Farmers' Agribusiness Consortium, 2016). FPO is the new paradigm in Indian economy. Farmer producer organizations are crucial for both improving the livelihoods of small farmers and increasing the supply of diverse, nutritious foods that are increasingly in demand across India (The Economic Times, 2021).

FPO is an organization, by the producers and for the producers. One or more institutions and/or individuals may have promoted the FPO by way of assisting in mobilization, registration, business planning and operations. However, ownership control is always with members and management is through the representatives of the members. FPOs as a legal entity was enacted in 2002 as per section IXA of the Indian Companies Act, 1956 that will empower and improve the bargaining net incomes and quality of life of small and marginal farmers/ producers (Venkatesan and Sontakki, 2017). Farmers Producers Organization provides end-to-end support and services to the small farmers, and cover technical services, marketing, processing, and others aspects of cultivation inputs.

The Government of India has approved and launched the central sector scheme of "Formation and Promotion of 10,000 Farmer Producer Organizations (FPOs)", to form and promote, 10,000 new FPOs till 2027-28, with a total budgetary outlay of Rs. 6865 Cr. Under the scheme, the formation and promotion of FPO is based on produce cluster area approach and specialized commodity-based approach. In India so far, 8600 FPOs (including FPCs) been registered and actively working in agriculture and allied activities. Four states namely Karnataka, Madhya Pradesh, Tamil Nadu and West Bengal, together account for more than fifty percent of the farmers mobilized towards FPOs (Manaswi *et al*., 2018).

Small farmers have a disadvantage in terms of access to agricultural inputs, such as markets, credit and seeds. By joining together in FPOs farmers work to jointly reduce costs and improve market access, helping to drive higher agricultural productivity, enhanced food security, and livelihood development. To facilitate this process, FPOs were formed under various initiatives of the Govt. of India (including SFAC), State Governments, NABARD, as well as other organizations over the last 8-10 years. Out of which, 5000 have been promoted by NABARD. It has been seen that farmer belonging to the FPOs get additional benefits ranging from 40 percent to 60 per cent. Farmers are getting inputs at a lower price and higher realization for selling. From the 5000 FPOs promoted by NABARD, 2500 of them have gone to investment grade and getting investment grade money from the banking system named “Nabikisan” (The Hindu, Oct 2021).

The vast majority of FPOs are at their nascent stage and are still in the early growth phase of their life cycle. (MANAGE Report, 2019). There is a lot of dissimilitude in formation and functioning of the FPOs across the regions and states of the country. The main goal of FPO is to enhance farmer’s competitiveness and increase their advantage in emerging market opportunities. At this juncture, this study has been devised with the objectives of studying the functioning of the RHFPC and to analyze the constraints identified by the members in the RHFPC.

Review of Literature

Onumah *et al*. (2007) stated that “Farmer Producer Organizations (FPOs) are one such farmers‟ aggregate. FPOs are registered under the Indian Companies Act, 1956. Producer Organizations therefore are supposed to be non-political entities aimed at providing business services to smallholder farmer members, founded on the principal of self-reliance.

Singh & Singh (2013) studied the performance of 25 Farmer Producer Companies from the states of Madhya Pradesh, Maharashtra, Gujarat and Rajasthan. The parameters of the study were turnover, profit and source of working capital. Apart from the financial performance, the study found that there were very few genuine FPCs operating; other FPCs are owned and controlled by professionals and businessmen who are not producers. Also, the Farmer Producer Companies were facing several other problems such as weak market linkage, Farmer Producer Companies are ignored by the Central and State Governments and NGOs and banks hesitate to provide them loans.

Chauhan (2015) also studied 18 Farmer Producer Companies in Madhya Pradesh. She assessed the performance of the companies using variables such as total number of member-shareholders, total net profit and annual turnover for a period of three years. The overall financial performance of the companies was found below the desired standards. In addition, the study also found that the decisions in the companies are taken by other professionals as the role of BOD member is very low, due to the fact that they are illiterate and unaware of various business regularities. The companies do not have a proper storage system; hence the agriculture produce cannot be stored for long period causing a loss in the bargaining power of the company. The major reason for poor performance is the unavailability of funds. The companies found it hard to get loans from the bank. Insufficient funds to hire professionals to address 'working capital requirements' problem has been another challenge to the companies.

Materials and Methods:

The present study was carried out in Anantapur District, randomly selected from Rayalaseema region of Andhra Pradesh state. Raithu Hitha Farmer Producer Company (RHFPC) was selected purposively for the study. Primary data required for the study were collected from the member farmers of RHFPC. The sample size selected for the study was of 30 members. The primary data was also collected from the officials of promoting institutions that helped in the formation of FPC. Like most of the FPCs, this company has been formed with the help of promoting organizations like APMAS (Mahila Abhivriddhi Society Andhra Pradesh).

Tools of analysis:

1. SWOC analysis

Strength, weakness, opportunity and challenge analysis is a technique used to identify the external and internal factors that play a part in whether a business venture or project can reach its objectives. Strengths and weaknesses are internal factors, while opportunities and challenges are external. The analysis is carried out on a four-square or four-cell matrix. The outcome of the analysis allows the company to decide if it should proceed and if so to build a strategic plan. A more common term for this approach is SWOC analysis, in which "Challenge" replaces "Threat." (Mehazabeen, 2016)

2. Garrett Ranking Technique

In this study, Garrett ranking technique was used to rank the constraints identified by the farmers and traders in the FPC. In the Garrett's scoring technique, the respondents were asked to rank the factor or problems and these ranks were converted into percent position by using the following formula.

$$\text{Percent position} = \frac{100(R_{ij}-0.5)}{N_j}$$

Rij = Rank given for ith factor by jth individual

Nj = Number of factors ranked by jth individual

Results and Discussions:

Organizational structure

It could be seen from the organizational structure of the RTFPC in the study area (Fig.1) Farmers are the owners of the producer company, contribute to individual share capital, and produce market through FPC. The selection of Board of Directors is done by members of the company. The selected directors would take important business decisions of the company. The technical advice and other financial resources for the effective functioning of FPCs would be done by supporting and promoting institutions like Department of Horticulture and APMAS (Mahila Abhivruddhi Society Andhra Pradesh). The chairman, project manager and CEO are the key persons in the company. CEO regularly inspects the farms of the members, give them the required information regarding the production and sources of inputs, and marketing of the end produce. In the study area, it was found that the CEO was a professional graduate with an agricultural degree.

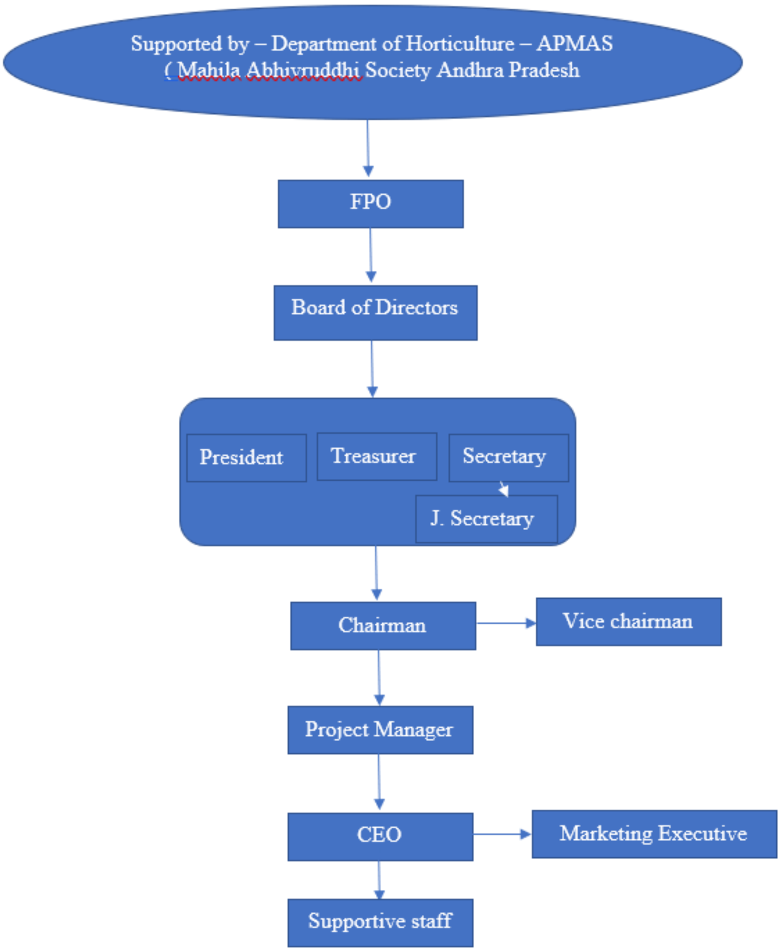

Figure 1: Organizational structure of RHFPC Ltd.

Basic profile of RHFPC

The basic profile of RHFPC is given in Table 1. From the table it is inferred that the date of registration of RHFPC is on 30.5.2019 and corporate id is U01110AP2019PTC112041. The Board of Directors meeting is conducted on 6th of every month. The number of shareholders in the company is 406 members. This company has drawn members from 6 villages in Garladinne Mandal. The equity share base was Rs. 92000, whereas the turnover of the company was Rs. 30 Lakhs. The principal crops concerned by FPC are sweet lime, mango, bhendi and cluster beans. The office space and storage facility are available and is used for the supply of agricultural inputs to members of the company. The awareness about the aspects, activities and benefits from the company among the farmers has been manifested by conducting the meeting at each and every level.

Services offered by RHFPC

A view at Table 2 shows the services offered in the sample FPC. The marketing of seeds and fertilizers are done by the FPCs. Crop productivity increasing activities like extension meetings are conducted by supporting institutions, namely the Department of Horticulture. Regular farm inspections along with technical advice to the farmers are provided in the FPO. Visits to successful FPOs in the study area are effectively scheduled with the help of promoting institutions. Since this is a newly formed FPC, it is concentrating on aid farmers with dispensing of farm inputs and equipments, and procurement of produce as well as marketing it. The government schemes should be routed through FPOs, which will serve as an incentive for other farmers to join FPOs. Larger is the membership more is the equity base and larger is the size of business of FPOs (Manaswi e*t al.*, 2019).

Table 1: Basic Profile of RHFPC

Particulars	**RHFPC**
Date of Registration	30-5-2019
Corporate Id	**U01110AP2019PTC112041**
BOD meeting	6th of every month
No. of Memberships	406
No. of villages linked	6
Equity base (Rs)	92000
Turnover (Rs. Lakhs)	300000
Crops concerned	Sweet lime, Mango, Bhendi, Cluster bean
Facility available	
a. Office space	Yes
b. Supporting staff	Yes
c. Storage	Yes

Table 2: Services Offered by RHFPC

Particulars	RHFPC
Marketing of Seeds	✓
Distribution of fertilizers	✓
Conducting Extension meetings	✓
Field supervisions	✓
Exposure visits to successful FPOs	✓

SWOC analysis of RHFPC

The strengths, weakness, opportunities and challenges of RHFPC were analysed through SWOC analysis and the results are depicted in Table 3.

Table 3: SWOC Analysis of the RHFPC

Strength	Weakness
• Promoting organisation support to RHFPC. • Income stability due to guaranteed price. • Direct marketing of farm fresh produce. • Good coordination with other institutions.	• Poor infrastructure. • Insufficient experience in some business activities. • Non- availability of dedicated management professionals.
Opportunities	**Challenges**
• Sharing of ideas among farmers members. • Pro – government policies encouragement of the system. • Presence of farmer's willingness to join FPCS. • Limited government control.	• Stiff competition from other private companies. • Social and cultural constraints. • Price fluctuations of produces. • Administrative controls.

The FPC has plunged into an agreement with agencies and wholesalers for bulk supply of pesticide, fertilizer and seed etc. FPOs look for the aid of departments like the Department of Horticulture, APMAS working at Mandal and village level equipping of advice technically and training for member farmers. The marketing of farm-fresh produces of fruits and vegetables directly to consumers. It was observed that the FPC of the study area is lack poor infrastructure, which was the main aspect of obstructing the development of their business. The Government policies are immensely encouraging towards the promotion of FPCs. The small and marginal farmers are willing to come together under the FPC to utilize price reductions and minimize transaction costs and realize a better share of consumer price.

Benefits realized by beneficiaries of RHFPC

The benefits perceived by the farmers after becoming a member of RHFPC were interpreted below. The RHFPC will provide a range of services to its member farmers. The beneficiary members observed that higher price realization was the major benefit of joining the FPC. The reliable market with higher price realization increased the net income of the member farmers. The members of RHFPC will be provided with good quality inputs. Fertilizers, pesticides, seeds etc. will be supplied by the company. The company will do direct marketing by detaching the intermediaries after procurement of agricultural produces. It will help farmers to retrieve transaction costs, time and quality maintenance, transportation costs etc. The majority of assembling of farm produce would facilitate members to apposition from where they can negotiate as per the market. The farmers were acquiring extension services and trainings from the state Department of Horticulture, KVK etc. The members jointly use the farm equipment and store their agricultural commodities.

According to a survey organized by the National Institute of Agricultural Marketing (NIAM), some FPOs undertook the distribution of masks, a cash advance to members and reaching out to vulnerable communities within their areas during a covid-19 pandemic. As many as 24 FPOs distributed food and groceries to vulnerable communities (The Indian Express, 2020).

Table 4: Benefits Realized by Beneficiaries of RHFPC

Benefits	Average Score	Rank
Higher price realization	54.4	I
Good quality of inputs	53.9	II
Training and extension services	52.2	III
Reducing input costs	52.1	1V
Marketing	51.3	V
Joint use of storage and farm equipment	43.8	VI

Constraints Identified by RHFPC

The member farmers of the RHFPC are facing some constraints. The constraints were identified and ranked by the members. Garrett ranking technique has been used to rank the order of the constraints faced by them.

From Table .5 the results revealed that lack of infrastructural facilities was accorded as most serious constraints by the members of RHFPC and ranked first with average score of 63.1 followed by yearly fluctuation in prices. The third major constraint is the lack of developed storage facilities, followed by unawareness of grading and packing as fourth one. Perishable nature of produces recorded as fifth constraint, whereas high cost of labour as sixth constraint. The seventh major constraint is the lack of proper market information followed by undeveloped processing facilities and non-inclusion of local leaders in FPCs.

Table 5: Constraints Identified in RHFPC

Constraints	Average Score	Rank
Lack of infrastructural facilities	63.1	I
Fluctuation of prices	58.6	II
Lack of developed storage facilities	57.3	III
Unawareness of grading and packing	57.1	1V
Perishable nature of produces	56.6	V
High cost of labour	52.8	VI
Lack of proper market information	51.7	VII
Undeveloped processing facilities	50.66	VIII
Non-inclusion of local leaders in FPCs	48.6	IX

Conclusion:

Farmer producer companies become a buzzword in recent days as it has proven to be a successful model. The assessment of the company was done using the primary data collected from farmer members of RHFPC from Anantapur district of Andhra Pradesh. The RHFPC was recently formed and was assisting in marketing of farm produce of farmer members. This company has drawn members from 6 villages in Garladinne Mandal. The SWOT analysis was carried out to identify the strengths, weakness, opportunities and threats of the member farmers of the RFPC. It was seen that the major strength of the company is fortunate to have been supported by promoting institution. The RHFPC is striving towards the welfare of farmers through guaranteed price, direct marketing of produce and good coordination with other institutions. The major weakness is insufficient experience in some business activities and poor infrastructural facilities. The opportunity felt important by the members farmer of company was the pro-government policies encouragement of the system and sharing of ideas among members.

The cut throat competition from other private companies found to be the major threat of RHFPC. The beneficiary members observed that higher price realization was the major benefit of joining the FPC. Based on Garrett's ranking, the major findings are lack of infrastructural facilities ranked first followed by fluctuations in prices. The farmer members in RHFPC truly gained with regard to better price assurance and availability of the quality of inputs are benefits as a result of joining of the FPC.

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UTILIZATION OF FOOD WASTE AS FUNCTIONAL FOODS BY FOOD INDUSTRY

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Introduction:

Food wastes or by-products are produced in the large amount in the food industries, annually around the world. About 38% of food wastes occur during food processing. Food wastes are produced by a variety of sources, animal-derived processing food wastes include- by-products from bred animals such as carcasses, hides, hoofs, heads, feathers, manure, offal, viscera, bones, fat and meat trimmings, blood; wastes from seafood such as skins, bones, oils, blood; wastes from dairy processing industry such as whey, curd, and milk sludge from the separation process; vegetable-derived processing food wastes includes peelings, stems, seeds, shells, bran, trimmings residues after extraction of oil, starch, juice and sugars. The disposal of these food industry wastes in the environment it is inconvenience to the ecosystem. Food wastes streams however present a promising source of functional compounds which may be utilized because of their favourable nutritional and rheological properties. The increasing interest of consumers in functional foods has brought about a rise in demand of natural food. (Prathamesh Bharat Helkar *et.al*, 2016). The global demand for functional foods was estimated about $100 billion in 2013. In 1999, a European Community (EC) concerted action on functional foods science in Europe (FUFOSE) defined "functional food". It declared a food as "functional" if – "it is agreeably exhibited to influence helpfully one or more target capacities in the body, past sufficient nourishing impacts, in a way that is important to either and an enhanced condition of wellbeing and prosperity and/or lessening in danger of ailment". 2016). This review presents the functionalities and health benefits of food waste and their functional ingredients. Food industries are constantly trying to utilize as much of their product as possible, and this paper puts forward an alternative use for their 'waste' as a functional or financial benefits to their industries. Efficient utilization of by-products has direct impact on the economy and environmental pollution of the country. Non-utilization or under utilization of waste not only lead to loss of potential revenues but also lead to the added and increasing cost of disposal of these products.

Food waste or by-products most commonly refered to edible food products, which are intended for the purposes of human consumption, but have instead been discarded, lost degraded or consumed by pests, and does not include the inedible or undesirable portions of food stuffs. Various food industries dispose their valuable waste and some food industries re-process their waste and use it as functional food ingredients and develop their economy to survive in the neck cutting competition of the market. The food industries can be categorized as following (Helkar *et al.*, 2016):

1) Fruit and Vegetable Industry
2) Grain Processing Industry
3) Brewery and Winery Industry
4) Marine Industry
5) Meat Industry
6) Dairy Industry

Table 1: Typical percentage and nature of fruits and vegetable processing waste (Source: Gupta and Joshi, 2000)

Fruit and vegetables	Nature of waste	Production in Tones	Approx. Waste (%)	Potential quantities of waste (tones)
Mango	Peel, stones	6987.7	45	3144.4
Banana	Peel	2378.0	35	832.3
Citrus	Peel, rag and seed	1211.9	50	606.0
Pineapple	Skin, core	75.7	33	24.7
Grapes	Stem, skin and seeds	565	20	-
Guavas	Peel and core and seeds	565	10	-
Peas	Shell	107.7	40	68.3
Tomato	Skin, core and seeds	464.5	20	90.3
Potato	Peel	2769.0	15	415.3
Onion	Outer leaves	1102.0	-	-
Apple	Peel, pomace and seeds	1376.0	-	412.0

Different forms of usage of food waste produced by food industries are mentioned below:

As source of dietary fiber:

Byproducts, rich in dietary fiber are a prize to food processors, especially since consumers prefer natural supplements, fearing that synthetic ingredients may be the source of toxicity. Also, DF possesses remarkable beneficial nutritive and human protective effects, such as prevention of colon cancer and diverse types of cardiovascular diseases (Palafox-Carlos *et al.*, 2010). Incorporation of rich-fiber byproducts, including wheat bran in breakfast cereals, rice bran, sugarcane bagasse, wheat bran in bread and peach dietary fiber concentrate in jam have been investigated (Elleuch *et al.,* 2011). DF from different sources has been included in different functional food such as bar fruits, bread, beverages and other processed foods. Additionally, fiber-rich byproducts may be incorporated into food products as inexpensive, non-caloric bulking agents for partial replacement of flour, fat or sugar, and enhances water and oil retention to improve emulsion or oxidative stabilities (Elleuch *et al.*, 2011). In real terms, the fiber from fruit and vegetables byproducts may be of great interest to the food technologist. Fruits and vegetable exhibit the important content of DF. Amongst the fruits with major fiber content includes guava, carambola, mamey, mango, sapodilla and raspberries (2.70, 2.78, 3.0, 3.10, 5.31 and 6.50 g/100 g, respectively) (USDA, 2010). The food industry can take advantage of the physicochemical properties of fiber to improve the viscosity, texture, sensory characteristics and shelf-life of their products (Elleuch *et al.*, 2011). Antioxidant capacity is another important property of DF that is given by the presence of different antioxidant linked compounds. Antioxidants associated with the dietary fiber matrix are substances that are not detected in the usual analytical procedures for either dietary antioxidants (targeting antioxidants extracted by aqueous organic solvents) or DF (targeting carbohydrates and lignin) quantification. However, these antioxidant compounds make up a substantial portion of the dietary antioxidant capacity; they are not minor constituents of DF, and as such they may contribute significantly to the health effects attributed to DF and dietary antioxidants (Saura- Calixto, 2011).

Fruits industry: Orange pomace was mainly rich in fibres with applications suited to products requiring improved water/oil holding and binding properties for example a high water hydration capacity (4.40 ml/g). It had a valuable nutritional composition: high dietary fibre content (40.47%), low fat content (2.14%) and a high mineral content.

Apple pomace is a waste or by-product biomass generated after apple fruit processing. Higher content of total dietary fibre (74%) and another functional property such as density, water and oil holding capacity, swelling capacity including glucose dialysis retardation index (36.91%). Dietary fibres demonstrated to have imperative role in improvement and management of human health, particularly gastrointestinal system. The major part (approx. 95%) of the generated biomass is skin or pulp tissues, which consists of cell wall polysaccharides (e.g.

pectin, cellulose, hemicellulose, lignin and gums) and phenolic compounds bound with skin, i.e. dihydrochalcones, flavonols, flavanols and phenolic acids (Rana, 2015).

Grain Industry: Muffin batter supplemented with peach dietary fiber, and cake dough enhanced with prickly pear cladode fiber at levels up to 5% were deemed as acceptable as the control, based on sensory scores reported by consumer panelists (Ayadi *et al.,* 2009). Other studies, mainly on breads for special diets, have shown that the addition of dietary fiber from maize and oat in gluten-free formulations gave breads with significantly higher loaf volume and crumb softness, compared to the control non- fiber gluten-free bread, improving their acceptability (Sabanis *et al.*, 2009).

Dairy Industry: The use of fibers in dairy products is also widespread (Elleuchet *et al.,* 2011): e.g. fiber improves the texture of ice cream, providing a uniformly smooth bulk, desirable resistance to melting, and improves handling properties primarily by hindering crystal growth, as temperature fluctuates during storage (Soukoulis *et al.,* 2009). They also showed the potential use of dietary fibers (oat, wheat, apple and inulin) as crystallization and re-crystallization controllers in frozen dairy products.

As antioxidents:

Fruit Industry: Star fruit (*Averrhoa carambola* L.) is a good source of natural antioxidants and that poly-phenolics are its major antioxidants. The residue of star fruit, which is regularly disposed of amid juice drink preparing, was found to contain much higher antioxidant activity than the extracted juice. The residue extract shows strong antioxidant activity in delaying oxidative rancidity of soya bean oil.

Vegetable Industry: Tomato waste polysaccharide, showing a structure similar to a xyloglucan biopolymer, was investigated its biological activity and showed that anticytotoxic in the Brine Shrimp bioassay; moreover it also exerted a high anti-oxidant activity.

Brewery Industry: Every byproduct would become fertilizer, animal feed, or fuel (Nerantzis, 2006). Wine waste is characterized by the presence of natural antioxidants much safer than synthetic antioxidants. Wine waste-derived antioxidants have been recently used in the food industry. Winery wastes could be an alternative source for obtaining natural antioxidants, which are considered totally safe in correlation with engineered antioxidants. Grape pomace speaks to a rich wellspring of different high-esteem items, for example, ethanol, tartrates and malates, citric acid, grape seed oil, hydrocolloids and dietary fibre. The utilization of grape seed extracts (GSE) has gained ground as a nutritional supplement in view of its antioxidant activity (Arvanitoyannis *et al.*, 2006)

Marine Industry: Astaxanthin, the chromophore of shrimp shells, can be extracted and used as an antioxident, since it has a viability 500 times higher than that of vitamin E, and as regulator of the plasma HDL-cholesterol level. In the fish industry, processing of raw fish into food products generates large quantities of by-products that contain proteins and lipids (Tahergorabi *et al.*, 2012).

As source of Nutraceuticals:

Fruits and Vegetable Industry: Fruits and vegetables are good dietary sources of natural antioxidants for dietary prevention of degenerative diseases. An inexorably developing business sector for nutraceuticals and practical sustenance's has triggered the study on normal wellsprings of cancer prevention agents and their potential for nutraceutical and utilitarian nourishments.

Pomegranate peels and seeds, a by-product of pomegranate juice and concentrate industries, present a wide range of the pharmaceutical and nutraceutical properties (Kaderides, 2015).

Apple pomace is an important starting material for pectin extraction. Phlorizin, the most abundant phenolic compound in the apple pomace extracts, and that is the basic structure of a new class of oral antidiabetic drugs. Type 2 diabetes mellitus, cured by the inhibition of sodium-glucose co-transporter-2 (SGLT 2).

Aloe vera (*Aloe barbadensis* M.), is an herb and little astringent in taste, extensively used in many medicinal and therapeutic remedies. Extracted gel of this plant exhibited very good antioxidant activity which is comparable to that of the synthetic antioxidant activity like butalated hydroxyl toluene (BHT).

Apple pomace showed high visco-elastic properties that could improve structures within products (O'Shea, 2012). Fibre and pectin derived from apple wastes are currently used as food ingredients and functional foods. Pectin is also used in pharmaceutical industries as drug carriers and excipients. The numerous health benefits of apple peels and apple polyphenols such as antioxidant, antihypertensive, anti-cancer, anti-diabetic and hypolipidemic activities could provide new perspectives for their commercial utilisation. Apple peels are considered as important by-product of apple industry and crore of tonnes of these peels are wasted every year due to inadequate or under processing (Rabetafikaa, 2014)

Grain industry: Rice bran is a by-product of rice processing industry and constitutes around 10% of the aggregate weight of unpleasant rice. Rice wheat is a rich wellspring of vitamins, minerals, key unsaturated fats, dietary fiber and different sterols. Rice grain is finding expanded applications in nourishment, nutraceutical and pharmaceutical commercial ventures. Milling of paddy yields 70% of rice (endosperm) as the real item and by-products comprising of 20% husk, 8% bran and 2% germ. Rice bran is rich in antioxidant compounds like polyphenols, vitamin E, tocotrienols and carotenoids that help prevent the oxidative damage to DNA and other body tissues. Rice bran being high in dietary fibre and in view of its therapeutic potential, its addition can add to the improvement of quality included sustenances or practical nourishments that at present are sought after.

Oil Industry: De-oiled sunflower press cake is a promising wellspring of nourishment protein as an alternative to soy and egg protein being devoid of toxic substances and low in antinutrients (Dietmar, 2014).

Dairy Industry: The dairy processing industry is the real segment of nourishment preparing industry in the India. Whey, a by-product of the dairy business, contains numerous profitable constituents, particularly solvent proteins, for example, β-lactoglobulin, α-lactalbumin, immunoglobulin, bovine serum albumin, lactoferrin, and lactoperoxidase. They are widely accepted as food ingredients in a few sustenance details (e.g., confectionery, bakery, health, and sport supplements), normally in dry form, whey items have pertinent nutritious (e.g., high content of essential amino acids), functional (e.g., gelation, foaming, and emulsifying agent), and biological (e.g., antimicrobial, anticarcinogenic, and biological (e.g., antimicrobial, anticarcianogenic, and immunomodulatory activities) properties for wellbeing. Advances in processing technologies of whey protein powders, their major practical and organic properties, and the most encouraging applications in rich protein source and high biological. Dumping of milk whey with sewage cause large-scale losses of valuable milk components also, builds the refinement expenses of dairy plants squanders. Whey it is a valuable nutrient. Now it is recognized as an important auxiliary dairy crude material which can even surpass the skim milk in deep processing technologies. Increasing deficiency of dairy crude material and innovation of new preparing technologies and equipment which made milk whey utilization more profitable. Milk whey has also rich mineral structure and considerable amount of nitrogenous substances such as whey proteins, free amino acids, urea, uric acid, creatine, creatinine and ammonia. Thereby milk whey can be used for direct biosynthesis of the bioactive mixes for sustenance improvement. The enriched whey can be used for production of functional foods for meeting human demand. Curd it is one of the by-product of milk industry that is act as a probiotic functional food. There is strong evidence indicating that probiotics have preventive and therapeutic effect on pathologies such as acute diarrhoea, antibiotic associated diarrhoea, NEC, and allergic pathology.

Meat Industry: The definition of by-products depends on several factors including traditions, society and religion, however they are for the most part acknowledged as carcasses, skins, bones, meat trimmings, blood, fatty tissues, horns, feet, hoofs or internal organs. Meat by-products are rich in lipids, carbohydrates and proteins. Bioactive peptides can be created from meat proteins utilizing hydrolysis, cooking or fermentation. These bioactive peptides may also apply gainful physiological advantages. Bioactive peptides are known to have antimicrobial, antioxidative, antithrombotic, and antihypertensive, anticancerogenic, and satiety regulating and immunomodulatory activities and may affect the cardiovascular, immune, nervous and digestive systems. Peptides may also be effective in the treatment of mental health diseases, cancer, diabetes and obesity (Lafarga, 2014).

Marine Industry: Marine foods are seen as an amazing wellspring of high calibre protein, containing lipids with high levels of unsaturated fatty acids. The enhancement of human health by reducing the risk of cardiovascular disease (Kadam S, 2010). Seafood's and their by-products are a great wellspring of nutraceuticals and bioactives, and these can be extracted/isolated and added to a range of nourishments subsequently upgrading usefulness of the foods in terms of human health. Fish is often referred to as 'rich food for poor people' and gives quality proteins, fats, vitamins and minerals. By-products from seafood processing may account for up to 80% of the weight of the harvest depending on the species, and include a variety of constituents with potential use as nutraceuticals and bioactives. These include ω-3 PUFAs from the livers of white lean fish, waste flesh parts of fatty fish, blubber of marine animals, hydrolysates from fish guts/cleanings, peptides, and products from crustaceans such as chitosan, chitosan oligomers, and glucosamines. Hence, by-products processed from seafoods could serve as important value-added nutraceuticals and functional food ingredients (Gormley, 2013).

As antimicrobial and flavouring agents:

Fruit Industry: The citrus industry produced large amounts of byproducts. Oils obtained from skin have been used for different applications. Studies of the application of lemon extract on dairy products have also been performed (Conte *et al.,* 2007). Different antimicrobial packaging systems including lemon extracts have been used to preserve Mozzarella cheese. Results showed an increase in the shelf life of all active packaged Mozzarella cheeses, confirming that lemon extract may exert an inhibitory effect on the microorganisms responsible for spoilage phenomena without affecting the functional microbiota of the product (Conte *et al.,* 2007).

The antimicrobial and antioxidant potentials of pomegranate peel and seed extract were investigated in chicken products (Kanatt *et al.,* 2010). Pomegranate peel extract (PE) showed excellent antioxidant activity while the seed extract did not have any significant activity, probably to the difference in the type and amount of bioactive compounds present in both tissues. Pomegranate peel extract showed good antimicrobial activity against Staphylococcus aureus and Bacillus cereus. In general, addition of pomegranate peel extract to popular chicken and meat products enhanced its shelf life by 2–3 weeks, during chilling temperature storage. PE was also effective in controlling oxidative rancidity in these chicken products (Kanatt *et al.,* 2010).

The antimicrobial properties of mango seed kernel phenolic extracts were investigated. Minimum inhibitory concentrations of the mango kernel extract against 18 species of 43 strains, containing food-borne pathogenic bacteria were determined using the agar dilution method. The mango kernel extracts had a broad antimicrobial spectrum, and was more active against gram-positive than gram-negative bacteria with a few exceptions. These results also indicated that the active component of the Mango Kernel extract was a type of polyphenol (Kabuki *et al.,* 2000).

As a source of colorants:

Fruits Industry: Anthocyanins are important colorants and can be extracted principally from plant byproducts such as grape pomace or banana bracts (Stintzing and Carle, 2004). Commonly applied preparations obtained from byproducts include red cabbage, red radish, purple sweet potato, black carrot, aronia, cherry, elderberry and blackberry. In general, vegetable sources such as radish, purple sweet potato, red-fleshed potato, or red cabbage have been shown to provide a higher percentage of acylated anthocyanins than fruits which reflects in higher tinctorial strength of the respective extracts at food pH (Stintzing and Carle, 2004). Amongst fruits acerola, guajiru, jambolao, jussara and acai have shown to be a good source of anthocyanins and other flavonoids (de Brito *et al.,* 2007).

As food additives:

Fruits Industry: Apple peel was accounted for as a quality included sustenance element for nourishment items to elevate great wellbeing because of its phytochemical substance. Pectins can be found in most natural product pomaces and, after extraction and filtration can be included as gelling specialists in various sustenance items, for example, jams, fillings, desserts, and so on.

Pomace can likewise give other sustenance added substances including dietary filaments, lactic corrosive, colors, vinegar, characteristic sweeteners and cellulose.

Vegetable Industry: Lemon and Granadilla polysaccharides, showing a xylan-like and a pectin-like structure, respectively, were also investigated of their rheological properties and for their biological activities, both confirming to be anticytotoxic compounds (Poli *et al.,* 2011).

Marine Industry: The fish pepsin can be used as a rennet substitute in cheese production. Marine algae are well known natural sources of gums, such as alginate, agar and carrageenan (Hernandez-Carmona, 2013). Omega-3 oils are much mainstream and broadly utilized than some other elements of marine source. Chitin and chitosan are polysaccharides, which are increasing much consideration.

As anti-browning additives:

Fruits Industry: The optimum pH for polyphenoloxidase activity has been reported to be from acid to neutral in most fruits and vegetables, and the optimum activity is observed at pH 6.0–6.5 while the minimum activity is detected below pH 4.5. This is the reason behind the use of chemicals that decrease the product's pH or acidulate to control the enzymatic browning. Acidulate are used in conjunction with other treatments because reducing browning by controlling only the pH is difficult. Acidulates such as citric, malic, and phosphoric acids, are capable of lowering the pH of a system, thus reducing the polyphenoloxidase activity (Rojas-Graü *et al.,* 2007). It is important to mention the plant phenolic compounds as a large group of natural antioxidants ubiquitous in a diet high in fruits (Arts & Hollman, 2005). These compounds are divided in two groups: phenolic acid and flavonoids, which both exhibit remarkable antioxidant activity (Palafox-Carlos *et al.,* 2010). Fruits like mango, kiwi, guava, red dragon, papaya, longan and sapodilla exhibit important antioxidant capacity and significant polyphenol contents among other fruits (Mahattanatawee *et al.,* 2006). Certainly, these compounds are a serious candidate to be applied as additives in food products to preserve and enhance quality, avoiding food oxidation.

Vegetable Industry: The Onion by-product offering better attributes for its potential improvement as a food ingredient: source of antioxidant and anti- browning bioactive compounds. Sulfhydryl (SH or thiol) groups are good inhibitors of the enzyme PPO. Therefore, it is assumed that the thiol compounds contained in onion might be the active components in charge of the PPO inhibitory effect of onion. Onion extracts could be used as natural sustenance elements for the anticipation of searing brought about by PPO (Shui, 2006).

As emulsifiers:

Fruit Industry: The high growth in consumption of green coconut water in brazil comes with a proportional growth of its waste, constituted of coconut apply green coconut pulp in ice cream formulation to replace milk, fat, gums and emulsifier. According to sensory evaluation 93.2% of the positive responses fell in 8 and 9 of the hedonic scale. The results indicate that coconut pulp was used to manufacture free milk, no lactose, low fat and no cholesterol food (Iguttia, 2011).

For Value Addition in other foodss:

Grain Industry: Pearled barley, if enriched with β-glucans, can be joined into durum wheat semolina to give a pasta that displays great cooking quality. Flaxseed on the other hand flaxseed supper rich in lignans can be helpfully added to different cereal-based formulations like bread, muffins and other bakery products (Bainao, 2014)

Fruits Industry: Some tropical organic products contain protein-corrupting chemicals (papain in papaya, or bromelain in pineapple) usable as meat tenderisers or in washing powders or lager fermenting (Shui, 2006)

Brewery and winery Industry: The brewing process promotes the generation of three intrinsic wastes, the spent grain, the hot trub and the residual yeast. The solids remaining after the fermentation of red grapes, racking-off the wine, and subsequent pressure is usually known as Wine Pomace (WP), which mainly comprises solid grape parts (skin, rest of pulp and seeds) along with small pieces of stalk. WP also contents residual yeasts and bacteria which were the main agents to carry out alcoholic and malolactic fermentations. WP revalorization is usually approached by producing extracts rich in antioxidants, which can be incorporated into different food matrixes and also used in the cosmetics and pharmaceutical industries due to their antioxidant properties and antimicrobial effects. Brewer's spent grain as the main by-product of brewing industry, representing approximately 85% of total by-products generated, is rich in cellulose and non-cellulosic polysaccharides. Raw material for extraction of compounds such as sugars, proteins, acids and antioxidants (Aliyu, 2011).

As supplementation food:

Fruit Industry: Papaya seeds constitute 22% of the waste from papaya puree plants papaya seeds are recently gaining importance due to its medicinal value, since it recently had been used in curing sickle cell diseases, poisoning related renal disorder (Imaga *et al.*, 2009) and as anti-helminthes (Okeniyi *et al.*,2007).

Grain Industry: Supplementation of rice bran has been effectively conveyed in various foods like bread, cakes, noodles, pasta, and ice creams without essentially influencing the functional and textural properties (Gul *et al.*, 2015). It is a hypoallergenic food ingredient and possesses anti-cancer activity. The high fiber content in rice by-items can likewise back off the ingestion of the glucose, while the colonic fermentation products of fiber may enhance glucose utilization. Antioxidants additionally help in abating the onset of diabetes and Alzheimer's sickness, and play a role in the prevention of coronary heart diseases and cancer.

Marine Industry: Hot-water extract of pulverized oyster shell produces polypeptides having tyrosinase inhibitory movement (a list for skin-brightening impacts) while CaCO3 from oyster shells can be used as a calcium supplement. Shrimp and crab shells can be recuperated to fabricate chitosan, a “fat-binder” used for weight administration to upgrade tying of bile corrosive and discharge of sterols, and thus, lowering cholesterol, and as soluble dietary fibre to enhance gastrointestinal capacity. Algae and seaweed have been observed to be great wellspring of dietary fibre and antioxidants and carotenoids on other hand fish bone and shark cartilage are extensively used as source of calcium (Kadam, 2010).

Conclusion:

Food industry waste also have the potential to boost new markets in functional food industry as functional food ingredients. Food industry waste are a good source of proteins, minerals, fatty acids, fibre, antioxidants, antimicrobials, flavouring, colorants, texturizer, potential source for functional food ingredients, natural antioxidants, antimicrobial compounds, source of dietary fiber and bioactive compounds. The importance of food industry waste is that it can serve as an important raw material for the development of functional foods. The demand for new functional foods is steadily increasing because of their disease curing properties. The efficient utilization of waste from food industry can help in reducing the negative cost, reduce environmental pollution, demonstrating sustainability in food industry and that has direct impact on the economy of the country.

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AGRONOMIC TECHNIQUES FOR ORGANIC PEST MANAGEMENT

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Abstract:

Ecosystem damage and negative health impacts are linked to an overreliance on chemical pest control. The rise of insect resistance is another hazard to agricultural productivity. Designing farming methods that rely less on synthetic pesticides is therefore necessary. Organisms that harm or restrict beneficial plants are referred to as crop pests. Organic farming is a farming method that adheres to ecological principles and maintains the wellbeing of living organisms, ecosystems, and soils. Agronomical tactics are viewed as the cornerstone for organic pest management, thus it is beneficial to take into account all of the possibilities when designing a pest management strategy.

Keywords: cultural practices, organic pest management

Introduction:

Any living thing, whether it is an animal, a plant, or a bacterium, that is invasive or problematic for wild or managed plants is considered a crop pest. Worldwide, it is estimated that a variety of pests cause 48% of yearly productivity losses in food and fibre crops. Two million tonnes of pesticides are consumed annually globally. In India, insecticides make up more than 80% of all agrochemicals used, followed by herbicides (15%) and fungicides (2%). (Agarwal *et al.*, 2015). The 1962 release of Rachael Carson's book "Silent Spring" sparked a heated discussion over the actual and potential risks associated with pesticides. It made a significant contribution to the creation of chemical substitutes for pest management.

Organic farming is a strategy that combines conventional agricultural techniques based on biological processes that occur naturally with scientific understanding of ecology and contemporary technologies. One method for bridging the yield gap is plant protection. Applying agronomic strategies to control insect pests and microbiological infections is crucial.

The approaches that farmers implement into their farm management systems to boost water usage effectiveness, manage the crop, and improve the environment via improved practise are known as agronomic strategies. An agronomic strategy focuses on the long-term avoidance of pests or the harm they cause using a variety of strategies, such as changing cultural practises and habitats. Agronomic methods include using resistant cultivars, preparing the soil, using pest-free planting materials, choosing the right cropping systems, planting at the right time of year, managing weeds and water, conducting intercultural operations, harvesting, etc.

Tillage

The mechanical manipulation of soil is known as tillage. Plowing, deep tillage, puddling, and other preparatory tillage techniques alter the soil immediately and endanger the existence of pests that live there. This agronomic procedure exposes nematodes and insect pests that live in the soil to inclement weather and natural predators. Insects that deposit their eggs in the top soil layers include grasshoppers and borers. The exposed pupae are eaten by birds including the crane, king crow, common myna, starling, and others. When the soil is being prepared, the eggs and pupae are exposed and eventually dry out. The pest life cycle is broken and disturbed. Additional tillage mixes crop leftovers into the soil's deeper layers and makes it easier to bury pest-infested crops and weed stubbles.

Summer ploughing/Off season ploughing

Fields are deeply ploughed during the summer's heat (April-May). Doing two summer ploughs at intervals of 15 to 20 days before the monsoon arrives is the ideal management strategy. It exposes the pupae and larvae that are hibernating to both the scorching heat and the hungry birds. By subjecting them to the higher temperatures, weeds and disease-causing organisms are also assisted in dying. For instance, the red-haired caterpillar is one of the main pests of peanuts. If summer ploughing is done, the pupa of this moth, which are present in the soil, will be destroyed by the summer heat (Vimal, 2015). The crop of maize was also wiped off by the autumn armyworm. Summer ploughing can be the best method to avert possible attack of falli armyworm (Anon, 2019).

Figure 1: Summer ploughing/Off season ploughing

Soil solarization

When plastic sheets are put on damp soil, solar energy is trapped and heated the soil surface, a process known as soil solarization (also known as plasticulture). Before planting crops, solarization is a chemical-free method of eradicating pests including insects, weeds, and harmful microorganisms (fungi, bacteria, and nematodes) from the soil (Gelsomino *et al.*, 2006).

This pre-planting technique uses sun radiation to heat the soil about four to six weeks in the summer, when the soil gets the most sunshine. The mechanism of action is based on the fact that plant infections and pest mortality are caused by elevated soil temperature (about 45–55 °C) at a soil depth of 5 cm below transparent polyethylene sheets.

Soil solarization plays a significant role in the next years because it could be considered a sort of paradigm of sustainable crop protection method, particularly useful for countries such as India (Gill, 2017). The low environmental impact (due to plastic film disposal, avoidable if biodegradable films are used), the wide-spectrum of actions against pathogen and the environmental requirement for effective solarization treatments seem fit perfectly with the Indian needs of plant protection. Unfortunately, in India, most of the farmers are not aware of the applications of soil solarization technology (Kapoor, 2013).

Figure 2: Soil solarization

Host-plant resistance or tolerance

An effective strategy for controlling hereditary pests is crop resistance, which is present in seed or propagation materials. Crop resistance is a great strategy for controlling a variety of pests since it requires little to no input expenses. In addition to the conventional pest resistance created by conventional plant breeding methods, cultivars with considerable pest tolerance or resistance are also commonly used.

Using clean and certified seeds

A formally recognised mechanism for ensuring the quality of seed production and multiplication is seed certification. The kind of seed production should be considered while choosing seeds. Breeder seeds are needed to make foundation seeds, whereas foundation seeds are needed to make certified seeds. Since certified seed is meticulously manufactured within a quality assurance procedure, it can be free of harmful pests. Choose pest- and disease-free seeds and planting supplies, and whenever feasible, get certified plants and seeds from reliable vendors.

Cropping systems

One of the main strategies for preventing insect pests is the creation of farming systems that are naturally managed utilising a variety of agronomic techniques (Barzman, 2015). Providing judgments about cropping patterns can be made at the appropriate time and that it fulfils the farmer's socio-economic viewpoints, multiple cropping may be a significant part of cultural pest management. From very low intensity, low input, high acreage systems to high intensity, high input, low area systems, cropping systems vary along a continuum.

Intercropping

In the same farming system, intercropping is the practise of growing many crops next to one another. For organic farms, using intercropping systems offers an option for bug management. By making it harder for pests to identify a host crop, intercropping can help lessen pest issues. Planting a crop that has an attractant or repellent effect is one of the intercropping strategies used to manage insect pests. on a targeted insect that is adjacent to a crop that might be attacked by the insect, or a combination of the two.

Crop rotation

Crop rotation offers variety in both time and place, and it is frequently the best way to control soil-borne pests and plant-parasitic nematodes. Under monoculture, many intensively managed crops that are vulnerable to nematodes and insect pests frequently have significant pest issues. Crop rotations can also include the usage of plants that are directly hostile to particular pests. Crop rotation's efficacy as a technique for controlling insect pests relies on the target insect's life cycle.

Repellent cropping

An intercrop that has a repellent effect can also be used for insect pest control. This often requires more rows of the intercrop to be planted than in a trap crop system. In this system, the repellent intercrop masks the production crop from the insect pest, deterring the insect from its host crop. The repellency may be due to chemicals exudates by the plant or due to the physical structure of the intercrop. African marigold provides excellent pest control under certain conditions.

Trap cropping

Trap, decoy, or sacrificial cropping refers to the planting of an attractant crop adjacent to the main crop. The bug is attracted to the trap crop because it finds the used plant more appealing than the producing crop. The concept behind trap crops is that insects have various host preferences and are drawn to plant volatiles.

The placement of trap crops can take many different forms, and the choice of design will depend on the target pest, pest pressures, and farm size. Trap cropping is less effective at controlling highly mobile insects than it is in controlling slower moving insects. Perimeter trap cropping, row trap cropping, and strip trap cropping are a few examples of the spatial layouts.

In conventional systems, the trap crop can be treated with insecticides on its own, negating the need to treat all of the acres with pesticides. In organic systems, the trap crop might be treated with an authorised pesticide or mechanical insect control methods like tractor-mounted vacuums could be utilised. For instance, the yellow margined leaf beetle seemed to find turnips more appetising than cabbage, therefore the insects ate the turnips instead of the cabbage.

Figure 3: Trap cropping

Border crops

A two to four row crop planted around the edge or border of the main agricultural area serves as a barrier against the spread of pests. The most common trap cropping pattern employed by farmers is perimeter trap cropping, often known as border cropping. In order to create a physical barrier for moving insects, perimeter trap crops can be planted on all four sides of the main crop at a sufficient density (often at least two rows).

Early pest population development makes it easier to manage using bioinsecticides or by allowing the natural enemies of the pest to grow there. Compared to those bordering by fallow land, aphid infestation in potatoes was successfully managed by the use of wheat, sorghum, and maize borders. This border cropping can increase natural enemy populations, which would control the numbers of pests (Nderitu *et al.,* 2008).

Figure 4: Border crops

Insectary plantings

Plants known as insectary plantings give helpful insects supplies like nectar and pollen. Insectary plants are included into fields by farmers to increase the ability of natural enemies to control insect pests. Insectary plants may result in enhanced biological insect pest management to the degree that these food supplies increase the number of beneficial insects surrounding farms.

Insectary gardens with a range of plants that bloom at various times of the year provide beneficial insects access to food all year round. The potential availability of floral resources is extended by insectary plantings with species that blossom at various times.

Different approaches used in

a) Inside the field of the current crop, insect plantings.

b) Insectary plantings outside of the crop field.

c) Presence of insects in cover crops.

d) Insect planting in weeds regions that have been well controlled.

Push-pull cropping

In an intercropping system, insect pest management can be achieved by combining crops that repel insects and those that attract them. This kind of technique, known as a push-pull (stimulo-deterrent) cropping system, was created in Africa (John *et al.,* 2014). The repellent crop prevents (pushes) the insect from entering while the attractant crop attracts (pulls) it in (Mutyambai *et al.,* 2019). The push-pull method, which was created in Africa, guards maize against stem-boring moth larvae by planting a grass (Napier grass) as a border that is more alluring to the moths and a crop (Desmodium, a legume) that is repulsive to them in between the rows of maize (Midega *et al.,* 2018).

Farm biodiversity

The management of insect pests has a lot of promise thanks to biodiversity. Insect pest populations are frequently reduced by diverse plants. Pest insects are more likely to locate and remain on pure crop stands where there are a lot of food sources. Many times, fields with a variety of crops are abundant with above- and below-ground beneficial creatures that act as natural pest controllers, disease inhibitors, and boosters of a crop's natural defences.

Perennial crop component-agroforestry

Through greater top-down management by natural enemies, agroforestry methods may affect both pest incidence and abundance. In annual and perennial agricultural systems, agroforestry techniques can assist minimise pesticide drift and harmful effects on pollinators, predators, and parasitoids (Vaughan, 2017). Agroforestry methods provide predatory birds with an environment where they may feed on insects while still in their juvenile phases, such as larvae and pupae. For owls, which could be important in rodent control, trees provide a habitat.

Seed treatment

When seeds are treated before being sown, diseases, insects, and other pests that attack seeds, seedlings, or plants are suppressed, controlled, or repelled. Seed treatment can be physical, chemical, or biological. Solutions for biological seed treatment are becoming more and more in demand. The treatment of seeds with biological pesticides and fertilisers also promotes the rapid development of seedlings and plants. This makes it easier for strong, robust plants to resist vicious insect attacks.

Figure 5: Seed Treatments

Time of sowing

By changing the planting period, the crop is protected against insect occurrence. The timing of sowing or planting can be utilised to shorten the sensitive time of attack and allow younger plants to develop to a tolerant stage before an attack begins. Early crop planting helps crops like sorghum, chickpeas, mustard, cotton, etc. avoid insect infestation. For instance, shifting the dates of sowing helps deter pests like flea beetles or cabbage maggots. Similarly, maize earworm issues are less common in early-planted sweet corn than in late-planted corn.

Optimum plant spacing

As plant spacing shrunk, the extent of insect infestation harm to plants got worse. Crop plants are healthier and less vulnerable to pests when they are spaced properly.

Nutrient management

Compared to nutrient-deficient plants, plants that are in good nutritional condition have a stronger resistance (tolerance) to pests. The kind and quantity of fertiliser can have a big impact on how susceptible a crop is to pests. Plants that are strong and able to develop fast are better equipped to resist insect pest harm. Overfertilizing crops, however, might exacerbate insect pest issues. Plants whose N fertilisation is increased may become less pest-resistant, leading to larger pest densities and crop loss.

For instance, increased N application rates have been linked to sharp rises in aphid and mite populations. Similarly, in the majority of Asia's rice-growing regions, significant population increases of major insect pests of rice, such as plant hoppers (*Nilaparvata lugens* and *Sogatella jurer*), leaf folders (*Chaphalocrocis medinalis*), and stem borers (*Scapephaga incertulas*, *Chilo suppressalis*, *S. innotata*, *C. polychrysus*, and *Sexamia inferen* (Lu *et al.*, 2007). An agricultural plant is protected from severe insect assault by balanced plant nutrition.

Irrigation management

One of the initial prerequisites of a successful integrated pest control system is appropriate and timely watering. The kind and quantity of irrigation affect the pest population by changing the crop's microenvironment. Different irrigation techniques (flood, drip, overhead sprinkler) have different effects on insects. If irrigated plants are lusher and more appealing than adjacent plants, pest bug populations may rise. Similarly, plants under stress from a drought may be less resistant to insect pests or more receptive to them.

Selective weed management

Numerous common weed species can act as hosts for a variety of harmful insect pests. Weeds can hinder the management of insects if they are not managed in the field. However, certain key insects, such honey bees and native pollinators crucial for cucurbit and seed development, may find nectar and pollen from blooming weed species. In weedy environments, parasitic wasps and other predatory insect species can multiply rapidly. They then move into nearby agriculture areas where they can eat harmful insect pests.

Intercultural operations

Earthing-up

A technique used where the soil surrounding a plant is mounded against the main stem. It helps in controlling early shoot borer in sugarcane and potato tuber moth in potato.

Figure 6: Earthing-up crops

Hoeing

During intercultural operation and hoeing, several insects that feed on the root systems of plants, such as cutworms, root borer grubs, and white grubs, are also subjected to the whims of nature.

Detrashing

Detrashing, which entails removing undesirable bottom-dried and yellowish-green leaves during the 5th, 7th, and 9th months, is a recommended method in sugarcane farming. The discarded leaves should be added to the soil or turned into compost to ward off various pests. Controlling insects such as scale insects, mealy bugs, and white flies in sugarcane. By keeping the field clean, detrashing reduces the number of rats and squirrels that may otherwise harm the crop.

Harvesting as close as to ground level

The plant components that serve as the principal supply for the following cropping season still have some insect pest development stages on them. Therefore, harvesting crops closer to the earth may reduce insect activity the next season.

Sanitation

By avoiding breeding or hibernation locations, sanitation prevents or lowers insect pest infestations. Crop wastes also include insect pupae. When agricultural waste is removed, insect pupae are ruined. Pests like stem borer in rice stubbles and scale insect in sugarcane trash may be efficiently controlled by handling agricultural leftovers appropriately. The plant waste following harvesting can be converted into hay, compost, or useful organic manure.

Conclusion:

Pests create a serious risk for primary producers as they can impact on market access and agricultural production. Chemical pesticides are typically used to manage pests in agricultural crops because they are efficient and have the ability to "knock down" different phases of insect life. However, it is advised to use non-chemical weed control methods in organic systems. Numerous possible advantages of agricultural techniques include cost-effectiveness eco-friendly, efficient, and non-toxic to non-target creatures, including people.

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PROMISING BIO-CONTROL AGENTS AGAINST PLANT PARASITIC NEMATODES

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Abstract:

Plant parasitic nematodes (PPNs) are one of the most important and challenging to manage pests of agri-horticultural crops. PPNs are a potential threat to the crop causing crop losses, the global annual loss in monetary terms amounting to the extent of ~$173 billion. Biological control is a sustainable alternative to chemical control. The use of fungi and bacteria to control the pests like root-knot nematodes and cyst nematodes may be developed to protect the environment from the pesticides. Although it's several limitations, biological control of PPNs is a cost-effective and eco-friendly method.

Keywords: Plant parasitic nematode, Biological control

Introduction:

Plant-parasitic nematodes are a potential threat to the crop causing crop losses, the global annual loss in monetary terms amounting to the extent of ~$173 billion (Elling *et al*., 2013). In India, plant-parasitic nematodes cause crops loss to the extent of 10,204 crores per annum (Kumar *et al*., 2020). Changing climate and agricultural practices are leading to resurgence of nematode problems in newer crops and geographical localities. They are crops pests that not only reduce the yield and quality of produce but also predispose them to fungal and bacterial pathogens. Research on the development of environment friendly methods of pest control, especially the use of biological agents has gained momentum in the past three to four decades. The best documented cases of effective biological control are demonstrated in native soils where the nematophagous fungi and bacteria increase naturally under some perennial crops or in monocultures controlling cyst and root-knot nematodes.

Biological control:

Biological control is defined as "the action of parasites, predators or pathogens in maintaining another organisms' density at a lower average that would occur in their absence.

One definition of biological control that is easy to use and to remember is that biological control is "three sets of three." the sets of three represent

The "**who**": the natural enemies themselves - predator, parasitoids and pathogens.

The "**what**": it includes prevention, reduction, or delay of infestation.

The "**how**": The approach that is taken with the natural enemy achieves the objective which can be importation, augmentation or conservation.

Bio-control agents against plant parasitic nematodes:

In the 1990s, most research on nematode bio-agents was with egg parasitic fungi that also produced nematicidal metabolites like *Purpureocillium lilacinus, Cylinderocarpon, Gliocladium, Pochonia chlamydosporia* etc.(Kamra and Dhawan, 1997). The relationship between nematodes and these fungi was variable, but as some of the isolates were highly virulent, they were extensively used and are still available as formulations in the market, especially for sedentary endo-parasites (Table 2). However, it is important to ascertain the quality parameters (like the colony forming units, presence of contaminants etc.) of these formulations before use. Although it's several limitations, biological control of PPNs is a cost-effective and eco-friendly method.

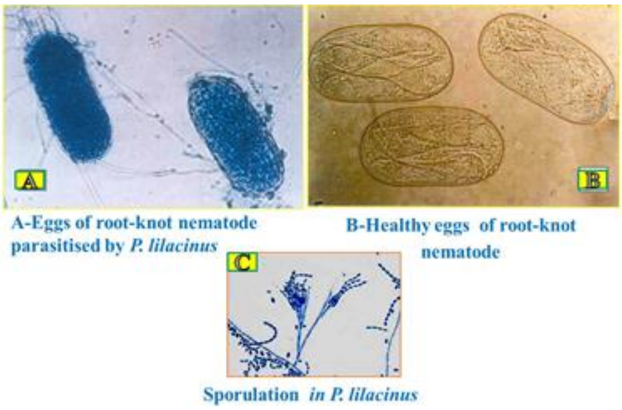
Biological control of RKN (root-knot nematode):

As a component of integrated nematode management, biological suppression of RKN is well known. There has been some success in managing *Meloidogyne* spp. in the fields with *A. irregularis* (Royal 350), *Arthrobotrys robustus* (Royal 300) and *Purpureocillium lilacinus* (Biocon, Paecil, Nemachek, PL Plus). A number of bio-control agents (BCA) have been exploited against this, but only a few BCAs, viz. *Purpureocillium lilacinus*, *Pochonia chlamydosporia*, *Trichoderma viride*, *Pasteuria penetrans* and *Pseudomonas fluorescens* have been found effective and showed promising for managing root-knot nematode. The current prospects of *Trichoderma* for management of PPNs have been documented. At this time, a few commercial formulations of *P. lilacinus* (Bionematon, Yorker), *Trichoderma viride* & *T. harzianum* (Bioderma, Ecoderma, Tricho guard,), *Myrothecium verrucaria* (DiTera) and *Pasteuria penetrans* (Pasutsuria 50WP) are available in the market for controlling root-knot and other nematodes (Khan 2015).

Nematode trapping fungi (Predacious fungi):

Those fungi which produce different types of modified capturing organ to consume their prey (nematode) know as predatory fungi. Trapping organs of predatory nematophagous fungi are adhesive nets simple complex, adhesive knobs and branches, adhesive spore sessile and stalked, non-constructing rings, constructing rings open and closed.

Nematode trapping fungi	Examples
Sticky branches	*Dactylella lobata*
Sticky network	*Arthrobotrys oligospora*
Sticky knobs	*Dactylella ellipsospora*
Non-constricting rings	*Dactylaria candida*
Constricting rings	*Arthrobotrys dactyloides, Dactylella bembicoides*



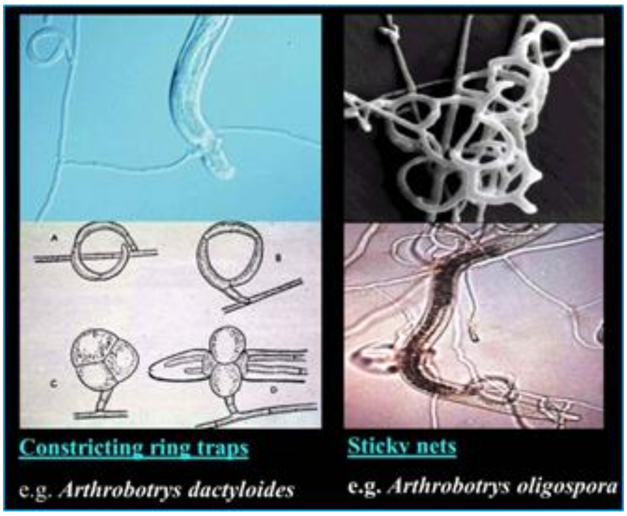


Table1: Bacteria as bio-control agents of nematodes

Agents	Mode of action	Advantages	Limitations
Pasteuria spp. 1. *P. penetrans*, 2. *P. thornei*, 3. *P. nishizawae*, 4. *Candidatus Pasteuria usage*	Adhesive spores	Most isolates highly virulent; infective spores' resistant to drying; good shelf-life; reduce infectivity of nematodes as well as fecundity.	No proliferation in soil in absence of nematodes, isolates are highly specific; difficult to culture in *vitro.*

Table 2: Commercially available bio formulations against nematode pests in India.

Bioagent	Formulations	Source
P. fluorescens	Biocure, Bioshield, Multiplex, Sparsh, Sudocel, Dagger-G	Jeypee Biotech , Multiplex, State Biocontrol Laboratory, Biotech International Ltd
P. lilacinus	Multiplex Niyantran, Abtec Paecilomyces, Bionemator, Biocon, Bioact, PL plus,	PBDC Bangalore, Agritechnol Infmn Centre, Bangalore
T. harzianum	Ecoderma, F-stop, Binab- T, Supravit, Tricodex	ADA (BCL), Pest Control Pvt Ltd.
P. chlamydosporia	Bionema, Biovert, Multiplex Versha	PDBC Bangalore, Agritechnol Infmn Centre, Bangalore
Streptomyces avermitilis	Abamectin	Syngenta

The improvement and success of a biological control agent for plant-parasitic nematodes needs a complete understanding of the biology and ecology of the agent, the nematode target, its host cultivar, method and time of application and the various biotic and abiotic factors governing the efficacy the agent so that we can direct our research efforts in removing the constraints wherever feasible (Elgawad *et al*., 2018).

Conclusion:

The past 30 years have seen a significant growth in the number of scientists involved in research on the bio-control of nematodes. Biological control is a sustainable alternative to chemical control. The use of fungi to control the pests like root-knot nematodes and cyst nematodes may be developed to protect the environment from the pesticides. Although several bioagents for nematodes have been reported, only a few organisms were developed as commercial bio agents (http:/www.oardc.ohio- state.edu/apsbcc/productlist.htm). Unless they are more difficult to produce, store and use, they can be a suitable solution to protect the crops. Isolating indigenous strains is the best way to ensure the success of the use of these biological control agents, because they are then adapted to the pest they have to control and to the environment they will be used in. The present experience with biocontrol agents will not replace the use of nematicides, but integrated with other control measures including chemicals, they can help maintain nematode pests below damaging levels, and reduce the application of chemical nematicides.

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IMPLEMENTATION OF NANOPESTICIDES AS SUBSTITUTION FOR CONVENTIONAL PESTICIDES IN AGRICULTURE: A REVIEW

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Abstract:

According to several research articles, implementing Nanopesticides in place of conventional pesticides effectively reduces insect infestations. Considering all the above factors, farmers should look at nanopesticides as a new pest control method and use them to prevent pest or insect infestation. The use of nanopesticides will contribute to the development of agriculture and herald a new era of agribusiness. Agriculture is most affected by the effects of climate change, and as a result, farmers must deal with various issues, including heavy and erratic rains. Using various nanopesticides will enable farmers to prevent the infestation of insects and pests in the future; as a result, farmers should advocate using nanopesticides rather than conventional pesticides in the future. In this article, the author describes in detail the study of the importance and benefits of nanopesticides as a substitution for conventional pesticides in agriculture.

Keywords: Nanopesticides, Implementation, Agriculture and Conventional pesticides.

Introduction:

Pesticides are becoming a necessary component of agriculture. There are numerous environmental and health risks as a result of the larger dosage of these pesticides per hectare. Nanopesticides have been created as a result of the growth of a new scientific discipline called nanotechnology. The carrier molecule or active component in these chemicals is nanosized. The research community has created several formulations, including nanoemulsions, nanosuspensions, controlled release formulations, and solid-based Nanopesticides. In comparison to conventional insecticides, the chemical's smaller size aids in proper distribution on the pest surface. In the meanwhile, we should be more aware of the negative consequences of using these Nanopesticides (Rajna *et al.*, 2019). The potential prospect of agricultural nanotechnology uses is gradually becoming an improving innovation. The genetic modification of plants and animals made possible by nanotechnology has the potential to increase agricultural productivity. The potential for precision agriculture, resource management, and effective delivery systems for fertilisers, pesticides, food processing, packaging, and other areas is growing as suitable techniques and sensors are identified. For India to become a key participant in the field and contribute to the creation of new technologies, the Department of Science and Technology developed the Nano Science and Technology initiative in 2001, which was directed by Prof. C.N.R. Rao (Jaga *et al.*, 2021).

Nanotechnology is a rapidly evolving field that has the potential to change food systems and address the current problem of food security. It plans to transition agriculture from the era of careless resource use and environmental degradation to the brave new world of advanced systems with improved material use efficiency and targeted applications to reduce crop losses brought on by abiotic-biotic stresses as well as to give the environment proper consideration. Pesticides must be used in agriculture to control plant diseases and insect pests. The increasing concentration of these chemicals per hectare has, however, led to numerous environmental and health risks. A new branch of research known as nanotechnology has resulted in the development of novel pesticides to address problems associated with conventional pesticides. The main benefit comes from the particle's small size, which aids in evenly dispersing the components on insect surfaces and produces a better effect than traditional pesticides. Due to their better efficiency and lower dosage requirements, nanoparticles are increasingly being used as Nanopesticides, Nano fertilizers, and Nano delivery systems. However, humans and other species are exposed to nano-entities during or after the application. It is currently mostly unknown how these created nano-entities interact with biological systems. Therefore, a deeper knowledge of their interactions and potential negative effects is essential for a sustainable transition before widespread use in crop production and crop protection (Yadav *et al.*, 2022).

The extensive use of pesticides in agriculture has been a topic of much debate due to their negative effects on the environment and human health. Chemicals like carbamate, pyrethroids, and organophosphorus are employed as pesticides in conventional agriculture. The majority of the time, even though these chemical pesticides are effective, researchers have found that they either miss the target insect and are lost in the air or are leached out into the soil and water. Farmers experience significant agricultural losses as a result of insect infestation because of the overuse or improper use of these chemicals, which can lead to resistance. These chemicals are also toxic to humans and have negative impacts on agricultural fields. The use of nanotechnology has made it possible to combat these negative effects. Plant protection pesticides made with nanotechnology use active chemicals that are applied on a nanoscale. Nanoparticles have been used by scientists to deliver active compounds that are effective against specific pests or as components in novel insecticidal compositions. Contrary to traditional hydrophobic pesticides, nanocides are water-soluble substances that can replace them without the use of harmful organic solvents. They also have homogeneous coverage and strong bioactivity. Due to their frequent application in small doses and fast uptake by cells, these nano-based insecticides can impede the emergence of resistance in pests that are their intended targets. For instance, an analysis of the fruits and leaves of the green sweet pepper used in the study revealed no metal nanoparticle accumulation (Bose, 2021).

Conventional pesticides and their disadvantages:

Pesticides have been utilised extensively in agriculture and are regarded as one of the key elements of crop protection strategies. In addition to using high-yielding crop types alone, their adoption during the green revolution era considerably increased crop yields (Popp *et al*., 2013). Investigations on the hazards of pesticide use, their toxicity to humans and animals, and their harmful effects on the ecological balance of life are ongoing worldwide. These days, one of the most researchable topics is said to be this one (Laborde, 2008). Only 0.1% of pesticides administered in various ways (spray, soil, seed treatment, etc.) have been shown to reach the intended target; the remaining 99.9% seep into the environment, causing soil and groundwater pollution, which eventually worsens the ecological imbalance (Goulson *et al*., 2015; Kumar *et al.*, 2018). Another limitation on pesticide use in agricultural applications (such as Wettable Powders) is their solubility, as appropriate dispersion of the active ingredient in the liquid phase is necessary for spraying. Due to its affordability, accessibility, and ecological compatibility, water is the most practical medium for applying pesticides. However, many pesticides are either weakly or even completely insoluble in water (Whitehouse and Rannard 2010).

Almost all types of plants, including crop plants, forest trees, medicinal plants, herbs, and weeds, are edible to insects, who make up around two-thirds of all known animal species. In addition to destroying stored grains and crops, they eventually reduce food quality. Pest insects are those that harm a crop and/or its food grains by more than 5%. (Rai and Ingle, 2012). A pesticide is any substance created to prevent, destroy, repel, or reduce pest populations. Additionally, they can function as desiccants, defoliants, or plant regulators. Pesticides are divided into various subgroups according to their chemical makeup and method of action (Pereira *et al.,* 2015; Sparks and Nauen, 2015). As a result, a practice known as bioaccumulation occurs where the pesticide concentration rises at each level of the food chain, having deleterious effects on both animal and human health. Sometimes, as a result of interactions between pesticide formulations, phytotoxic effects can also manifest, which might result in total crop failure (Rizzati *et al*., 2016).

There was no longer only a small concern about the effects of chemical pesticides on the environment and human health in the new era of the food revolution. Since then, pesticides have been sprayed onto the field as part of appropriate agricultural practices such as crop rotation, land, water, and post-harvest management (Yu *et al.,* 2017). They are first sprayed to deposit into the crop foliage, and then by mechanisms of diffusion, uptake, and/or transfer, they reach the pest attack site, resulting in poisoning or contact attacks (Nuruzzaman *et al.,* 2016). However, regular use of chemical pesticides has increased the risk of bio-magnification as well as the evolution of pesticide resistance in the targeted pest. Chemical pesticides' active ingredients frequently disrupt metabolic processes by preventing enzymatic activity (Pandey *et al*., 2016). Chemical pesticides have been used for a longer period because high-yielding crops are more susceptible to diseases, insects, and other biotic factors. In recent years, bee populations have experienced a significant decline. Around the world, 75% of the honey has been found to contain traces of insecticides that are harmful to bees, particularly neonicotinoids like acetamiprid, clothianidin, imidacloprid, thiacloprid, and thiamethoxam (Sheridan 2017; Zhang 2018). In the aforementioned situation, using biopesticides to manage pests in crops has become an essential substitute for using traditional chemical pesticides.

Due to the harmful environmental and public health consequences, the widespread use of insecticides in agriculture has received a lot of attention. Chemical insecticides used in traditional agriculture include carbamate, pyrethroids, and organophosphorus. The majority of the time, even though these chemical insecticides are effective, researchers have found that they miss their intended insect target and instead either evaporate into the air or get washed away in soil and water. Farmers suffer significant agricultural losses due to insect infestation as a result of the overuse or misuse of these chemicals, which may lead to resistance. These chemicals are also dangerous for humans and have negative impacts on agricultural fields.

Nanopesticides:

The term "Nanopesticides" refers to those little molecules that constitute just pest control derivatives or encase the active ingredient of a pesticide in a protective nanocarrier (Kookana *et al*., 2014). Through "smart field management," must guarantee the advancement of precision farming. ENMs can reduce photodegradation and improve the physicochemical stability of the materials due to their increased surface-to-volume ratio, quantum effects brought on by their small size, atypical phase change, and stabilisation (Bakshi *et al*., 2015; Kuswandi 2018), among other factors (de Oliveira *et al.,* 2014). To deliver an active pesticide component to the targeted agricultural pest with improved durability and efficiency and without posing any environmental risks (Chowdhury *et al.*, 2012), a new diffusion, erosion, and swelling controlled nanodevice can be tailored (Chowdhury *et al*., 2017).

There are certain disadvantages to using biopesticides with pesticidal activity. New creative formulations for biopesticides, including nanoformulations with a lower quantity of active ingredients for a variety of applications in crop protection, have been created to make these biopesticides more effective by overcoming existing disadvantages. In certain investigations, these biological molecules served as capping and reducing agents for the creation of stable nanoparticles with synergistic features from inorganic compounds (Ag, Cu, ZnO, and S) with pesticidal activity (Dimkpa *et al.*, 2013; Gao *et al*., 2014; Singh *et al*., 2014). These nanoparticles can be utilised as pesticides immediately after being stabilised with biopesticides and nanobiopesticides. With lower concentrations of the active ingredients, these nanobiopesticides successfully aid in pest management (Vimala Devi *et al*., 2019).

Although botanicals provide an environmentally friendly method of controlling insect pests, their use is constrained by their poor environmental stability (Forim *et al*., 2013). In this regard, nanotechnology holds out enormous potential, and nano-formulations can be employed to increase the stability and potency of these natural chemicals (Ghormade *et al*., 2011). Nanostructured botanicals are particularly efficient against insect pests, including azadirachtin, rotenone, carvacrol, thymol, and curcumin, among others (Shah *et al.*, 2016). According to (Forim *et al,* 2013), spray-dried neem (*Azadirachta indica*) nanoparticles can kill diamondback moth larvae completely while also having improved UV stability.

Advantages of Nanopesticides:

Toxic chemicals or pesticides employed in nano-formulations go through some modifications to prevent nano-pesticide runoff in the air, water, and soil, but the poisons may build up in the food chain, posing a serious threat to the environment and human health. To hold and improve the insecticidal value while also preventing accumulation in the environment, nanopesticides molecules are incorporated into a delivery substance such as biopolymers, micelles, or composites. These nanobiopesticides are triggered to release themselves by environmental factors including temperature, humidity, wetness, or light. Clay nanotubes (halloysite), designed as pesticide transporters, release when an environmental trigger occurs, similar to how biopolymers do. This allows for improved interaction with pests. Similarly, nanopesticides and nanofertilizers are encased in specialised carriers to allow controlled release for targeted effects (Bergeson 2010; Manjunatha *et al.*, 2016).

Nanotechnology offers a platform for developing novel formulations of eco-friendly pesticides because the majority of nanopesticide formulations are particularly target-specific. In general, targeted delivery and controlled release of nanopesticides can enhance pesticide usage, decrease residue, and reduce pollution. In particular, nanomicrocapsule formulations for the delivery of pesticides have gradual release and protective performance since they were created utilising high polymer materials that are light-sensitive, thermosensitive, humidity-sensitive, enzyme-sensitive, and soil pH-sensitive. Nanopesticides are remarkable tools for creating a system of agriculture that is eco-friendly and sustainable since they cut down on overall chemical use and hazardous residues and improve crop protection (Rajna *et al*, 2019).

Disadvantages of Nanopesticides:

It is yet unclear how dangerous nanoparticles (also known as Nanopesticides) may be for the environment and human health. Since nano-pesticides appear to be far more persistent and harmful than their conventional equivalents, nano-pesticides may also result in new types of contamination of soils and rivers (Rajna *et al.*, 2019). Due to their long persistence, improved mobility, and increased toxicity, nanopesticides may also result in new sorts of pollution of soils and rivers. The use of some nanoparticles could have negative effects; for example, silver nanoparticles (AgNPs) have more harmful effects than silver nitrate (Griffitt *et al.*, 2008) and can penetrate biological barriers including cell membranes (Verma *et al.*, 2008), which can result in toxicity (Sondi and Sondi, 2004; Morones *et al.*, 2005; Nel *et al.*, 2006). Nanosilver toxicity (bile duct hyperplasia) results from oral and inhalational consumption (Kim *et al.*, 2009). In five types of plants, cucumber, cabbage, carrot, corn, and soybean alumina nanoparticles (aluminium oxide) reduced the formation of roots (Yang *et al.*, 2005).

Conclusion:

Recent studies have demonstrated that nano-pesticides can reduce the harmful effects of chemical-based pesticides, provide target-specific pest control, and aid in the development of intelligent nano-systems for minimising issues like environmental imbalance and detrimental effects on crop productivity and food security (Nuruzzaman *et al.*, 2016). Due to the limited release of functional ingredients, they are effective for long-term utility and offer a solution to environmental-related issues including the nutrient-richness of water bodies and the accumulation of non-biodegradable components in the food chain. Furthermore, because of the enhanced solubility and stability of their active ingredients, nanopesticides exhibit effective pest control properties (Venugopal *et al.*, 2016).

Therefore, there is enormous potential for using nanoparticles in plant protection, and these new delivery mechanisms may lead to the creation of safer and more environmentally friendly pesticides. Nanoparticles can however have certain disadvantages in addition to their many benefits, such as limited selective toxicity, low biodegradability for inorganic nanoparticles, and the emergence of pesticide resistance in both target and non-target organisms as a result of their indiscriminate use. Additionally, there is a lack of evidence and limited data regarding the environmental fate of these nanoparticles and their potentially harmful effects on non-target creatures. As a result, there has to be more focus on the potential impact and negative consequences of nanoparticles on the environment, nontarget creatures, and the creation of environmentally friendly nanopesticides (Jayant Yadav *et al.*, 2022).

Considering all of these factors, future research should concentrate on the following aspects are as formulation of ingenious nanopesticide formulations to overcome the drawbacks of conventional formulations; Creating environmentally friendly nanopesticide development technologies using green chemistry; Creating technologies to lower the cost of producing nanopesticides; and Comparing the activity of nanoformulations with conventional analogues at the field level.

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VARIOUS STRATEGIES FOR MEDICINAL PLANT CONSERVATION AND ENHANCING BIOACTIVE COMPOUNDS IN HERBAL MEDICINES

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Abstract:

The demand for therapeutic plants has sky-rocketed, and the market of these plants has expanded as well and consequently constituted a serious threat to medicinal plants' existence, which may be measured as a result of the fact that several valuable therapeutic florae are in jeopardy or endangered, and accumulative amount of types are being replaced in herbal medicine preparations. As a result, there is a necessity to find a poise among conservation and development. More than a quarter of all pharmaceutical medications on the market today are made from natural plant materials. Plant secondary metabolites (PSMs) are fascinating and essential study subjects because of their chemical variety, diverse biological roles, and pharmacological activities. Furthermore, these contributions offer advice on uncommon plant cultures, including large-scale propagation, storage, and reintroduction approaches. Biotechnological tackles are significant for excellent, increasing, recovering and inspecting species for desired traits. Metabolic engineering and biotechnological approaches such as plant cell and tissue culture and plant genetic transformation are progressively existing active to improve the high-quality and frequent plant-derived medicinal composites under *in-vitro* conditions. Tissue culture is a beneficial approach for proliferating and preserving medicinal plant species that are difficult to regenerate using traditional procedures. Metabolic engineering is becoming a popular method for improving and modifying the secondary metabolite composition of medicinal plants. Tissue culture is a beneficial approach for proliferating and preserving medicinal plant species that are difficult to regenerate using traditional procedures. Medicinal plant conservation, on the other hand, is linked to genetic transformation in the sense that it provides a favourable characteristic in a crop for improved performance and health. Combinatorial biosynthesis is another method in the generation of novel natural products, as well as producing infrequent and luxurious natural compounds.

Keywords: Tissue culture, Gamma irradiation, Mutagenesis, Plant secondary metabolites, Metabolic engineering.

Introduction:

The majority of the world's population still gets their medicine from plants, which are the world's eldest basis of pharmacologically active composites. They have been the sole source of important medicinal ingredients for millennia, and they continue to be the bedrock of outdated medicine schemes throughout the world's eldest societies. Two-thirds of the world's inhabitants is thought to utilize plant-based treatments nowadays. According to WHO estimates, plant-derived drugs are used by 80 percent of the population of developing countries for basic health care Gurib-Fakim (2006). Medicinal plants are prevalent and extensively used as a chief basis of herbal preparations and therapeutic mixtures. Today on market more than a quarter of the pharmaceutical medications are obtained from plant products.Medicinal plant research has been carried out all over the world to develop new herbal treatments, based on plant information gleaned from old medical literature, folklore, cultures, civilizations, field research, and discussions with traditional healers. Plants are the source of at least 25% of drugs in today's pharmacopeia, and many more are synthetic analogues based on prototype molecules identified in plants.Plant-derived secondary metabolites (active ingredients) are now in use, and medications developed from them account for a major portion of the total healing agents. Many vital steroid chemicals and hormones are also semi-synthesized from plant ancestors (Pandey Shukla, 2006).

Due to ever-increasing difficulties, medicinal plants are challenged with a batch of problems, including effectiveness and safety to accomplish commercial desires, management, and exaggeratedly aided replicas. On the other hand, crude drugs continue to serve an essential role in medical treatment. A global movement toward a more natural way of life has emerged in recent years, culminating in a greater focus on the importance of medicinal herbs and traditional health care systems. The international trade in medicinal plants is expanding as a result of this greater understanding, often at the expense of natural ecosystems. Uncontrolled harvesting wipes down the only supply of raw materials is still natural populations. Many pharmacological plants are endangered, as indicated by the increasing use of replacement species in herbal treatments. As a result, there must be a balance between conservation and utilization to avoid extinction in the future by using some techniques (Loreau *et al.*, 2002).

Conservation of medicinal plant resources

The preservation of fragile curative plants should be a top precedence for which existing technologies should be used. Cultivation is one means of avoiding genetic erosion in medicinal plants, however, only a few species have been standardized. In actuality, only a few types are commercially cultivated on a large basis. Set significant parameters for selected plants that are unlikely to be produced by tissue culture, such as their status, cost, medicinal value, traditional use, active components, and so on. Conservation strategies should be adequately classified based on their individual goals and methods for achieving them. Static conservation techniques aim to radically modify plant species' natural evolutionary pathways to preserve a genetic snapshot. Plant species, their pathways of evolution, and the organic, agro-ecological, and/or human artistic processes that constitute their initial evolutionary milieu are all part of the in-situ strategy (Balmford *et al.,* 2003). Ex-situ approach does not give a panacea for protecting naturally occurring plant species and sustaining habitats in the face of changing climatic circumstances.In the case of final loss or extinction, ex-situ collections benefit from an in-situ strategy as a backup plan.According to a current conservation approach, seeds should be conserved in gene banks (Srivastava *et al.*, 2016). However, such storage is hard for species that do not set seeds or produce infertile or intractable seeds. The most therapeutic plant seeds fall into this group. Medicinal plant field conservation, on the whole, demands more space, as well as more time and effort. Natural catastrophes and biotic stresses might be harmful to them (Khan *et al.,* 2012).

Cryopreservation:

Biotechnology includes cryopreservation. Worldwide plant preservation efforts and the safeguarding of genetic resources worldwide both benefit from biotechnology. Biotechnology advancements have provided new tools for assessing and evaluating plant genetic resources (Tripathi Singh, 2005). Cryopreservation, which has just been established in the previous 25 years, is a critical and valuable technology for the long-term preservation of genetic materials. The major benefits of cryopreservation are its ease of use and adaptability to a variedvariety of genetic constitution. Pre-growth, withering, pre-growth-desiccation, vitrification, encapsulation, and droplet-freezing are some of the methods that may be used to achieve this (Vijaya *et al.*, 2013). Plant material (such as kernel, sprout tip, zygotic and somatic embryos, and pollen) is cryopreserved at ultra-low temperatures in liquid nitrogen (-196°C) or its vapor phase (-150°C). Cryopreservation was created to evade the genetic changes that might occur when tissue cultures are stored for lengthy eras of time (Ganeshan, 2010).

Increasing the production of secondary metabolite

Biotechnology has had a significant influence on the production of secondary metabolites. Plant chemical synthesis stimulation, Plant cell, and tissue culture, cell culture, screening and selection of high yielding cell lines immobilization,feeding metabolic precursors and biotransformations,elicitor usage, genetic engineering,Hairy root culture, and current advanced analytical methods like as NMR, HPLC, GC-MS, and LC-MS have all been used etc. (Ellis, 1988; Namdeo, 2007).

Plant cells' totipotent biosynthetic and biotransformation skills have provided humans with a powerful tool for utilizing their totipotent biosynthetic and biotransformation capabilities. *In-vitro* circumstances that provide secondary metabolite production a much-needed boost Techniques including plant source tailoring, plant cell and protoplast culture, nuclear and plasmid gene modification, plant cell, and enzyme immobilization, and industrial scale biotechnological methods all emerged in 1975.Plant biotechnology is primarily concerned with the creation of goods through biotransformation. The idea of *in-vitro* secondary metabolite generation, first proposed by Gauthier in 1941 and involves the cultivation of all sorts of plant cells, tissue, organs, excised embryos, and protoplasts under sterile conditions, holds a lot of potential for the manufacture of choice drugs. The cellular form obtained from an explant and cultured under aseptic circumstances on a nutritional medium can be grownup on a renewed medium many times to produce stable cell lines (Ellis, 1988; Namdeo, 2007).

Tissue/cell conservation

There are numerous significant plant species that cannot be saved as seeds and pose various concerns. Tuber, root, shrub, and tree species conservation is becoming increasingly challenging. Several approaches for conserving vegetatively broadcasted species have lately been devised, and some are now being tested. *In-vitro* conservation is the sole alternative accessible for some species. Though tissue culture has considerable promise for preserving germplasm from vegetatively propagated plants, genetic instability of the material retained as a result of soma clonal variation and storage length have been key technical obstacles. Large-scale implementation of these strategies will be achievable after they are further perfected (Khan *et al.*, 2012).

Chemo-biological exploration

Medicine produced from traditional sources such as plants and plant products, as well as folklore, has become a major element of pharmaceutical manufacturing. Chemical residents of plants known as 'Active Principles' that act on a specific organ or the entire body endure the foundation for a large portion of today's commercial medications for the treatment of a variety of challenging diseases such as heart disease, high blood pressure, discomfort, asthma, and other disorders (Rao, 2002).

With the advancement of genomics research, combinatorial chemistry, novel bioassay techniques, cell-based assays, high throughput screening (HTS), and computer-aided de-novo drug creation, a higher number of new therapeutic leads may be predicted. To answer the rapidly increasing issues, several ways have been tried to identify and invent novel therapeutic molecules. As a result, using mechanism-based screening methodologies, a significant number of natural product-derived drugs, such as pravastatin, lovastatin, and FK-506, have been found in recent years. Three species of Calophyllum have previously shown promise in the screening of medicinal plants for the behaviour of AIDS, according to researchers. Calonolihas, an active principle, has shown to be particularly powerful against viruses. The Indian laurel, *C. inophyllum*, was one of the species examined and judged promising (Ellis, 1988).

DNA storage

In principle, DNA storing is simple and extremely helpful. The process of storing DNA appears to be rather easy. With the progress of genetic engineering, species and genus restrictions to gene transfer have been removed. Transgenic plants have been created using genes from bacteria, viruses, fungi, and even mice. DNA libraries have been developed as a result of these efforts, which hold the whole genetic information of germplasm. Techniques and methods for using the content contained in the form of DNA, on the other hand, must be developed. As a result, the significance and utility of this approach in PGR conservation are still unclear (Adams, 1992; Ganeshan, 2010).

Pollen storage

Barnabas and Kovacs (1997) and Rajsekharan and Ganeshan (2002) have sufficiently evaluated the use of pollen storage technologies for numerous plant species. Pollen grains are ideal for preservation because of their tiny size and resistance to desiccation. Because pollen cannot be used to save complete plants, it has only been used in a restricted number of cases for the long-term conservation of plant species. It may, however, be beneficial for clonally propagated species storage, as it preserves intra-clonal genetic diversity. Because most pollen does not carry disease organisms, the international transmission and Plant genetic material exchanged by dry pollen is not considered to be normally regulated. Pollen collection and storage are perhaps the most important viable alternative in near future as a supplemental conservation approach in the case of species that are generally protected ex-situ, with the benefits outweighing the downsides (Adams *et al.*, 1992).

Synthetic seeds

Synthetic seed is a novel idea in biotechnological studies of seed that is mostly used for tissue culture plant micropropagation and delivery. Toshio Murashige first proposed the notion of synthetic seeds in 1977, but other scientists put it into practice when developing artificial seeds for several encapsulations of in-vitro propagules, crop species 24 through 26, (somatic embryos, axillary buds, shoot apices, corm lets, bulbs, etc.) is used in this method to create functional seeds that can grow into seedlings under the right conditions.

Biotechnological approaches

Biotechnological tools are significant for choosing, investigating, bourgeoning, and enlightening plants.Several biotechnological methods are present rummage-sale for the enhancement of herbal classes for anticipated characters (Khan *et al*., 2009). There are quite a few systems that are implemented for increasing bioactive constituents in curative plants (Baratali *et al.*, 2011).

Bio-production by tissue culture

Since trivial shoots or saplings are initially produced, this practice is referred to as micropropagation. Organogenesis is a developmental route in which a cell or group of cells is driven to differentiate into shoots or roots (Khan *et al.*, 2012). In biotechnology, cell suspension methods are used to harvest naturally occurring 2° metabolites. Taxol is a good example of anticancer medicine that has been developed using cell suspension culture for scalable manufacture (IpekSüntar, 2021). Shikonin, ajmalicine, anthocyanins, vinblastine, taxol, and vincristine have all been produced in this way. Hairy root culture has been shown to increase metabolite content. Other than Taxol, hairy root cultures can generate natural products for example artemisinin, camptothecin, ginsenosides, catharanthine, and plumbagin (Demain, 2011).

Combinatorial biosynthesis

Combinatorial biosynthesis is a technique for synthesizing bioactive chemicals in plants by combining genes from several species. The primary idea behind this method is to combine metabolic pathways in several species on a genetic level. A root-inducing plasmid containing t-DNA is infecting plasmids found in Agrobacterium rhizogenes. The plasmid infects plant cells and causes hairy root disease which is categorized by the formation of root-like hairy structures. In a hormone-free medium, the neoplastic roots formed by infection exhibit genetic and biochemical stability as well as a rapid development degree, subsequent in a significant mass/medium proportion. These inherently modified root cultures can create high quantities of 2 °metabolites that are equivalent to those seen in whole floras, and the altered root lines might be a potential basis for consistent and homogenous secondary metabolite production (Mattijs *et al.*, 2006).

Molecular pharming/bio-pharming

Molecular pharming or bio-pharming is the production of potential medicinal substances employing plant transformation technologies and temporary expression systems like agro infiltration, viral infection, and magnification. As a result, it concentrates mostly on the production of proteins and 2°metabolites, both of which are extremely beneficial to individuals but are prohibitively expensive in the market place (Wink, 2009; Kato, 2010). It was previously performed on GMOs to produce high-value chemicals that are now widely employed for industrial purposes. Plants may be used as biosynthesis factories for medications or substances that are highly expensive on the market. Compound biosynthesis in plant-based systems provides several benefits over other methods. Molecular pharming is used to create a variety of bio-products such as vaccines, antigens, proteins, antibodies, and therapeutic and nutraceutical compounds (Buyel, 2019).

Protoplast culture

Fusion is a corporealmarvel in which 2 and more energids collide and then attach, either naturally or fusion-inducing chemicals. Illnessconfrontation, nitrogen obsession, quick development, and a higher amount of product production, protein excellence, rise toughness, drought confrontation, herbicide resistance, heat, and cold resistances are all beneficial genes that may be transferred from one species to another. As a result of this biotechnological method, strains with desirable features have been created by combining genes from several species. P-sexual cross protoplasts can be created by fusing 2hereditarily distinct protoplasts secluded after corporeal cells together in the lab (Bera, 2015).

Somatic embryogenesis

It is the progression of creating a corporal rudiment after one or several cells. Plant tissue propagation procedures aimed at rejuvenation under appropriate conditions are required for hereditary alteration and gene duplicating. Plant propagation through somatic embryogenesis allows for the production of a greatnumber of floras in any season and has numerous benefits ended previous approaches (Kikkert, 2005; Ravi Shankar, 2011).

Metabolic engineering

Herbal metabolic engineering raises intriguing possibilities for restoring the plant's efficiency as a cell factory. This strategy might lead to new opportunities in chemical manufacturing, farming, ecological claims, and pharmaceuticals. By familiarizing the appropriate heterological genetic factor with a plant and other ancestors, a new-fangled chemical and other ancestors can be formed. To give nutrition, florae, or ornamental floras an original individual (Lorenzo, 2004). To upsurge the synthesis of a wanted organic enzyme in cell culture as well as in the plant. To harvest in thoroughly alike plant classes or even microbes. Through the expression of specific metabolites, to enhance agronomic features such as plant resilience to different stressors, vermin, and ailments, and to boost the seed production of a harvest plant. If the biosynthesis process for silymarin is completely understood and the genetic factors involved are identified, metabolic engineering in Silybum marianum to improve the accretion of silymarin may be feasible (Zhou *et al*., 2009).

Metabolic engineering stratagems and systems in medicinal plant biotech

Hairy root cultures

The invention of 2 °metabolites is critical to the commercial feasibility of the hairy root culture technique. Strain improvement, medium selection, environment optimization, immobilization, evocation, ancestral mentation, permeabilization, metabolic engineering, biotransformation, and bioreactor principles are some of the strategies developed to increase the manufacture and output of shaggy root biomass for the combination of 2° composites (Verpoorte *et al.*, 1999)

Gamma irradiation mutagenesis

Vinblastine is a plant-derived indole alkaloid that is one of the most often used cancer medications. Despite the therapeutic value of vinblastine, manufacturing procedures still rely on cell culture, bud culture, tissue culture, semi-synthesis, and total chemical synthesis from the leaves of the medicinal plant *Catharanthus roseus* (Bulgakov, 2008). Those processes are costly, and the yields obtained are poor, resulting in insufficient medical supplies that are unable to fulfil market demand. For all of these reasons, finding alternate and sustainable sources of the most significant anti-neoplastic medication vinblastine, especially endophytic fungi, is a serious societal and scientific necessity (El-Sayed, 2021). In general, microbial strain mutation breeding has arisen as a viable strategy intended for increasing the production of this draining in the zymolysis business. Gamma emissions are the most energetic ionizing radiation midst of the corporeal mutagenic managers. The mutagenic agent of the initial optimal has been indicated as gamma-irradiation. Several alterations in the illuminated cell, with basic variations in the DNA substantial and oxidized centres and elementary places, were found after exposure to gamma rays, resulting in the development of mutations (Ramani and Chelliah, 2007).

Conclusion:

Biotechnological concepts have now risen to the forefront of secondary metabolite manufacturing technology development. Because the medicine acquired by chemical synthesis is moreover less active than the identical drug obtained through normal synthesis or has certain negative effects, attention in the drug of natural origin has resurfaced. The expansion of small and micro-enterprises, particularly for the dispensation and commercialization of medicinal plants, appears to have the latent to provide underprivileged people with financial prospects.

Rapid advancements in biotechnology-based natural product manufacturing hold considerable promise for realizing the true potential of natural products. Although biotechnological methods of plants can improve product output, there are still certain problems such as culture heterogeneity, yield unpredictability, poor growth rates, stress sensitivity, and cell aggregation. To summarise, biotechnological production of a wide range of NPs and biopharmaceuticals has entered a new phase as a result of the accelerated discovery, improved understanding of cellular trails, and emphasized areas of progression optimization. Emerging manufacturing techniques aimed at discovering new chemicals, identifying biosynthetic structures labs and improving genome editing skills over artificial ecology yield significant assistance in rapport of practical keys for the long-term manufacture of useful products.

Abbreviations

PSMs - Plant secondary metabolites

ME -Metabolic engineering

WHO - World Health Organization

HTS- High throughput screening

MPs- Medicinal Plants

AIDS-Acquired immune deficiency syndrome

DNA–Deoxyribose Nucleic Acid

PGR - Plant growth regulators

SE -Somatic Embryos

T-DNA -transferred DNA

GMOs -Genetically Modified Organism

GI -Gamma Irradiation

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ADVANTAGES AND DISADVANTAGES OF AGRICULTURAL PESTICIDES ON HUMAN AND ENVIRONMENT

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Abstract:

To stop the growth of undesirable living creatures, pesticides are a necessary component of modern life. Although numerous toxicological studies have shown that pesticides and their residues pose little risk, the community has been very worried in recent years about the widespread use of pesticides in a variety of fields. Therefore, it is crucial to assess risk from hazards, especially in the long run. In reality, there are at least two very distinct methods for evaluating the use of pesticides: first is a probabilistic or objective risk assessment, and the second is based on prospective advantages to the economy and agriculture. This chapter explores potential strategies to strike a balance between the positive and negative impacts of agricultural pesticide application.

Keywords: pesticides, benefits, hazards, environment, etc.

Introduction:

Increase in food production is the main objective of all countries, as world population is expected to grow to nearly 10 billion by 2050 (Gill and Garg) increasing by an estimated 97 million per year (Saravi and Shokrzadeh, 2011). The idea behind food security is to make more food available to the population so that the gap between food supply and demand is better and to the consumer's advantage. In order to improve productivity and maintain soil fertility, application of fertilizer has been crucial. Recent developments in plant breeding, genetic engineering, and food technology have made it possible for some parts of the world to have enough food, which has decreased the rate of under nutrition. One of the most significant and divisive global concerns of the present is how to feed the world's expanding population while maintaining an adequate level of nutrition. Increase in food production is faced with the ever growing challenges especially the new era that can be increased for cultivation process is very limited (Saravi and Shokrzadeh, 2011).

Different type of pests wasted over half of the agricultural output. To protect plants from pests and other diseases and to boost production yield, pesticides must now be applied. When pesticides are applied correctly, they protect items, improve their quality, save labor cost, and yield a large economic advantage. However, using pesticides excessively is exceedingly detrimental for both the environment and human life.

What are pests?

Any organism that spreads disease, causes damage, or is otherwise a nuisance is considered a pest. Mosquitoes, mice, and weeds are a few types of pests. The phrase is especially used to describe animals that disturb people, especially in their houses, or cause harm to forests, cattle, or crops. Insects are not always a pest. Insects of many different varieties are helpful creatures because they consume other insects. Examples of helpful insects include lady beetles and dragonflies, which primarily consume mosquitoes and also eat aphids, scale insects, mites, and other insects.

What are agricultural pests?

Any species, strain, or biotype of animal, plant, or pathogenic agent that harms plants or plant products is referred to as an agricultural pest. Pests can include weeds, plant pathogens (certain fungi, bacteria, and viruses), rodents, and nematodes in addition to the plant-feeding insects and mites, and are estimated to destroy as much as one-third of all agricultural yield. Higher levels of interconnection lead to greater consequences of agricultural pests globally. Pests of all kinds affect agricultural and horticultural crops, but the most significant ones are gastropod mollusks, mites, nematodes, and insects.

The harm they inflict stems from both the direct harm they bring to the plants and the indirect effects of the bacterial, viral, or fungal illnesses they spread. In situations where the plants are already stressed or where the pests have been mistakenly introduced and may not have any natural enemies, plants have their own defenses against these attacks, but these may be overwhelmed. The majority of pests that damage trees are insects, many of which have been unintentionally imported, have no natural adversaries, and some have spread novel fungal diseases with disastrous effects. Aphids, Caterpillars, Cutworms, Grasshoppers, locusts, Thrips, Weevils, Whiteflies, Mites, Snails, slugs, Slaters etc. are some common agricultural pests.

What is pesticide?

Physical, chemical, and biological strategies are used to control pests, and the way to use relies on a number of factors (type of industry, species, amount and distribution of pests, environmental conditions, etc.). The usage of substances known as "pesticides" is the basis of the most efficient pest control techniques. Agricultural and forestry industries are the biggest users of pesticides. Additionally, pesticides are frequently utilized in a variety of trades, industries, storage facilities, and other spheres of domestic and commercial life. The Food and Agriculture Organisation of the United Nations (FAO) presents following definition of pesticides:

'Pesticide means any substance or mixture of substances of chemical or biological ingredients intended for repelling, destroying or controlling any pest, or regulating plant growth'.

In the world, Asia uses more than half of all pesticides. In terms of pesticide use worldwide, India ranks third in Asia, behind China and Turkey. The agriculture industry, which is the most significant sector of the Indian economy, employs around 70% of the entire population. Additionally, a crucial component of contemporary agriculture is the use of fertilizers and pesticides. Insecticides, fungicides, and herbicides are often used pesticides to manage uncontrolled weeds and pests on agricultural areas. In India, however, insecticides account for the largest portion of all pesticide consumption. Only 1% of the world's pesticides are used in India. According to FAO data, India used approximately 58160 tonnes of pesticide in 2018. India uses pesticides differently than the rest of the world as a whole. In India, 76% of pesticides are insecticides, compared to 44% globally, as seen in Table 1.

Table 1: Consumption pattern of pesticides

Pesticides	World	India
Insecticides	44%	76%
Fungicides	21%	13%
Herbicides	30%	10%
Others	5%	1%

Role of pesticide in agricultural production

Pesticides play important roles in agriculture production. Pesticide is a more general term than Plant Protection Product (PPP). Plant protection products are 'pesticides' that protect crops or desirable or useful plants. They contain at least one active substance and have one of the following functions:

- Protecting plants or plant products against all harmful organisms (e.g. fungicides, insecticides, molluscicides, nematicides, rodenticides, etc.).
- Influencing the life processes of plants (e.g. Plant Growth Regulators).
- Preserving plant products (e.g. fumigants).
- Destroying undesired plants or parts of plants (e.g. defoliants).
- Checking or preventing undesired growth of plants (e.g. herbicides).

Types of pesticides

These are grouped according to the types of pests which they kill:

- Insecticides – insects
- Herbicides – plants
- Rodenticides – rodents (rats & mice)
- Bactericides – bacteria
- Fungicides – fungi
- Larvicides – larva

Pesticides can also be considered on their degradability as:

- **Biodegradable:** The biodegradable kind is those which can be broken down by microbes and other living beings into harmless compounds.
- **Persistent:** While the persistent ones are those which may take months or years to break down.

Advantages of pesticides

Higher production, increased efficiency and Intensification of the farming system are the main point of present agricultural policy. Therefore uses of pesticides are essential to do this. Here are some advantages of the use of pesticides in agricultural production

- **It helps in keeping food affordable:** Pesticides help farmers to grow more food which directly in making food cheap and easily available. Whereas the traditional way of removing weeds tends to make food costly.
- **Pesticides help in an abundant harvest:** By using pesticides it ensures that crop is protected by pests and are healthy for harvest. Pesticides ensure crops are not damaged and not infected by any pests.
- **Pesticides help to prevent insects and waterborne transmission diseases:** Pesticides help in preventing diseases such as malaria, lyme, etc. It helped in enhancing human health and preventing many diseases.
- **Pesticides help farmers to grow more crops in the same or less land:** when there are low chances of pests in crop fields then it becomes more chances of more production of crops in the same land. The growth between 40 to 50 percent of productivity allows farmers to gain more benefits.
- **It helps to protect the storage:** After the harvest, it sometimes becomes difficult to protect the crop from rodents and pests. Pesticides help in preventing pests and storage can be done easily and longer.

- **Pesticides helped in making it easy to remove weeds or prevent pests without hardship:** Picking weeds by hand was a lengthy process that decreased productivity and also some pests which were harmful to plant's growth were now easily removed by the pesticides.
- **It helped globally to increase the economical growth of a country:** The economical growth of a country is very much dependent on the growth of food production and the pesticides help farmers with a healthy yield that helps in improving economic growth.
- **Pesticides help in preventing insects, rodents, and viruses at home, offices, etc:** At homes, offices there are so many insects, rodents, viruses that can be harmful to humans by spreading various diseases thus pesticides help them to kill or control these pests.
- Food security and safety, higher life expectancy, and lower maintenance costs are all benefits.

Positive effects of agricultural pesticides (Maksymiv, 2015) are summarized in Table 2.

Table 2: Positive effects of pesticides

Primary benefits	Secondary benefits
Regulating insects and plant disease carriers Improved crop/livestock quality Reduced fuel use for weeding Reduced soil disturbance Invasive species controlled	**Community benefits** Food security and safety Nutrition and health improved higher life expectancy lower maintenance costs
Prevent or control of organisms that harm other human activities and structures Tree/bush/leaf hazards prevented Recreational turf protected Wooden structures protected	**National benefits** National agricultural economy increased export revenues Reduced moisture loss/ soil erosion
Controlling disease vectors and nuisances organisms Human lives saved Human disturbance reduced Animal suffering reduced Increased livestock quality	**Global benefits** Less pressure on uncropped land Fewer pest introductions elsewhere International tourism revenue

Disadvantages of pesticides:

98% sprayed insecticides and 95% sprayed herbicides reach a destination other than their target species because they are sprayed across entire agricultural fields. This pesticide drift can take place by runoff by water to aquatic environment and wind can carry them to other fields, grazing areas, human settlements, potentially affecting other species. Poor production, transportation and storage practices requires application of pesticides. Rachel Carson's book "Silent spring" published in 1962, explained the environmental problems (Ecological effects) of pesticides. It was most influential book on the environment. After that people change their research towards ecological impacts of pesticides. Besides of numerous benefits, there are some important disadvantages of pesticides are also present on environment, and these may be classify in air, soil, water pollution and adverse effect on plant, human and animal life.

1. **Effect on air:** Pesticide can spread by volatilize and may be blown by winds into nearby areas. Weather conditions at the time of application, Temperature, and Relative humidity affect the spreading of pesticides in the air. Ground spraying produces less spread than aerial spraying. The rate of volatilization is dependent on time after pesticide treatment, the surface on which the pesticide settles, the ambient temperature, humidity, wind speed and vapor pressure of the ingredients (Kips, 1985). The volatility or semi volatility nature of the pesticide compounds similarly constitutes an important risk of atmospheric pollution of large cities (Trajkovska et al., 2009).
2. **Effect on water:** Pesticides reach the water by contaminate water when they are spraying, by percolation, and leach through the soil or it may be carried to the water either as runoff or carried to water by eroding soil. After contaminate the water it makes lot of problems: (a) Application of herbicides to bodies of water can cause fish kills., (b) Reduce the quality of drinking water., (c) Reduce the amount of water available for cultivation., (d) Altering the physical characteristics of water bodies. Pesticides move in water over soil into surface water, contaminated ditches, streams, rivers, ponds and lakes, surface water used for drinking and livestock water, irrigation, etc. Runoff amount depends on: grade or slope of the area, soil moisture, soil texture, vegetation, amount and timing of irrigation/rainfall, pesticide characteristics. Insecticides are typically more toxic to aquatic life than herbicides and fungicides.

   Ground water pollution to pesticides is a worldwide problem. Once ground water is polluted with toxic chemicals, it may take many years for the contamination to dissipate or be cleaned up. According to the United States Geological Survey (USGS), at least 143 different pesticides and 21 transformation products have been found in ground water, including pesticides from every major chemical class. During one survey in India, 58% of drinking water samples drawn from various hand pumps and wells around Bhopal were contaminated with organic Chlorine pesticides above the Environment Protection Agency (EPA) standards (Kole and Bagchi, 1995).

Indiscriminate use of pesticides and its active metabolites has led to the contamination of water bodies and ambient air, possibly affecting the health of aquatic biota fishes, amphibians and birds (Trevisan *et al.,* 1993).

3. **Effect on aquatic life:**
   - **Effect on fish-** Fishes provide food source for other animals such as sea birds and marine mammals and thus fishes form an integral part of the marine food web (Scholz *et al.*, 2012). Herbicides responsible for plant death, and dead plant decay consume water's oxygen, which further suffocating the fish. Repeated exposure can cause physiological and behavioral changes which leads to reduce fish populations. Herbicides kill the plant that fish eats and on which fish depend for their habitat. Pesticides kill the insects which fish feed and also kill zooplankton, which is the main food of young fish. These factors causing the fish to travel farther in search of food and exposing them to greater risk from predators.
   - **Effect on Amphibians-** Many studies showed that amphibians are susceptible to environmental contaminants (Relyea, 2003; Kerby *et al.,* 2010; Johnson *et al.*, 2013). Tadpoles from ponds containing multiple pesticides, take longer time to metamorphosis and are smaller decreasing their ability to catch, prey and avoid predators (decrease in number of splenocytes and phagocytic activity) (Christin *et al.,* 2013). Organochloride, endosufan kills the tadpoles, and causes behavioural and growth abnormalities. Atrazine (Herbicide) can turn male frog into hermaphrodites, decreasing their ability to reproduce. Reproduction problems, sex reversal and physical abnormalities were also found in crocodiles lived in contaminated water.
4. **Effect on birds:** Birds are also called "Aerial acrobats", consuming different kinds of insects such as mosquitoes, European corn borer moth (*Ostrinia nubilalis*), Japanese beetles (*Popillia japonica*) and many other insect species that are considered as some of

the most serious agricultural and health pests. Pesticide exposure by different means such as direct ingestion of pesticide granules and treated seeds, treated crops, direct exposure to sprays, contaminated water, or feeding on contaminated prey, and baits cause birds mortality (Veermer *et al.,* 1970; Hunter, 1995; Fishel, 2011; Guerrero *et al.,* 2012). Pesticides (carbamates, organochlorines, & organophosphates) can cause a decline in the populations of raptorial birds by altering their behavior and reproduction (Mitra *et al.,* 2011).

5. **Effect on soil:** The indiscriminate and repeated use of pesticides further aggravates problem of pesticide accumulation in soil. Several factors such as soil properties and soil micro-flora determine the fate of applied pesticides, owing to which it undergoes a variety of degradation, transport and absorption/desorption processes (Weber *et al.,* 2004; Laabs *et al.,* 2007; Hussain *et al.,* 2009). Pesticides adversely affect the soils vital biochemical reactions including Nitrogen fixation, nitrification and ammonification (Hussain *et al.,* 2009; Munoz *et al.,* 2011). Insecticides DDT, Methyl parathion, Pentachlorophenol etc. interfere with legume rhizobium chemical signaling, hence reduction in symbiotic chemical signaling results in reduced N_2 fixation and reduced crop yield. Pesticides (atrazine, primeextra, paraquatand glyphosate) influenced mineralization of soil organic matter, soil quality and soil productivity (Sebiomo *et al.,* 2011). Pesticides that reach the soil may disturb local metabolism and can alter the soil enzymatic activity (Gonod *et al.,* 2006; Floch *et al.,* 2011). Pesticides can alter/reduce the functional structure and functional diversity of microorganisms, but increase the microbial biomass (Lupwayi *et al.,* 2009). The use of pesticides decreases the general biodiversity in the soil. They effect on growth of the plants as well as the soil micro-organisms & decrease the soil fertility. They enter to the food chain & process of biomagnifications takes place. Residual effect of the pesticide in the soil is also very harmful to chemical environment of the soil and plant growth.
6. **Effect on animals:** Pesticides can eliminate some animal's essential food sources. Residues can travel up the food chain. Pesticide exposure can be linked to cancer, endocrine disruption, reproductive effects, neurotoxicity, kidney and liver damage, birth defects and developmental changes in a wide range of species. Earthworms digest organic matter and increase nutrient content in the top layer of soil. Pesticides have harmful effects on growth and reproduction on earthworms (Edward, 1987; Reinecke and

Reinecke, 2007; Pelosi *et al.,* 2013). Pesticides eliminate some animals essential food sources, causing the animals to relocate, change their diet or starve.

7. **Effect on plants:** Root nodule formation in plants saves the world economy 10 billion dollar in synthetic nitrogen fertilizer every year. Specially pentachlorophenol interfere with legume-rhizobium chemical. Reduction of this symbiotic chemical results in reduced Nitrogen fixation. Pesticide can kill bees and decline the pollinators. US farmers lose at least 200 million dollars a year from reduced crop pollination because pesticides applied to fields. Pesticides changes chemical environment of soil, which further adversely affect plant growth.
8. **Effect on pollinators:** Different species of bees, bumble bees (*Bombus* spp.) honey bees (*Apis* spp., fruit flies), some beetles, and birds (e.g. hummingbirds, honeyeaters, and sunbirds etc.) are some of the recognized pollinators. Pesticide application affects various activities of pollinators including foraging behavior, colony mortality and pollen collecting efficiency.
9. **Biomagnification:** The increase in concentration of pesticides due to its persistent and non-biodegradable nature in the tissues of organisms at the higher levels of food chain is known as biomagnifications. If any individual continuously eat contaminated food it will accumulate in the body. All the individuals are part of food chain as a result, toxins stored in the fats & oils pass one tropic level. The higher up the food chain more concentrate the pesticide called biomagnifications. This is danger expose to human because they are also in top of the food chains.
10. **Effect on non target organisms:** Most of the agricultural pesticides are non target specific. Adverse effects of applied pesticides on non-target anthropods have been widely reported (Ware, 1980). Unfortunately, natural insect enemies e.g., parasitoids and predators are most susceptible to insecticides and are severely affected (Aveling, 1977; Vickerman, 1988). Soil invertebrates including nematodes, springtails, mites, micro-anthropods, earthworms, spiders, insects and other small organisms make up the soil food web and enable decomposition of organic compounds such as leaves, manure, plant residues etc. and maintain soil structure, transformation and mineralization of organic matter. Pesticide effects on above mentioned soil anthropods therefore negatively impact several links in the food web.
11. **Pesticide resistance:** When pesticide use long period of time, some pest become resistance to the pesticide. Because of resistance development, these pests can’t be

control. Farmers have to increase the concentration or change the pesticide it make more & more adverse environmental effects.

12. **Pest resurgence:** Pest resurgence is defined as the rapid appearance of a pest population in injurious numbers following pesticide application. Use of persistent and broad spectrum pesticides that kills the beneficial natural enemies is thought to be the leading cause of pest resurgence.
13. **Pesticide poisoning:** Short-term exposure to high levels of pesticides can result in harm to organs and even death. Long-term exposure to lower levels of pesticides can cause cancer. Children are at a great risk than adults.
14. **Health effects of pesticides:**

    i. **Acute effects:**

    - Acute health problems may occur in workers that handle pesticides, such as abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problems.
    - Pyrethrins, insecticides commonly used in common bug killers, can cause a potentially deadly condition if breathed in.

    ii. **Long term effects:**

    - Cancer- Many studies have examined the effects of pesticide exposure on the risk of cancer. Associations have been found with leukemia, lymphoma, brain, kidney, breast, prostate, pancreas, liver, lung and skin cancers.
    - A mother's occupational exposure to pesticides during pregnancy is associated with an increase in her child's risk of leukemia, Wilm's tumor, and brain cancer.
    - Neurological- The risk of developing Parkinson's disease is 70% greater in those exposed to even low levels of pesticides. People with Perkinson's were 61% more likely to report direct pesticide application.
    - Reproductive effects: Strong evidence links pesticide exposure to birth defects, fetal death and altered fetal growth. It was also found that offspring that were at some point exposed to pesticides had a low birth weight and had developmental defects.

- Fertility: A number of pesticides including dibromochlorophane and 2,4-D has been associated with impaired fertility in males.

15. Residues of Pesticides:

i. Residues in human blood: Organochloro insecticides found in samples of blood serum in rural areas of Ahemdabad showed an average of 200.3ppb. Among all HCH (Hexachlorocyclohexane) and DDT (Dichlorodiphenyltrichloroethane) were chief contaminants.

ii. Residues in human milk: Potential risk to infants. Toxilogical implication cannot be assessed precisely. Hexaclorobenzenes a fungicide is found in human milk and fat.

iii. Residues in food commodities and average daily intake: Concentration of pesticides varies greatly. DDT and HCH are found in ground nut and sesame oils in Tamil Nadu.

iv. Residues in environmental samples: Residues in aerosol in Ahmadabad ranges from 2.06-18.96 ng/m^3 of BHC and DDT. DDT and HCH in drinking water samples 47.4-256.9 ng/L.

16. Ecological effects of Pesticides: Adverse ecological effects of pesticides includes loss of species diversity among the food chains and food webs, adverse effects on pollinators, negative effects on nutrient cycling in ecosystem**,** soil erosion, structure and fertility. Excess application of pesticides degrades water quality and affects on fish and other aquatic organisms, contaminate the food. Pesticides disrupt the natural balance between pest and predator insects**,** Pesticides cause pest rebound and secondary pest outbreaks**,** Pesticides may cause pest resistance. Intake of pesticides are responsible for physical and mental health of living beings (human, bird and animals).

Conclusion:

Although the use of pesticides was first intended to improve agricultural output and prevent the spread of infectious diseases, their negative consequences now outweigh those advantages. The aforementioned explanation amply illustrates the negative effects of indiscriminate pesticide usage on several ecosystem elements. Pesticides must be used correctly at this time to safeguard our environment and any potential health risks linked to them. Alternative pest control methods, such as integrated pest management (IPM), which employs a combination of different control measures, including cultural control, use of resistant genotypes, physical and medical control, and prudent pesticide use, may reduce the frequency and volume of pesticide application. Furthermore, advanced techniques like biotechnology and nanotechnology may help in the development of pesticides with less harmful side effects or genotypes resistant to them. Community development and various extension programs that could educate and encourage farmers to adopt the innovative IPM strategies hold the key to reduce the deleterious impact of pesticides on our environment.

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SUSTAINABLE AGRICULTURE – THE FUTURE OF INTEGRATED FARMING

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Abstract:

The need for multi-functional agricultural assets develops in conjunction with the need to feed a growing global population. The intensification of production techniques and the expansion of agricultural land both hit their ecological, financial, and social limits at the same time. Sustainable production, with its holistic principles, holds the key to solving these problems. Sustainability is based on the notion that we must meet the demands of the present without jeopardizing future generations' ability to meet their own needs. People going hungry in poor countries, obesity in rich countries, rising food prices, ongoing climate change, rising fuel and transportation costs, global market flaws, worldwide pesticide pollution, pest adaptation and resistance, loss of soil fertility and organic carbon, soil erosion, decreasing biodiversity, desertification, and so on. Despite remarkable developments in science that allow us to visit planets and reveal subatomic particles, major terrestrial food challenges demonstrate unequivocally that conventional agriculture is no longer capable of feeding humans and preserving ecosystems. Therefore, sustainable agriculture is a viable option for addressing basic and applied concerns related to food production in an environmentally responsible manner. While conventional agriculture is almost entirely driven by productivity and profit, sustainable agriculture integrates biological, chemical, physical, ecological, economic, and social sciences in order to develop new farming systems that are safe and do not harm the environment.

Keywords: Sustainable, Farmer, agriculture, Profit and cropping system

Introduction:

Over thousands of years, agriculture has been the main means of human subsistence. Even now, it supports the livelihood of half the world's population. The Food and Agricultural Organization (FAO) warns that if global food production does not increase by 50–60%, people in emerging countries—where population growth is particularly rapid—may go hungry. Despite the country's population growing from 361 million in 1951 to over one billion in 2005, Indian agriculture has made remarkable strides in recent years and is now more robust to the whims of the monsoon. By the turn of the century, it is anticipated that the size of farm holdings and the amount of agricultural land available per person will be approximately 1.4 and.14 hectares, respectively. This loss is projected to worsen due to conflicting demands on land for other development sectors. Over 6 billion people live on the planet today. By 2025, it is anticipated to reach above 8 billion, and by the end of the century, it will be close to 10.5 billion. Simply put, to maintain the present quo, basic food production must quadruple. The hunger must be banished from the surface of earth, as a first responsibility of any civilised society to provide sufficient food for the people who are below poverty line (Velten *et al*., 2015).

Indian agriculture before green revolution

Small and marginal farmers who produced food and basic animal products for their families and local village communities dominated our old farming systems. Agriculture was extremely decentralised, with indivisual farmers choosing the crops they cultivate based on the climate and soil characteristics. Even Alexander Walker, a resident of Baroda in Gujarat, noted in 1820 that green fodder was grown all year round and that practises like intercropping, crop rotation, fallowing, composting, and manuring had enabled farming to continue for more than 2000 years on the same land without a yield decline. The British government's collection of land income was one of the factors contributing to the downfall of a sustainable agricultural system. Even ancient sacred groves that had been conserved were converted into plantations for coffee, tea, teak wood, and sugarcane. India consequently suffered from the worst string of extended famines in its history from 1865 to 1900.

Green revolutuion

After the green revolution was launched in India, substantial increase in the production of food grains was achieved through the use of improved crop varieties and higher levels of inputs of fertilizers and plant protection chemicals. The ills of green revolution are stated to be:

- Reduction in natural fertility of soil
- Destruction of soil structure, aeration and water holding capacity
- Susceptibility of soil erosion by water and wind
- Diminishing returns on inputs
- Breeding more virulent and resistant species of insects
- Reducing genetic diversity of plant species
- Pollution with toxic chemicals from agrochemicals
- Health of farmers
- Cash crops displacing nutritious food crops 15
- Chemical changing natural taste of food

- High cost inputs
- Depleting fossil fuel resources
- Lowering drought tolerance of crops
- Appearance of problematic and difficult weeds
- Throwing financial institutions into disarray
- Agricultural and economic problems sparking off social and political turmoil resulting in violence

Sustainability

It operates under the tenet that we must satisfy current demands without jeopardising the capacity of future generations to satisfy their own wants. In terms of agriculture, organic agriculture makes claims about sustainability. Sustainability is the efficient use of agricultural resources to meet human needs while also preserving and improving the environment's quality and natural resource availability. Therefore, sustainability in organic farming must be seen holistically, taking into account ecological, economic, and social factors.

Environmental sustainability

- Produce and enjoy healthy foods and fibers without compromising the ability of future generation
- Controlled use of pesticides
- Proper management of fodder
- Maintenance of soil fertility
- Prevention of Habitat loss due to land conversion

Social sustainability

- Cooperative relationships
- Strong moral and work ethics
- Better human health and diet
- Development of rural communities
- Maintenance of agricultural heritage

Economic Sustainability

- Enhanced productivity in terms of quantity and quality
- To attain improved profitability
- Energy Efficiency
- Improved livelihood
- Food security
- Labour and employment

- **Figure 1: Perspective of sustainable agriculture**

Sustainable agriculture

The word "sustain" comes from the Latin word *sustinere* (*sus*-, from below and *tenere*- to hold) to keep in existence or maintain, implies long term support or permanence. It is a form of agriculture in which to fulfil the needs of the present generation without endangering the resource base of the future generations.

It is the practice of farming using principles of ecology, the study of relationships between organisms and their environment. It has been defined as "**an integrated system of plant and animal production practices having a site-specific application that will last over the long term**".

"For a farm to be sustainable, it must produce adequate amounts of high-quality food, protect its resources and be both environmentally safe and profitable. Instead of depending on purchased materials such as fertilizers, a sustainable farm relies as much as possible on beneficial natural processes and renewable resources drawn from the farm itself." (Reganold *et al*., 1990)

Sustainable Agriculture comprises "management procedures that work with natural processes to conserve all resources, minimize waste and environmental impact, prevent problems and promote agroecosystem resilience, self-regulation, evolution and sustained production for the nourishment and fulfillment of all." (MacRae *et al*., 1989)

Technical Advisory Committee or the Consultative group on International Agricultural Research (TAC/CGIAR) States: Sustainable agriculture is the successful management of resources for agriculture to satisfy human changing needs, while maintaining or enhancing the quality of the environments and conserving natural resources.

It is the balanced management of renewable resources including soil, wildlife, forest, crops, fish, livestock, plant genetic resources and ecosystems without degradation and to provide food, livelihood for current and future generations maintaining or improving productivity and ecosystem services of these resources.

Sustainable agriculture has to be economically viable both in the short and long term perspectives. Sustainable agriculture is also known as Eco farming or organic farming or natural farming or permaculture.

A Sustainable agriculture system is one that can indefinitely meet demands for food and fibre at socially acceptable, economic and environment cost. Sustainable Agriculture refers to an agricultural production and distribution system that:

- Achieves the integration of natural biological cycles
- Protects and renews soil fertility and the natural resource base
- Reduces the use of non-renewable resources and purchased (external or off-farm) production inputs
- Optimizes the management and use of on- farm inputs
- Provides an adequate and dependable farm income
- Promotes opportunity in family farming and farm communities
- Minimizes adverse impacts on health, safety, wildlife, water quality and the environment.

Concept of sustainability in cropping system

The concept of sustainability applied to agriculture developed mainly as a result of growing awareness of negative impacts of intensive farming systems on the environment and the quality of life of rural and neighbouring communities.

- Protecting the natural resources
- More efficient use of arable lands and water supply
- The sustainability concept has promoted the need to propose major adjustments in conventional agriculture to make it more environmentally, socially and economically viable and compatible. The concept of sustainability is useful
- It captures a set of concerns
- Several possible solutions to the environmental problems.
- The main focus lies on the reduction or elimination of agrochemical inputs.

Basic principles of sustainable agriculture

- Based on both biological potential and biological diversity, land can be classified into conservation, restoration and sustainable intensification areas.

- Effectiveness in water saving, equity in water sharing and efficiency in water delivery and use are important for sustainable management of available surface and groundwater resources.
- An integrated system of energy management involving the use of renewable and non-renewable resources of energy in an appropriate manner is essential for achieving desired yield levels.
- Soils in India are often not only thirsty but also hungry. There is need for reduction in the use of market purchased inputs and not of inputs. It is in this context integrated systems of nutrient supply assume importance.
- Genetic diversity and location specific varieties are essential for achieving sustainable advances in productivity.
- The control of weeds, insect pests and pathogens is one of the most challenging jobs in agriculture.
- Whole plant utilization methods and preparation of value added products from the available agricultural biomass are important both for enhancing income and for ensuring good nutritional and consumer acceptance properties.
- Recycling of crop waste and livestock management.
- Growing legume crops
- Genetically Engineering crops (GM crops)

The goal of sustainable agriculture

The goal of sustainable agriculture is to maintain production at levels adequate to meet rising global demand without negatively impacting the environment, and sustainability implies environmental concern are:-

i. Generation of income
ii. The promotion of appropriate policies
iii. The conservation of natural resources
iv. Enhance efficiency of use of input
v. Minimize adverse environmental impacts on adjacent and down stream environments
vi. Minimize the magnitude and rate of soil degradation and to enhance soil quality and resilience so that the crop productivity can be sustained with minimum adverse impact on soils and environment
vii. Enhance compatibility with social and political conditions.

However, many people use a wider definition judging agriculture to be sustainable if it is:

- **Ecologically sound**: quality of natural resources is maintained

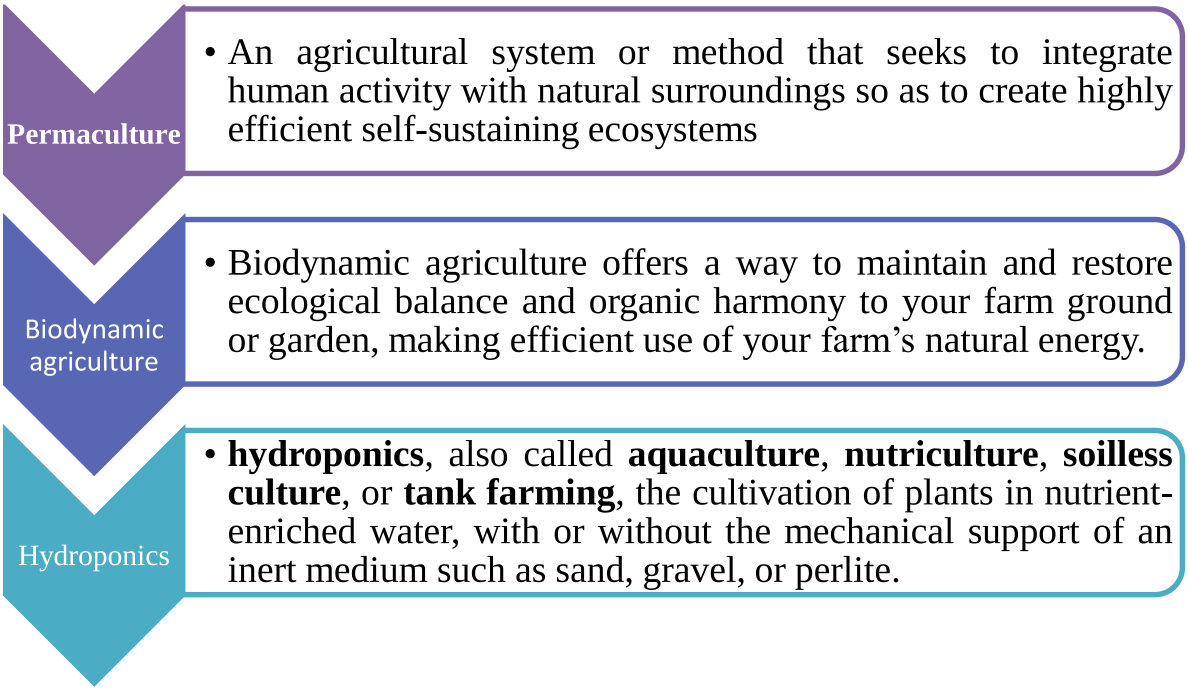
- **Economically viable**: farmers can produce enough for self-sufficiency
- **Socially**: resources and power are distributed in such a way that basic needs of all members of society are met and their rights to land use, adequate capital, and technical assistance and market opportunities.
- **Human**: all forms of life (plant, animal and human) are respected.
- **Adaptable**: rural communities are capable of adjusting to the constantly changing for farming, population growth, policies, market demand etc.

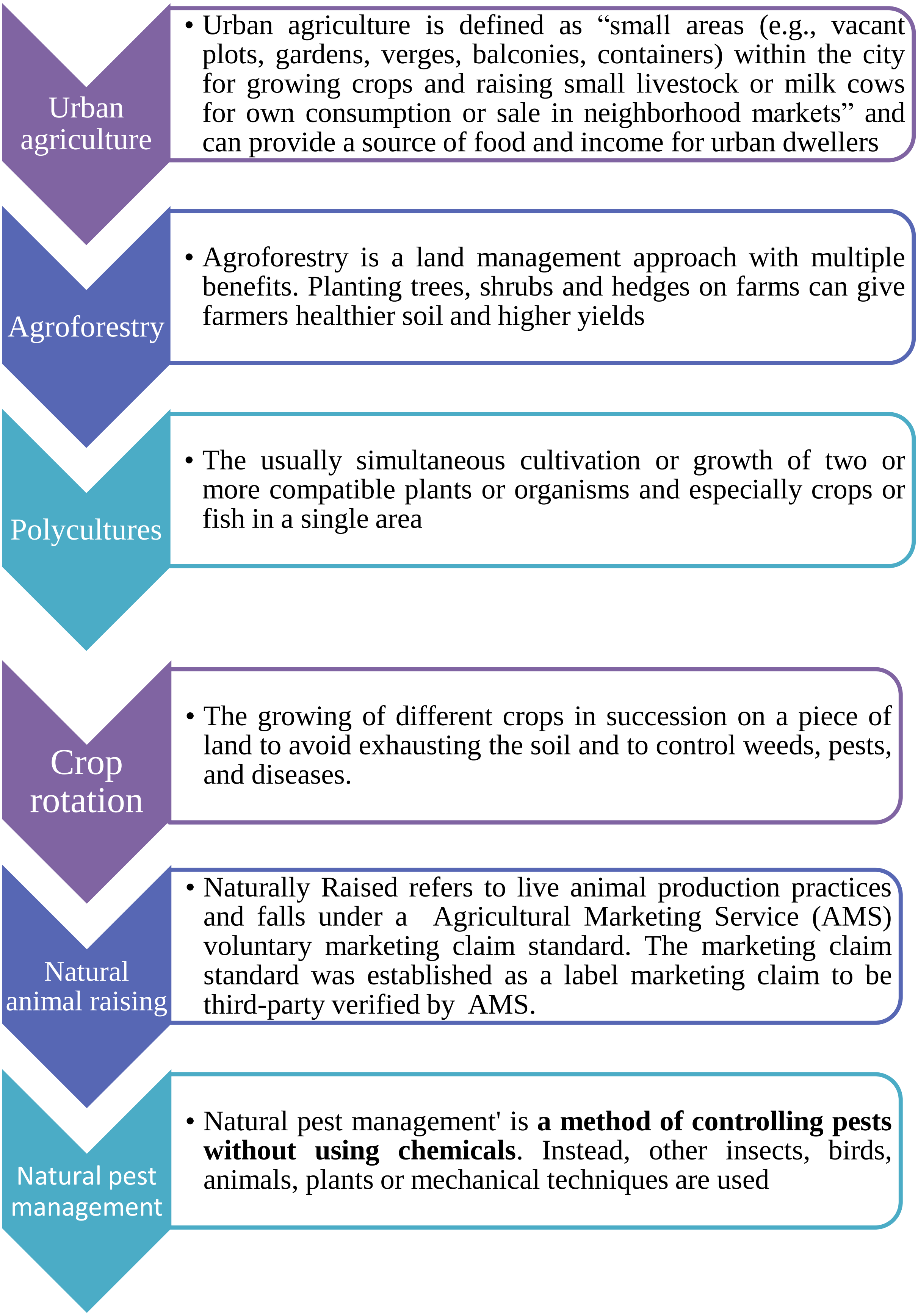
Objectives of sustainable agriculture

The main objectives of sustainable agriculture are:

- Make the best use of the resources available
- Minimize use of non-renewable resources
- Protect the health and safety of farmworkers, local communities and society
- Protect and enhance the environment and natural resources
- Protect the economic viability of farming operations
- Provide sufficient financial reward to the farmer to enable continued production and contribute to the well-being of the community
- Produce sufficient high-quality and safe food
- Build on available technology, knowledge and skills in ways that suit local conditions and capacity.

Approaches to sustainable agriculture





Gomiero *et al*. (2011)

Table 1: Difference between sustainable agriculture and conventional agriculture

Particulars	Sustainable agriculture	Modern agriculture
Plant Nutrient	Farm yard manures, compost, vermicompost, green manure, bio-fertilizer and crop rotation are used.	Chemical fertilizers are used.
Pest control	Cultural methods, crop rotation and biological methods are used.	Toxic chemical are used.
Inputs	High diversity, renewable and biodegradable inputs are used	High productivity and low diverse chemicals are used fragile ecology.
Ecology	Stable ecology	Easily broken
Use of resources	The rate of extraction from forests, fisheries, underground water source other renewable do not exceed the rate of regeneration.	The rate of extraction exceeds threat of regeneration. Falling of trees, deforestation, overgrazing and pollution of water – bodied takes.
Quality of food material	Food material are safe	Food material contain toxic residue.

Reasons why sustainable agriculture is important

1. Nourishes and restores the soil

Generally, conventional agriculture is characterised by heavy tillage and heavy use of fertiliser to increase farm output. While fertilisers can help to spur plant growth, they often lead to polluted runoff water that ruins the natural environment. Additionally, the heavy use of fertilisers is not only harmful to soil ecology but can also be noxious to humans.

2. Saves energy

One distinguishing feature of industrial farming is its heavy reliance on energy-intensive machinery, especially fossil fuels. In fact, industrial agriculture is one of the leading sources of greenhouse gas emissions in the world today.

3. Conserves and protects water

- Conventional industrial farming uses a lot of water to irrigate the vast tracts of land under cultivation without emphasising on conservation. As opposed to these conventional methods, sustainable agricultural systems use several techniques to conserve water, such as drip irrigation and mulching. In addition, it focuses on planting perennial crops with deep roots that don’t require a lot of water.

- Moreover, sustainable farming embraces methods that protect water bodies from pollution. Specifically, this farming system uses practices such as contour farming and filter strips near rivers to limit contamination of the water mass.

4. Values diversity

- The defining feature of industrial agriculture is monoculture, a system of farming that involves planting vast tracts of land with a single plant breed.
- The over-reliance on only one plant breed increases the vulnerability of plants to diseases, which may quickly spread from one plant to another and wipe out the entire crop.
- Because monocrops are highly vulnerable to pests and diseases, the large industrial farms heavily depend on herbicides and pesticides to keep their plants healthy. Regrettably, these chemicals can be hazardous to pollinators, wildlife, and people.
- Unlike industrial agriculture, sustainable farming focuses on diverse farming systems which use a variety of crops.

5. Provides crops with resilience

- As already stated, sustainable agriculture plays a vital role in reducing greenhouse gas emissions as well as conserving energy and water.
- For a planet that is increasingly facing the vagaries of climate change, sustainable agriculture provides resilience because it focuses on growing a variety of crops as opposed to single breed crops while ensuring that the soils are healthy to provide the required minerals required for good plant health.
- Additionally, if sustainable agricultural systems incorporate perennial plants and trees, coupled with free-range livestock grazing systems, agriculture will play a key role in sinking the carbon footprint

6. Works in harmony with nature

- Unlike conventional industrial agriculture which is purely an embodiment of man, sustainable agriculture works in harmony with nature.
- It places a lot of emphasis on natural productivity by relying on the regenerative aspects of the natural environment. Moreover, it doesn’t strive to dominate nature, as is often the case with industrial agriculture. Instead, it allows nature to take its course.

7. Supports local communities

Sustainable agriculture is generally localised and places a lot of emphasis on domestic food production. Consequently, the localised food system enables farmers to reinvest their money within their communities where it circulates, and this ultimately uplifts the living standards of community members while also creating rural jobs.

8. Stabilises food supply

- The consolidation of individual farms into big corporations that offer economies of scale to individual farmers characterises industrial agriculture.
- However, the development of huge corporations may be quite risky because if one of them faces a problem, the results may have far-reaching consequences on food security.
- On the contrary, sustainable farming tends to be highly decentralised and therefore limits the chances of food insecurity occasioned by the financial troubles, or any problem that a corporation may encounter.

Advantages of Sustainable Agriculture

Sustainability in agriculture is the way to ensure and maintain agriculture productivity without the depletion of natural resources. It is economically, ecologically and socially adaptable and has many fold advantages in human life. Some of its advantages can be summarised as:

- **Biodiversity Conservation:** Healthy soil is one of the prerequisites for agricultural productivity and sustained biodiversity. However, due to the use of excess chemical fertilizers and pesticides soil health is degraded reducing its productivity. We know that soil is the foundation for production as without it we are unable to produce. There are many ways to improve soil health to sustain biodiversity. Feeding soil with animal manure, green manure, crop residue etc may improve soil health and maintain biodiversity. Sustainable agriculture mainly focuses on the use of such types of matter and the reduction of the use of chemicals.
- **Environmental benefits:** Sustainable agriculture encompasses the use of renewable energy resources thus reducing environmental hazards. Sustainable agriculture also focuses on crop rotation, thus mitigating the problem of pest outbreaks and hence fewer pesticides are used. In this way, it helps in pollution control. It also focuses on the less waste of food for sustainability. Thus provide a basis for food supplements for an increased population.
- **Reduction in cost of production:** Sustainable agriculture reduces production costs in several ways. Sustainable agriculture focuses on minimum tillage or zero tillage by which the cost is reduced. Besides the less use of chemicals and incorporation of green manure, crop residue and organic substances improve the soil health. This reduces the infestation of pests and hence farmers do not have to spend on pesticides.
- **More production:** Crop production is improved if one follows the measures of sustainable agriculture. Better soil health due to the use of green manure, crop residue and less use of chemicals improves the production.

- **Better for health:** Sustainable agriculture focuses on the use of fewer chemicals like pesticides, fertilizers and more to organic farming. So, people may consume fresh products that are good for their health.

Disadvantages of sustainable agriculture

Besides its many-fold advantages, sustainable agriculture also has few disadvantages. Some disadvantages of sustainable agriculture are mentioned below:

1) Since sustainable agriculture focuses on less use of machines. So, it takes more time for farmers to carry out farm operations.
2) It's not so easy to increase the soil fertility status without the aid of chemical fertilizers.
3) It is more costly to produce any product sustainably as compared to a non-sustainable manner.
4) Land, labour and capital are not used to their fullest efficiency.

Conclusion:

- Social, economic, and environmental sustainability are closely intertwined and necessary components for a truly sustainable agriculture.
- For example, farmers faced with poverty are often forced to mine natural resources like soil fertility to make ends meet, even though environmental degradation may hurt their livelihoods in the long run.
- Only by creating policies that integrate social, environmental, and economic interests can societies promote more sustainable agricultural systems.

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"MAGGOT" -BEYOND "ICK-FACTOR" A DIVERSIFIED AGENT TO SUSTAINABLE FARMING

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Introduction:

Poultry industry is one of the fastest growing sector of India today. With the rapid change in the lifestyle, fixed cultivable land, diet, protein demand and population explosion the rise of the egg and meat is rising very fast approximately at rate of 8 to 10 percent per annum. India has exported 5, 44, 985.06 MT of Poultry products to the world worth of Rs. 687.31 Crores during 2018-19.Presently India is producing about 37 billion egg, 735, 000 tonnes poultry meat.The major share of cost in poultry husbandry lies with the feed cost (Sogbesan *et al.*, 2005), it is more important to consider when poultry rearing is associated with the lower income group farmers to accept poultry farming as sustainable income source.So to cope with the rapid rise in protein demand as meat, egg and to reduce the feed cost to provide a sustainable farming strategies many works have been done to find the alternative feed resources to replace the maize GNC, soyabeen meal. Dairy, poultry, meat and fish are the main sources of animal proteins, lipids and vitamins in human diet (AIFP, 2004). The higher cost of poultry, this is due to soya beans and groundnut cake which are also used in human food. Traditional protein sources are in high demand for both animal and human populations and expensive. The cost of poultry feed is increasing very fast so it is very utmost need to find some inexpensive, non competitive, easily available and protein, energy rich substrates to reduce cost of feed either by inclusion or replacement of expensive components. In the recent times use of Maggots as alternate feed resources for the poultry has gained lot of interest because of easy availability, low cost, nutrient rich, bio compatible, to incorporate in the poultry feed for a sustainable profitable farming (Ugwumba and Ugwumba, 2003; Ayinla, 1988).

Why maggots are chosen as alternative:

Maggots are the larval stage of the house fly, black soilder fly etc. Due to the fast and short life cycle they are readily available. The larvae can utilize organic waste materials very efficiently, like from vegetable waste, rotten meat, poultry excreta, and kitchen waste. The growth of the larvae is maximum in humid tropical condition. Maggot growing venture can be strategies for organic waste management. Maggot meal has been identified as a possible alternative to the available costly protein sources (Sheppard, 2002; Teguia *et al.*, 2002; Ogunji *et* *al.,* 2006). Calvert *et al.* (1971) Teotia and Miller (1974). Maggots are rich in protein and fats with other important nutrients value, cheaper and require less labour to produce. The production of maggots as an alternative feed source of poultry serves not only providing a nutrient-rich resource but also a source of waste transformation and reduction. Maggot meal is rich in crude protein from 43 to 64% (Awoniyi *et al.,* 2003; Fasakin *et al.,* 2003; Hwangbo *et al.,* 2009; Odesanya *et al.,* 2011) (Teguia and Beynen, 2005) Maggot meal can be used as partial or complete replace of costly protein (Dankwa *et al.,* 2002; Ekoue and Hadzi, 2000) and fish (Ebenso and Udo, 2003; Madu and Ufodike, 2003).

Maggot meal production: there are many locally adopted methods of maggot harvesting and maggot meal production. For the fast growth of the larvae, organic waste, or any good fly attractant organic matter flesh, Poultry offal can be used in a specially built tank with provision for entry of flies. The tank must be kept in open area in a partial sun exposures.The moisture content must be assured in the tank by sprinkling water on the harvesting substrate. After the maggots are sufficiently grown they are to be collected in a tray for storage. From 1 kg of poultry offal, approximately 300 g of maggot larvae can be produced. The collected maggots are then spread on a tray, cleaned with water, and dried at 550Celsius in a hot air oven. And can be kept in plastic bags after 36 h. Finally the proximate analysis, microbiological quality can be assessed.

Nutritional composition of maggot meal:

Maggot meal is rich in crude protein concentration reported from 39.16% (Atteh and Ologbenla, 1993) to 64% (Hwangbo *et al.,* 2009), Dry matter of 92-94 %, crude fibre 7.5-8.2%, ash 5-6 % and ether extract ranges from 20-25% (Aniebo *et al.,* 2008; Hwangbo *et al.,* 2009; Atteh and Ologbenla, 1993), 86.0 ±0.47% moisture and 3755 ± 190 kcal/kg energy Odesanya *et al.* (2011). Maggots are rich in nutritious fatty acids profile with highest lauric acid content, palmitic acid, oleic acid and stearic acid (Adesulu and Mustapha (2000) the content of essential amino acids cystine, glutamine histidine, phenylalanine, tryptophan and tyrosine in maggot meal is higher than in fish meal and soy bean meal (Adesulu and Mustapha, 2000; Zheng *et al.,* 2010) and mineral and vitamins (Teotia and Miller, 1973). However there is variation in the nutrient composition depending on the substrate used for their growth (Fasakin *et al.,* 2003), drying process, preservation. From the above data suggest the maggot meal can be a good source of animal protein in poultry diets to reduce the feed cost for sustainable farming.

Inclusion of maggot meal in poultry diets:

As poultry birds like to pick worms and larvae from the soil directly from the backyard or from the litter. Maggot meal can be included in broiler diets as a replacement for protein sources, like fish meal. Mostly maggot meals are included at 10% however it may be increase upto 30% without affecting the growth rate in broiler. More inclusion in the poultry diets may not be beneficial. However by improving the appearance and palataibility of the maggot meal it can be offered in higher ratio to the poultry diet (Atteh and Ologbenla, 1993; Bamgbose, 1999). By including maggot meal it is possible to replace 75-90% GNC (Adeniji, 2007) without any adverse effect on feed intake in broiler. The maggot meals can be incorporated with essential amino acids and other nutrient to increase the nutritional qualities and palatibility (Bamgbose, 1999). Including maggot meal in the broiler diet enhances the growth rate, carcass qualities, high feed conversion ratio, digestibility and overall performances (Hwangbo *et al.,* 2009). The maggot meal can be included effectively in starter, grower and finisher (Awoniyi *et al.,* 2003; Teguia *et al.,* 2002). Maggot meal can be used in laying birds to augment egg production and hatchability replacing the meat bone meal (Ernst *et al.,* 1984). In laying hens maggot meals can be used to replace 50% of fish meal protein (5% diet as fed) without any adverse effects on egg production. Inclusion of maggot meal in laying birds is reported to lower the cholesterole and calcium content (Akpodiete *et al.,* 1998).

Maggot related contamination:

As flies are carrier of many pathogens, like bacteria, fungi so it is a concern regarding transmission of diseases through the maggots. As the maggot harvesting substrate like poultry manure, kitchen wastes are contaminated. However no such research based evidence is reported regarding transmission or any disease onset or health problem due to inclusion of maggot meal (Sheppard and Newton, 1999; Koo *et al.,* 1980; Bayandina *et al.,* 1980; Poluektova *et al.,* 1980; Atteh and Oyedeji, 1990; Adeniji, 2007). As a precaution the maggot meals can be used after proper treatment (heat treatment) and fed to the birds. It can be achieved by reducing the moisture content (4-5% moisture), proper packaging and heat-sealing (Awoniyi *et al.,* 2004).

Maggot meal and dressing percentage of broiler:

Inclusion of maggot meal in the poultry feed has been reproted to enhance the dressing percentage with increase in the proportion in inclusion (Izaz Ahmad *et al.,* 2022).

Microbiological evaluation of maggot meal:

The predominant bacteria species found in the maggot meals were Bacillus cereus, Corynebacterium pyogenes, Micrococcus tetragenus, Pseudomonas aeruginosa, Staphylococcus aureus and Streptoccus faecalis. The fungi Aspergillus flavus, Fusarium moniliformis and yeast like Saccharomyces cereus). The avarage plate count for bacteria were 2.56x10 3 cfu g. improper storage of maggot meal is prone to deterioration by fungi and bacteria (Awoniyi *et al.,* 2004)..

Antibacterial activity of maggot:

The use of maggot in wound clearing is an already established concept. Research has also found the antibacterial activity of maggot against E. coli by simple mechanical irrigation and ingestion (Mumcuoglu *et al.,* 2001; Sherman *et al.,* 2000). Maggot secretion and excretion is alkaline in nature contain ammonium carbonate, calcium, allantoin, and urea which inhibits bacterial growth by increasing pH and proteolytic enzyme activity (Beasley *et al.,* 2004). Defensin peptide, lucifensin lucilin, (p-hydroxyphenylacetic acid (152 Da), p-hydroxybenzoic acid (138 Da), and proline diketopiperazine (194 Da) compund have been reported in maggot secretions (Bexfield *et al.,* 2004; Nigam *et al.,* 2010; Huberman *et al.,* 2007; Čeřovský *et al.,* 2010). lucifensin is a cataoinic anti bacterial compound which kills the bacteria forming trans membrane pore in them, or leakage in cell membrane (Shazely *et al.*, 2013; Čeřovský *et al.,* 2014; Zhang *et al.,* 2013). Wide range of activity were reported by various authors against gram negative and gram positive bacteria like Streptococcus A and B, Staphylococcus aureus, Pseudomonas, E.Coli and even methicillin resistant S. aureus (MRSA). The antibacterial activity of maggot depends on type of maggots, their numbers, bacterial type Barnes *et al.*, 2010). Maggot secretion is more effective against gram positive bacteria (Steenvoorde *et al.,* 2004). It was also reported that maggot secretion and excretion can produce synergistic effect with other antibiotic like vancomycin, daptomycin, and clindamycin (Cazander *et al.,* 2010).

Antifungal activity of maggot:

Due to presence of alkaline compounds like ammonium carbonate, allantoin, maggot secretion also showed antifungal activity against yeast and mould (Alnaimat S *et al.,* 2013). Various author has also confirmed the presence of antifungal peptide lucimycin. Lucimycin was active against fungi (Ascomycota, Basidiomycota, and Zygomycota, to the *Phytophthora parasitica*). Bioactive compound were also identified in maggot secretion and excretion active against Candida albicans (Evans *et al.,* 2015).

Anti-Inflammatory activity of maggot:

Maggot secretions are affective in anti inflamatory role by ruducing superoxide, H2O2 and myeloperoxidase production and pro inflamatory activity (Pecivova *et al.,* 2008; Van der Plas *et al.,* 2007; Cazander *et al.*, 2012). Maggot secretion was also reported to reduce activity of complement pathway (Tamura *et al.,* 2017).

Immunomodulatory function:

Bioactive compound was also isolated from maggot excretion and secretions to show immuno modulatory effect by producing BLIP, serpin protein, inhibition of mitogen-induced ovine T lymphocyte proliferation and hemolysin Elkington R. A et al 2009 and Zhang S et al 2011). Maggot secretion can promote serum globulin content, development of immune organs, stabilizes the intestinal microflora, intestinal health and enhance body immunity in birds. (WANG et al 2021)

Role of maggot fluid in healing via proangiogenic, coagulation and fibroblstic activity:

Maggot secretory fluids have been reported to stimulate the angiogenesis, cellular migartion to accelerate wound healing (Wang *et al.,* 2010). By production of proangiogenic growth factors like VEGF, FGF, HGF (Sun *et al.,* 2016). Cell proliferation and extra cellular matrix remodelling is prerequisite for tissue repair and healing. Maggot secretions are accelerates the migration of fibroblasts, fibroblast motilty and epidermal keratinocytes, production proteinases, dvelopment of microfibrillar network (Horobin *et al.,* 2005, 2006; Polakovičova *et al.,* 2015). Maggot secretions are also a potent procoagulatnt due to presence of chymotrypsin-like serine protease, Jonah-like protein (Pöppel *et al.,* 2016).

Antineoplastic activity:

Antineoplastic fatty acids (ω-6 PUFA) were extracted from maggot against in vitro. Maggot fluid was found to inhibit H22 tumor growth via activation of p38 mitogen-activated protein kinase (Hua, 2008; Zhang, 2017).

Effect on serum lipid profile:

Experimental model also suggested that maggot secretion could reduce serum level of triglyceride, cholesterol and low density lipoprotein and increase the level of high density lipoprotein (HDL) (Chu, 2010).

Conclusion:

Maggots beyond “ick-factor’ utilizes the organic waste materials and can convert it to many multi-potential bio active substance as wound healer, anti inflammatory, immuno modulatory agents. In the recent times with the population rise, protein demand, and for a sustainable poultry farming maggot meal can be an economic profitable venture. By further scientific validation of maggot can act as reduce the enviromental polution, wound management, alternative antibiotic, alternate feed resources for farming.

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MAJOR DISEASES OF WHEAT AND THEIR MANAGEMENT

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Abstract:

Wheat is the staple crop throughout the world and a great source of nutrition. Sometimes the wheat plant gets attacked by pathogens like fungi, bacteria and virus. Some of the common disease their symptoms and management are studied. The complexity of the interaction between a pathogen and its host, influenced by biotic and abiotic factors of the environment, make the control of these disease. Fungi is the most common causative agent in case of wheat. Some of the common disease caused by fungi are leaf rust, stem rest, stripe rust, loose smut, tan spot, powdery mildew, ergot and common bunt. Virus and bacteria also cause diseases in wheat. Wheat strike mosaic virus one of the diseases is bacterial blight of leaf. These diseases can be controlled by using disease resistant varieties. Due to the infection of these diseases there can be loss of 40-50% but sometimes it may be more. These diseases can be controlled by using some control measures. There are several chemical and herbal methods are used for the control of these diseases.

Keywords: Wheat, disease, management, control, symptoms, pathogen.

Introduction:

Wheat is on the top rank in the world among the cereals both on the basis of area and production that's why it is also known as "king of cereals". Wheat is a staple crop in the world. It is the second largest consumable cereal crop throughout the world after the rice. In India wheat is a Rabi crop. It is preferably grown in tropical areas of the world. Wheat is an annual grass cultivated mostly in all moderately dry temperature climates. It needs comparatively cool, moist, spring having 10-degree Celsius temperature at the time of sowing, warm, and bright days at the time of sprouting and dry harvest periods. Wheat is grown best in areas having 35cm to 60cm annual rainfall. The best soils for wheat are clay and loams. The best fertilizer is barnyard manure. For proper cultivation of wheat, the fields are cleared and then ploughed 4-5 times before sowing. Healthy and ripe seeds are sown in slightly moist soil. Sowing generally starts in October and continuous upto middle of November fertilizer is added for obtaining better yield.

The crop is harvested when the grains are well ripened and the straw becomes golden yellow or light yellow, dry and brittle. In our country it is generally harvested between February to start of June depending on various regions. Wheat is generally grown in northern part of India it includes states like Punjab, Haryana, Uttar Pradesh, Bihar, Gujrat etc. Wheat is full of nutrients like it contains dietary proteins, starch, fat, polysaccharides and lipids (Curtis *et al*., 2002). Mostly gluten protein is present in the wheat. It can be used for various purposes like making breads, dishes, cookies, pasteries and a lot of other eatables like this. It can be also used in cosmetic industries preparing lotion, creams or other items also. It is used in paste, malt, dextrose, gluten, alcohol and in making of various other products like this.Wheat belongs to a grass cereal family known as Poaceae one of the largest family of the cereal grains. It belongs to the genus *Triticum.* Most common variety of wheat is *Triticum aestivum* it is generally used to make breads (Melanin Figueroa *et al.*, 2018). Wheat belongs to family poaceae, it is a grass family. It belongs to order cyperales. Genus of the wheat is *triticum.* The wheat plant is typically 0.7 to 1.2m tall. It has long thin leaves. Leaf is formed at each node and a leaf sheath wraps around the stem and a leaf blade. Whea has small auricles. These auricles get around the stem at the point where around the stem at the point where the leaf sheath meets the leaf blade. Wheat has a single main stem containing 2 or 3 tillers per plant. Tillering starts when the plant is at 3-4 leaf stage when first nodal root is seen. The spike or ear is formed at the top of the plant. One spike contains 30-50 grains. Wheat plant has two types of roots i.e. seminal roots and nodal roots. The lower nodes are associated with the tillers and become increasingly important as the plant grows. Grain is small having weight of 30-60 gm depending on the variety and growing condition.

Common diseases in wheat:

On the basis of pathogens diseases can be of three types:

1. **Fungal diseases**

1.1 Loose smut (*Ustilagotritici*)

Symptoms

Loose smut is a wind-borne fungal disease in seed. The pathogen lives in the wheat seed till the germination and then it reaches to the shoots and infects the head part. A healthy wheat plants can be infected by the wind-borne spores in the initial two days of flowering from the infected plant. Fungus can also be spread with the help of rain and insect. Spores land on healthy flowers they get germinate and become dormant within the ovary until seed germinates. As much as the heads are infected more and more loss of the yield will be there. It damages the wheat crop by the means of the kernels (Bakkeren and Schirawski, 2008).

Management

The symptoms of the diseases can be seen in the headings of the plant. The membranes during flowering and smut pores are dispersed leaving the dark, bare rachis. Brown to black fungal spore masses develop on the diseased heads of the plants. To eradicate the disease always healthy, certified seeds should be used along with a fungicide as it's very hard to identify the infected seed and a healthy one. Most effective way to control over loose smut is the use of disease resistance variety. Certified seeds which are free from pathogens should is also the best way to control over it (Agarwal *et al.*, 1993).

1.2 Stripe rust (*Puccinia striiformis*)

Symptoms

This is the most common economically effecting disease (Chen, 2005). Stripe rust is generally found in cold temperature (13-24ºC). When the temperature is in range from 10ºC-16ºC the chance of the disease gets increased. Cold, long winters, mild and wet springs encourage the diseases (Chen *et al.*, 2014). The fungus can remain through cold climate on wheat as a dormant mycelium under the snow. Yellowish orange pustules get developed on the leaf of the wheat. These pustules are round having the spore masses of rust which develops on the top as well as leaf sheath. Long, narrow stripes and irregular growth are also seen in this disease. As the plant gets matured tissues seems to dry and brown, giving a burning like appearance to the plant. There are many varieties which are susceptible to *Puccinia striiformis* which causes loss upto one billion US dollar per year (Beddow *et al.*, 2015).

Management

The most important method to prevent the disease is to use the resistant varieties. Cultural practices can also help to reduce the effect of the diseases (Hovmøller *et al.*, 2015). We can also reduce the effect of the stripe rust by controlling over grassy weeds and volunteer wheat before three weeks of seedling. At proper interval of time there should be field inspection so that the symptoms can be identified in very earling stage and treatment can be done. Cultivators should have knowledge regarding the symptoms of stripe rust. Certified seeds should be used to prevent the stripe rust (Line and Chen, 1995). Monoculture of single variety should be avoided because chances of single variety becomes more prominent to a particular pathogen.

1.3 Powdery Mildew (*Blumeria graminis f. sp. tritici*)

Symptoms

Powdery mildew is generally grown in humid and semiarid areas. Mild temperature, increased humidity, high nitrogen fertilizers are some of the factors which are responsible for powdery mildew. Mildew affects the plant before the flowering stage causing the severe loss in the crop.

Major infection gives birth to lodging, early death of leaves decreasing the seed size and loss in the yield occurs up to 40%. Fungal patches of white or grey colour are formed on the leaves, stems and head parts of the plant (Daamen, 1989). The infection starts from lower leaves and get spreaded upto the upper part of the plant. The other side of the infected seed becomes chlorotic and gets yellow and brown coloured. When the plant gets matured, fungus changes the colour and turns into grey and brown, tiny round and black fruiting bodies formed on the leaves. Kernels are infected spikes are poorly developed, tiny and malformed (Fiedorow *et al.*, 2004).

Management

Most effective way to control to control this disease is to use the resistant varieties. Crop rotation can also be proved to prevent the leaves to destroy the volunteer wheat. One another method is by using a balanced nitrogen fertilization. Infrequent, heavier irrigations will be more beneficial than more frequent lighter irrigation. Mixture of two tablespoons of apple cider vinegar per quart of clean water then the spray of mixture over plants to organically powdery mildew traces.

1.4 Leaf rust

Puccinia triticina is the causative agent of the leaf rust (Anikster *et al.,* 1997). This is the most common fungal disease found on wheat. This disease caused destruction of wheat in many regions of U.S.A and India (Joshi *et al.,* 2004). Humid condition and mild temperature are the factors which make the disease occur. Reason for the occurrence of leaf rust is that *Puccinia triticina* has high diversity and has high adaptability to wide range of climate (Huerta-Espino *et al.,* 2011). Infection causes the loss of yield by reducing the size of grain and number of grains per head. Small reddishorange oval fruiting bodies are formed on the surface of the leaf. These postulates may be found in scattered or it may be in clustered form. When the plant gets matured the spores turn black. These pustules are mostly found on the lower leaves and leaf sheath. Disease mostly occurs in the lower leaves as fungus firstly develop here. When favourable conditions occur, spores get spreaded and exponential growth occurs and severity of the disease affects the crop yield. Pustules occurring on the leaves, cover almost whole the leaf.

Management

Leaf rust can be managed by using the wheat varieties which are resistant to leaf rust. There are some varietieswhich are susceptible to disease but these have the ability to tolerate the infection. Foliar fungicide can be used for susceptible varieties. Seed treatment can also be used to control the leaf rust (Ellis *et al.,* 2014). Avoid early sowing and excess nitrogen application. The eradication of volunteer plants and crop debris, which can harbour inoculum over the winter.

The prevalence of different rust races is always changing in response to the different wheat varieties being grown with different Lr genes.

1.5 Tan Spot (*Pyrenophora tritici-repentis*)

Symptoms

Tan spot is the most common disease in the northern plains caused by *Pyenophora tritici-repentis*. The disease occurs in conjugation with leaf rust and septaria leaf blotch and is associated with reduced tillage. Tan spot affects the yields and weight of the grains (Shabeer and Bockus, 1988). Oval or diamond shaped, brown leaf spots which are darker in the middle and yellow on the periphery. Yellow border gives an "eye spot' appearance. As the infection increases more spots starts to develop on the leaves. Large number of dead tissues get produced. Due to tan spot the leaves get damaged and early death of the plant occurs. Sometimes small fruiting bodies known as psudo-thecia appear on the stubble.

Management

Crop rotation minimum for one year out of wheat is one of the best methods to control tan spot. Along with this there are number of tan spot disease resistant varieties available. When there is high risk in flag leaf foliar fungicide is used. Host genetics and *Ptr* structure are also used tocontrol the tan spot (Strelkov and Lamari, 2003). When the conditions are favourable for disease fungicides can be used for effective result.

1.6 Ergot (*Claviceps purpurea*)

Symptoms

Claviceps purpurea is the causative agent for the ergot which leads to the loss of both yield and quality of the crop due to this disease. *Claviceps* produces mycotoxins which are of great concern. Tough, purplish-black sclerotic about halfinches length ergot bodies instead of healthy grains. Along with it a yellowish, sugary honeydew develops on the he infected seeds at the time of flowering before the development of the ergots. This honeydew also found on the other parts of the plant. Wheat straw should not be baled for feed if it still has ergoty heads.

Management

Before using the seeds for sowing clean the seeds properly which are free from sclerotia. Deeper planting proved to be very beneficial in the ergot disease as sclerotia cannot grow at depth. Use of varieties having short flowering periods can be done to avoid infection. Crop rotation should be applied with non-host crops such as legumes or corn. Foliar fungicides at heading have not been shown to be effective in managing ergot. Cleaning using gravity-type or colour sorters can help reduce the amount of ergot sclerotia in a seed lot. Ergot sclerotia tend to be lighter and less dense allowing for the removal of these structures. Removal of weeds and unwanted seeds can also be done. Crop rotaion is also an effective way to control over the ergot disease in wheat (Mantle *et al.*, 1977).

1.7 Common Bunt / Stinking Smut (*Tilletia foetida* & *T. caries*)

Symptoms

Common bunt is caused by two fungi *Tiletia foetida* and *T. caries.* These fungi generally grow on the surface of the seed and in soil. Infection mostly occurs at the time of germination when the conditions are cold and wet conditions. The fungi firstly penetrate and infect the coleoptilebefore seed emerges out. The grains are filled with black spores called as teliospores. The kernels get dull grey brown which are known as bunt balls. When the infection gets sever in the fields, dark clouds of bunt spores can be observed during the harvesting.

Management

Treat the seeds with fungicides prior to planting to control the common bunt. Certified and fungi tested seeds should be used. Seeds should be properly cleaned with the help of seed conditioner. Planting should be done when the temperature is warm and it is unfavourable for the fungi. Use of previous crop should be avoided for the next crop.

1.8 Stem Rust

Symptoms

Puccinia graminis is the disease-causing agent in case of stem rust of wheat (Leonard and Szabo, 2005). This fungus affects when the conditions are warm and moist. Red-brick masses urediniospores are seen on the leaf sheaths and stems. Due the effect of the stem rust there is reduction in size of grain and plant lodging occurs. This disease effects badly before grain fill. There is loss of spikes also.

Management

To control the stem rust disease plant resistant varieties should be used. The alternate host barberry should be eliminated so that disease causing spores can be controlled. In this particular stem rust disease fungicides are not so much effective as resistant varieties are used.

2. Viral diseases:

2.1 Wheat streak mosaic virus

Symptoms

This disease occurs generally in the spring season when the temperature starts rising. The symptoms of the WSMV can be generally seen in the peripheral region of the fields (Duveiller and Sharma, 2012). Effect of this disease seen in the growth of the plant as the plant shows stunted growth and gets yellow in colour. Leaves gets mottled and gains light green yellow colour having discontinues streaking. In the last when infection gets at the peak leaves gets brown finally resulting in death. Loss in the yield depends on the amount of infection. In dry conditions loss is observed at high rate.

Management

WSMV can be controlled by the use insecticides so that mites can be reduced. It's better to use disease resistant variety. Eradication and burning of the infected plants can also be a solution to control over this disease. Weeds like annual or perennial grasses should be removed at regular interval. Apply miticide in winter when the conditions are favourable (Connin, 1956).

3. Bacterial diseases:

3.1. Leaf blight

Symptoms

This disease is caused by bacteria *Psudomonas syringae*. Lesion margin get formed on the leaves of the wheat. When there is high humidity for a long-time symptom of the leaf blight starts to develop. When humidity gets decreased spots turns grayish and get tanned and bleached over the time. Sometimes whole the leaf also gets killed. Lesions of bacterial blight can be seen from the stem elongation stages through ripening. It is like tan spot. In Asia this pathogen is component of Helminthosporium leaf blight complex (Duveiller *et al.,* 2007).

Management

Planting diseases resistant variety is the best method to control over this disease. Use of fungicides is not so much effective. Proper diagnose should be there when the chances of infection are higher and precautions should be taken before the infection or at very early stage of infection.

Conclusion:

Pathogenic diseases affect wheat crop and offer challenge to increase its production and yield. The effort to summarize the most significant diseases affecting production of wheat plants and their management strategies has been made in this review. The management strategies including use of various chemicals and some herbal methods is found to be beneficial in controlling many fungal diseases.

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ILLUMINA SEQUENCING FOR ANALYSING SOIL MICROFLORA

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Abstract:

DNA holds enormous information which must be decoded to get better insight of functioning of living system. For this different sequencing methods were developed over the time. However, traditional methods like Maxam Gilbert method and sanger sequencing methods were time consuming and costly. Therefore, a method was required which could perform sequencing for multiple samples with time. Era of next generation sequencing technique includes various sequencers based upon sanger sequencing. These sequencing techniques hold an important place in microbiology. Microorganisms in general are less explored (large no. of unculturable strains) and potential of only few microbial strains have been explored for agriculture. With the advent of illumina sequencing, characterization of microbial strain is becoming easy and less expensive. Illumina sequencing has been proved to be a boon to the world.

Keywords: DNA, Sanger Sequencing, Illumina, nucleotide

Introduction:

It's been a while around a quarter of century when the tale of DNA sequencing began with all the credits to Sanger's study on insulin which provided the value of knowing the sequence of biological macromolecules. The information encoded in DNA is crucial to know the behaviour of cell, tissue and organism as the characteristics of genome outlines the genotype/phenotype relationships. The orderly arrangement of four nitrogenous bases i.e. adenine, cytosine, thymine and guanine, forms the blueprint of life and decrypting the DNA has many benefits and applications such as combating the illegal trade in African elephant ivory [WJCD+08], building the tree of life[Sta06], phylogenetic classification [KLZ+17] and improved understanding of genetic diseases [KC91]. Only since the late 1970's, people are able to obtain the DNA sequence of an organism and from than demands have been always high for revolutionary technologies that deliver fast, inexpensive and accurate genome information. This desire has paced up the development of next-generation sequencing (NGS) technologies apart from the classical Sanger and Maxam-Gilbert method of sequencing.

Major events in the history of DNA sequencing

- 1953- Discovery of the structure of the DNA double helix.
- 1972- Development of recombinant DNA technology.
- 1975- Bacteriophage φX174 complete DNA sequencing.
- 1977- It marked the beginning of DNA sequencing. Enzymatic and chemical degradation method of DNA sequencing were given by Fred Sanger and Allan Maxam and Walter Gilbert respectively.
- 1980- The first nucleotide sequence repository "EMBL-bank", was established at the European Molecular Biology Laboratory
- 1982- Gene bank was started as a public repository of DNA sequences. The first Automated sequencing method was commercialised by Applied Biosystems and was developed in Hewlett Packard by Andre Marion and Sam Eletr.
- 1984- The DNA sequence of Epstein-Barr virus was completed.
- 1985- PCR was developed by Kary Mullis and colleagues.
- 1986- Leroy E. Hood developed the first ever semi-automated DNA sequencing machine at California Institute of technology.
- 1987- ABI 370 sequencer was commercialised.
- 1990- The U.S. National Institutes of Health (NIH) begins large-scale sequencing trials on *Mycoplasma capricolum*, *Escherichia coli*, *Caenorhabditis elegans*, and *Saccharomyces cerevisiae* (at 75 cents (US)/base).
- 1991-Craig Venter introduced Expressed Sequence Tags.
- 1992- Bacterial Artificial Chromosomes were developed. First chromosome physical map of Y chromosome and chromosome 21, was published. Complete genetic map of mouse and humans were successfully established.
- 1995- Complete DNA of *Haemophilus influenzae* was sequenced. Applied biosystems commercialised the capillary electrophoresis base sequencer "The ABI310 sequencer analyzer".
- 1997- Complete sequencing of *E. coli.*
- 1998- NIH launched the mouse genome sequencing project. Genetic sequence of human chromosome 22 was published.
- 2000- Complete sequence of fruit fly *Drosophila melanogaster.*
- 2001- Human genome sequence draft was published in Nature by HGP consortium.
- 2007- Initiation of phylogenomic by the sequencing of closely related species (12 Drosophilidae)
- 2008- "The 1000 Genomes Project", was launched to study human genome and associated variations.

How it all started?

Sager and Coulson laid the foundation of DNA sequencing by the "plus and minus method which used DNA polymerase I from *Escherichia coli* and bacteriophage with different limiting nucleoside triphosphates along with the resolving ionophoresis on acrylamide gels. The first genome to ne sequenced using this method was of a phage Phi X-174 (PhiX). The inefficiency of the plus minus method, urged the Sanger and Coulson to develop a better method of sequencing based on "sequencing by synthesis" approach.

This method sat a major breakthrough in the field of genomics and was earlier known as Chain termination method or the dideoxynucleotide method. The key principle was to use dideoxynucleotide triphosphates (ddNTPs or modified nucleotides) as DNA chain terminators as they have hydrogen at 3 C of sugar instead of hydroxyl as in dNTPs, which temporarily blocks the reaction. To carry out the sanger sequencing, one requires a ss DNA template, primer, DNA polymerase, radioactively or fluorescently labelled dNTPs and ddNTPs, in four separated reaction tubes to which only one of the four dideoxynucleotide (ddATP, ddGTP, ddCTP, ddTTP) is added. Once the reaction has been completed the synthesised strands of different length are denatured and separated in four different lanes on gel electrophoresis with denaturing polyacrylamide urea gel, further the DNA bands are visualised by autoradiography or UV light. The band generated by chain termination are usually dark in colour and their relative position in the four lanes are used to read the DNA sequence from top to bottom. However, this method is highly non-specific as the primer binding is not accurate all the times, also the secondary DNA structures disturbs the fidelity of the sequence which makes this method unfit for DNA sequencing.

Simultaneously, in the same time period Allan Maxam and Walter Gilbert developed a method based on chemical modification of DNA followed by degradation of DNA strands. This method initiates with the radioactive labelling at the 5' phosphate group of DNA strand by the kinase enzyme, followed by denaturing gel electrophoresis. After denaturation, the labelled DNA is divided into four aliquots, to which specific chemicals are added which will breakdown the strands at a particular nitrogenous base. Chemicals like dimethyl sulphate (DMS) at pH 2, piperidine formate at pH 2, hydrazine and hydrazine with 1.5 M NaCl are employed to modify DNA strand at G, A+G, C+T and C respectively, in addition secondary amino piperidine is used to break down the sugar phosphate chain at the site of modification resulting in fragments of different length. To visualise the fragments, gel slab is taken for autoradiography by the X-ray film which as a result produces some dark bands corresponding to radiolabelled DNA fragment and from this the particular sequence associated with a fragment can be inferred. The method is popularly known as chemical degradation method and suffers some of the drawbacks including highly toxic chemicals, no control over the chemical degradation leading to increased cost of the method.

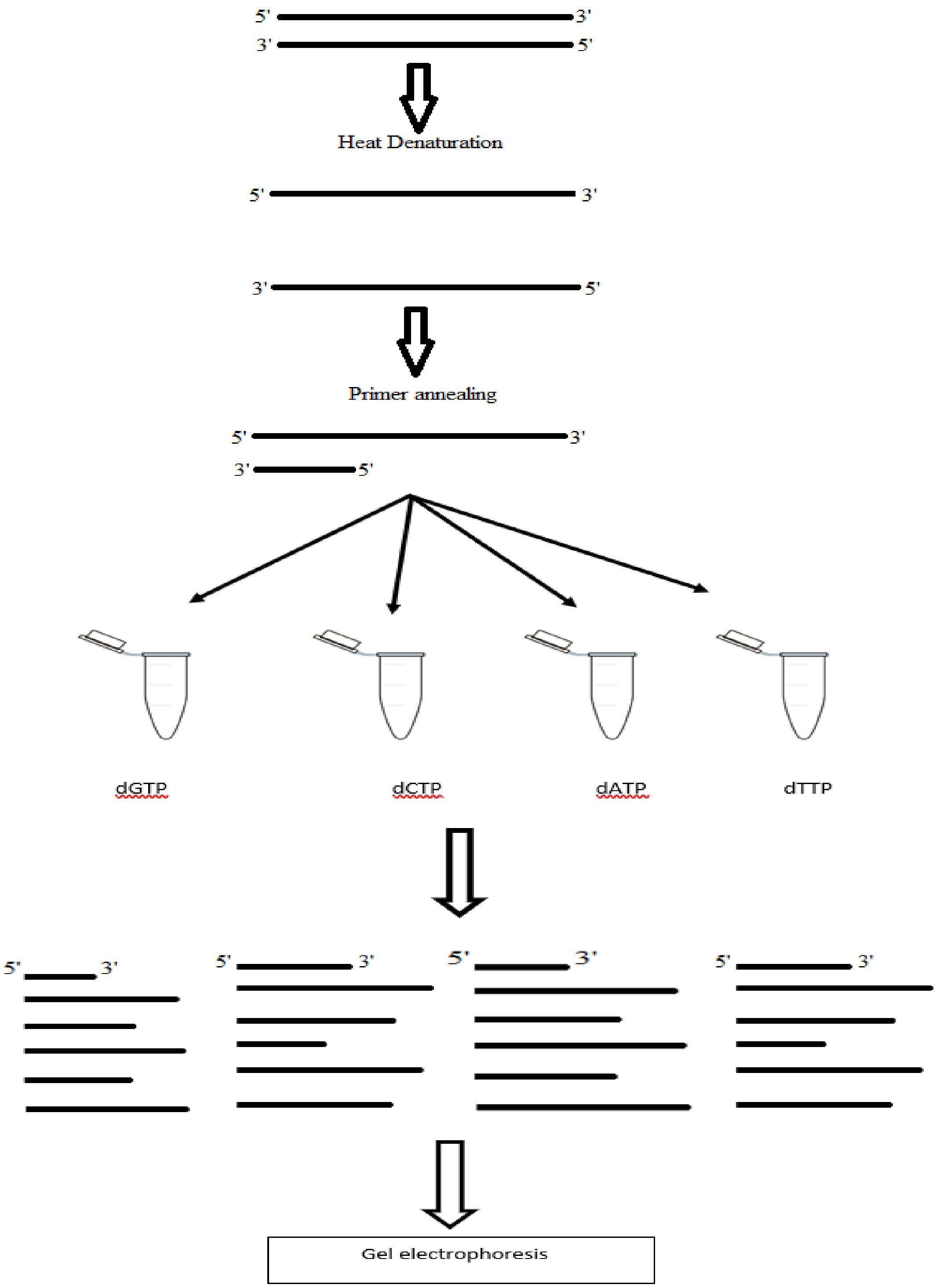

Figure 1: Sanger Sequencing

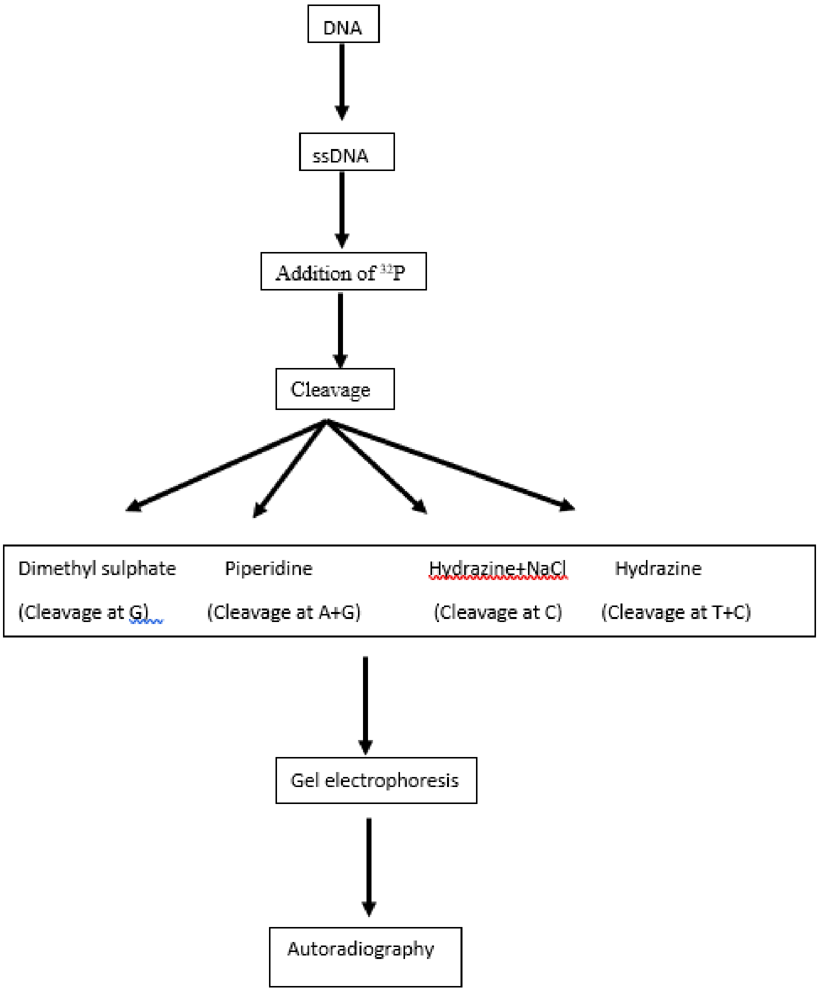

Figure 2: Chemical degradation method given by Maxam-Gilbert

Beginning of automated high throughput sequencer

Earlier, the most comprehensive approach to determine the nucleotide sequence was either the Sanger method of chain termination or the Maxam gilbert method of chemical, but as the time passed there was an increasing urge for advanced techniques which are reliable, in-expansive and fast, leading to the era of "Next Generation sequencing". The traditional as being stated to be very slow for example J.C. Venter took nearly 15 years to completely sequence Human Genome Project, remarking the need of high parallelism based on which now with the emerging revolutionary NGS techniques, the same can be accomplished in few hours.

At California institute of technology, Leroy Hood in his laboratory, started working on sanger sequencing so to modify it in such a way that an efficient system can be produced. Sanger sequencing is based upon radioactive labelling which is highly costly and toxic, so the key improvement was to use fluorophores attached ddNTP's. Also, to concise the reaction in one tube only, specific fluorophore tag was added to ddNTP's only, instead of primer. Further, by applying computerised fluorescence detection system for the analysis of fragments on polyacrylamide gel eases the load and thus enhancing the overall sequencing speed and greatly reduced the manual intrusion required during sequencing run.

The key step in the era of next generation sequencing was by the launch of ABI 370 automated sequencer which was based on Sanger sequencing and was launched by 'Applied Biosystems' (Life technologies) in 1986. ABI 370 was an improved version of DNA sequencing including additional characteristics of capillary electrophoresis instead of slab electrophoresis reducing the space and consumption of chemicals leading to a new way for reaching parallelism by multi-capillary electrophoresis, another feature was automatic loading of samples. Sequencers with higher throughput as compared to traditional ones like ABI 370xl comprised of almost 96 capillaries and it take 2-3 h to generate 1000 bp reads. Once the ends of sequencing reads are trimmed an overall accuracy of 99.999% can be acquired and the remaining percent of 0.001% is associated with the sequencing errors due to troubleshooting in amplification step.

Scientists universally in world realised the potential of DNA/RNA sequencing but sequencers discussed so far were lacking in terms of output inefficiency and failure in their expansion, additionally, the cost per base was alarming high. So, to overcome the mentioned drawbacks stress was emphasised to develop automated, faster, and cheaper sequencer. Traditional sequencers were modified in such a way that they can efficiently sequence a large amount of DNA in short span of time and this was achieved by introducing parallelism.

Next generation sequencing techniques

With the advent of technique, came the second and latter, the third generation of sequencing, diversified on the basis of library preparation, fragment amplification and sequencing, further sequencing is totally based upon optical detection. Sequencers like Roche 454 Genome Sequencer based on pyrosequencing, Life Technologies SOLiD System based on sequencing by ligation, Polonator G.007 and Illumina sequencers are second generation sequencers while single molecule sequencers like Helicos HeliScope, VisiGen, Pacific Biosciences and Nanopore sequencers are third generation sequencing techniques. Another current technique is fourth generation of sequencing, which is based upon single molecule sequencing. The basic distinguishing feature between the second and third generation of sequencing is that the former requires amplification of DNA clones while the later is characterised by production of long reads in short span of time and low cost. However, the fact that second generation sequencing techniques requires amplification step which is time consuming and increases the overall cost, cannot be neglected and hence came third generation sequencing. Two basic approach of sequencing by ligation and sequencing by synthesis are adopted in second generation techniques while the third generation characterized by The single molecule real time sequencing approach (SMRT) developed by Quake laboratory and the synthetic approach that rely on existing short reads technologies used by Illumina and 10xGenomics to construct long reads. As observed from year 2000, development of sequencing platform has highly impacted the field of genomics and new advancement with the passage of time have decreased the sequencing cost, the price per raw mega base of DNA sequencing have been decreased harmonized with that of Moore's law. Hence the fact suggesting that if price is fixed than the amount of sequencing data to be generated is supposed to be double exponentially approximately every two years, and hence new generation sequencing techniques making DNA sequencing accessible to small laboratories. This is how the $1000 genome project and $100 genome project, are finding its reality. Having so much access to this large number of sequencing platforms, it become strategically hard to elect which technique is better enough to be used in particular phylogenomic studies and to be purchased by the laboratories, however, without a doubt highest output is generated by HiSeq Illumina but it is quite expansive due to which it is only exploited by a few sequencing centres. Another illumina sequencer, MiSeq illumina, first came to market with the name of Genome Analyser in 2006 has been a revolutionary benchtop sequencer, developed by Solexa, which was latter purchased by the Illumina

Second generation sequencing: The revolutionary illumina sequencing

Illumina technology is a sequencing by synthesis approach, first developed by Solexa and Lynx Therapeutics. MiSeq was first released in 2011 as a compact benchtop sequencer, having features like onboard cluster generation, data analysis and access to BaseSpace®, the Illumina genomic analysis platform that provides onsite or internet (cloud)-based, real-time data uploading, data analysis tools, and run monitoring. In a single run, MiSeq efficiently produce hundreds of gigabases of data.

Illumina flow cell is hollow glass slide coated with polyacrylamide, constituted of eight lanes, in which reagents and DNA are added.

Figure 3: Illumina flow cell

For each sequencing platform there is specific procedure through which the sample DNA must go through, in case of illumina sequencing the basic process is of library preparation, cluster amplification and sequencing. The preparation steps and the overall scheme are described below:

- The initial stage being DNA fragmentation is generally performed by nebulisation in 30-60% glycerol at 30-35 psi. Fragments having size of 200-500 bp are standard size fragments to be used for illumina flow cells, above the mentioned size, cluster amplification will be inefficient.
- Once the standard fragments are obtained, they still are not fit for the illumina sequencing as the fragments may have recessed 3' or 5' ends, blunt ends and even some fragments may not have phosphate moiety so end repair is must in which blunt ended fragments are generated having phosphate moiety at 5' end.
- Further, to avoid concatemerization of the template, A tailing is performed at 3' end before adaptor ligation. After this, specific but different adaptors are ligated at 3' and 5' end of the generated fragments. Unligated adaptors are cleaned up using beads.
- Following fragmentation, end repair, adaptor ligation, libraries thus produced are amplified using PCR so to have a large amount of library available for sequencing. The next step is of denaturation which is proceeded by the addition of NaOH and libraries are rendered single stranded.
- The sequence at the ends of template strands exactly matches with the forward and reverse primer present on the flow cell and hence complementary sequences hybridise and further polymerised by DNA polymerase producing a reverse complimentary copy of the original template strand that is attached to the flow cell surface. The original template strand is not tethered, and is removed by flushing with sodium hydroxide.
- The next step is highly crucial as it is bridge amplification, in this, the strands on flow cell hybridise with the free primers available on the flow cell and are again extended with a different polymerase i.e. Bst polymerase and hence generating ds DNA. Further the ds DNA are denatured by formamide and as an outcome ss DNA can further anneal to available primer on the flow cell. These recurrent series of formamide denaturation, annealing, and extension result in a cluster of∼1000strands, each of which is derived from the same original template strand, and which hence are clonal.
- After bridge amplification, cyclic reversible termination is done for sequencing by synthesis approach. Firstly, DNA polymerase incorporates a single fluorescently labelled nucleotide which contains reversible terminator which is either 3' blocked or unblocked, this is similar to use of ddNTP's in case of Sanger sequencing. The addition of each nucleotide, produces specific fluorescence which is being recorded after sequencing the terminator is cleaved out, again DNA polymerase add another nucleotide having a reversible terminator which on binding gives a signal which is recorded and this cycle is continued till the whole sample is sequenced.

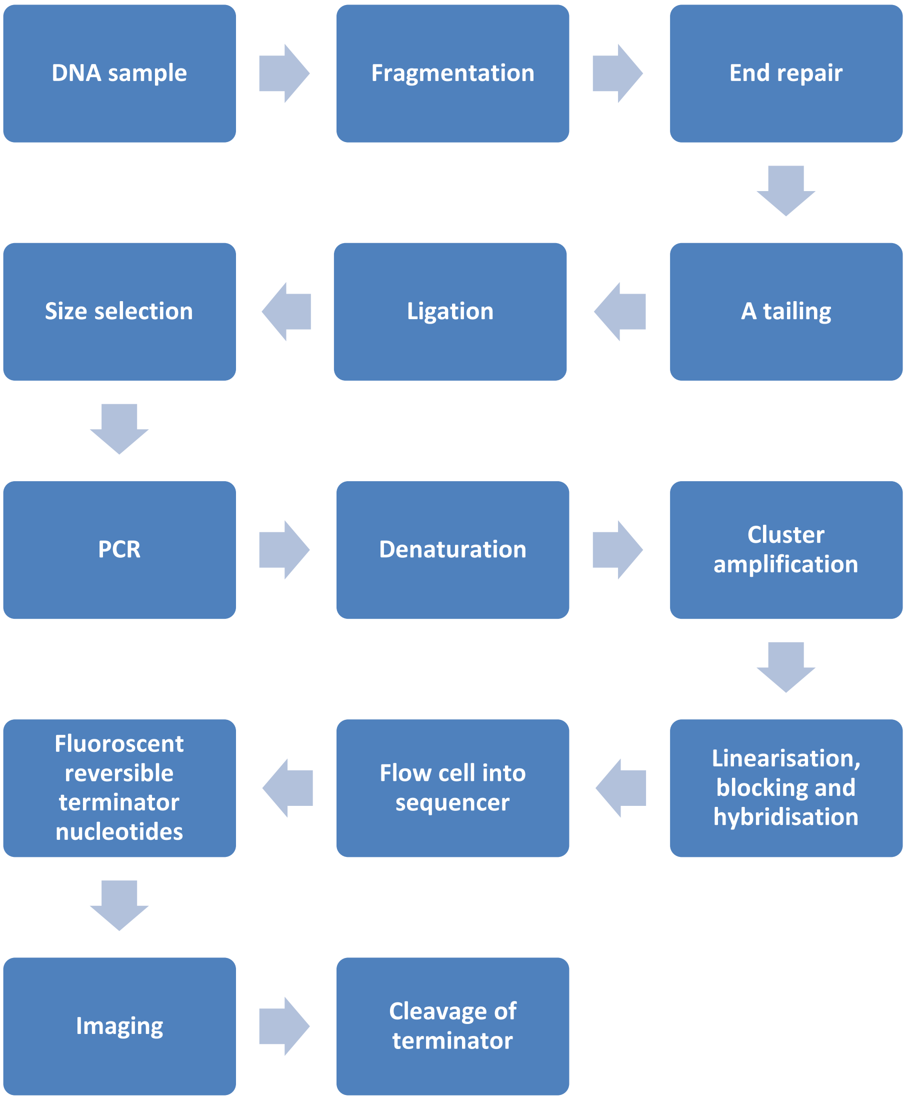

Figure 4: Illumina sequencing workflow source

Trouble shooting/problems faced while illumina sequencing

Problem	Cause
Low Quantity after fragmentation	Wrongly quantified Clean up not performed correctly
Uneven size after fragmentation	Inappropriate vials are used May be DNA is contaminated
Improper adaptor ligation	Clean up not performed correctly
Low intensity of cluster in lanes	Primers may be not hybridised properly
Blurred clusters	Poor focusing or oil is present in the flow cell
Base calling error	Poor cluster density
High % of duplicate sequences	Poor end repair/ A-tailing/ adaptor ligation

Each and every step performed either it is of sample preparation or it is or recording the signal, is very crucial and if not done right way, then trouble shooting occur. The major issue associated with illumina sequencing is error in sequencing while synthesis, as some time there can be lack of synchrony in addition of base and recording of signal. Some of the problems occurring while illumina sequencing are enlisted in table above.

Application of illumina sequencing in analysing soil microflora

Soil microbial diversity is constituted of diversion in genetic, species and ecosystem, across gradient of stress, disturbance or biotic and abiotic differences. Microbes are highly efficient living entities for environment, as in soil they degrade organic matter, fix nitrogen, improves soil texture and many more unknown functions. To take full advantage of this microbes, as in case of biofertilizer, biopesticide, one need to know the organism genome completely so to identify the former and to manipulate its genome for efficient functioning. Also, only a small fraction of 1% microbes is known to the world and still good fraction of microbes playing mysterious role in soil is unidentified. Further, not all microbes are culturable and cannot be identified by traditional techniques and hence require advance molecular techniques. The molecular techniques are based upon the extraction, amplification and sequencing of 16s rRNA genes which have conserved sequences and helps in identifying the organism. Recent, high throughput sequencers are being reported to be efficient way in analysing genome with high accuracy and in short span of time.

Conclusion:

With passing time, more advanced techniques are being developed in awe of easing the work, illumina sequencing based sequencers are MiSeq, HiSeq, mini on, Next Seq, Nova Seq and many more under research. With each and every coming sequencer, scientists are trying to reduce manual interference and trying to make a compact machine even a pocket friendly one. Further, much more efforts are being put on reducing the cost of sequencer along with the errors. However, with the fact that fourth generation of sequencing is the present era, it can be concluded that by far illumina sequencing is a good option.

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INDIGENOUS TECHNICAL KNOWLEDGE (ITKs) IN PULSE CULTIVATION

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Introduction:

In India, pulses being a major source of protein in the human diet and these are vital for sustainable agricultural growth due to its resource conserving nature through atmospheric nitrogen fixation and crop residue incorporation. In addition, it serves as a primary source of protein for vegetarian diet. In India, per capita availability of pulses has declined from 25.2kg/year in 1961 to 16.0kg/year in 2020 (GOI, 2022). It is attributed due to various factors *viz*., lack of crop cultivation knowledge of the farmers, low seed replacement rate, poor technological adoption, population explosion and so on. Pulses are growing in India under different agro-climatic conditions which support cultivation of different types of pulse crops. As per the Government of India estimate of 2020-'21, pulses are grown under 28.78 million hectares with an annual production of 25.46 million tonnes (Indiastat, 2022). Pulse production in India is very unstable, because it is predominantly cultivated in the marginal lands by the farmers having poor resources. Only smaller area of pulses (i.e., 19.1% of total pulse area) is cultivated under irrigated condition. There are various reasons for instability in pulse production, such as grown under rainfed cultivable area, complex growing environment, variability in soil fertility and productivity, poor technological adoption, etc.

Indigenous Technical Knowledge (ITK) is the product of centuries of trial and error, natural selection and keen observation that can form the knowledge base on which researchers and extension workers can plan their research strategy and experimental procedures. 'Indigenous' implies that, it is generated by local traditional knowledge based on the year's experiences, external actors, agencies and individual innovations. 'Technical' denotes the fact that this is specific knowledge that some people have as a result of their experience in a particular subject area. Thus, peoples' knowledge is more detailed than that of others, who have not had the same experience or do not have the same skills in observation or analysis (Sankaran, 2005). Generally, ITKs helps to overcome the uncertainty by the people. It is very holistic and specific to the particular location which makes them to overcome all problems which prevailing at the same location. ITKs having inherent nature of protecting the crops and cropping environment from over exploitation and it provide the way for sustainable agriculture. Over the past three decades, the view of scientists has turned on the side of traditional practices for employing those technologies with the current agriculture system at the present situation. ITKs are economically viable, technologically feasible, sustainable and eco-friendly in nature, less risk and conserving the locally available resources. ITKs are greatly relying upon the principles of organic farming.

Farmers have evolved a huge number of indigenous traditional practices and which immensely helps to tackle the pre-production, production and post-production constraints in pulse cultivation. There was so many Indigenous Traditional Practices (ITKs) which related to cultivation of pulses and post-harvest technologies in pulses have been reported by various scientists. These reported ITKs have a sound scientific knowledge and principles behind in that and there will be a greater advantage in terms of agricultural productivity and sustainability if it is rightly promoted at the current climatic variability situation. It is clearly known that ITKs are eco and farmers' friendly in nature and it also greatly promote sustainability in agriculture. There were lot of findings had been reported that indigenous practices in pulses which alleviate the various constraints in the pulses cultivation and also reduces the storage losses which caused by pests. For instance, farmers of Tamil Nadu had fixed optimum sowing time for pulse such as blackgram and peas for better yield. Likewise, treating of pulse grains with coconut oil prevents the storage pest infestation for a period of 6-8 months (Karthikeyan *et al.*, 2006). Therefore, there may be chance of maintaining of stability and promote organic way of pulse production (sowing - harvest) and reduction of storage loss while adopting and practicing the various ITKs in pulses cultivation.

ITKs in pulse production

The various ITKs being practiced widely at different operations in pulse cultivation are discussed in this chapter in a detailed manner.

A. Season

Generally, selection of season is the most important criteria which mainly have an impact on crop growth and yield. Various pulse crops require different seasons for better crop performance and thereby maximum productivity. *Kharif* pulses such as redgram, greengram, blackgram require warm climate throughout the growing season, whereas for *rabi* pulses which include chickpea, lentil, peas, rajmash require mild cold climate at time of sowing, subsequently crop needs cold climate during vegetative to reproductive stage and warm climate at the time of harvesting of crops.

A. 1. Blackgram

Blackgram is generally a tropical crop and it is relatively tolerant to drought situation. Sowing of blackgram in Tamil Nadu during the second fortnight of September (pre-monsoon sowing) is one of the indigenous practices. In this method, seed sowing is carried out with the advantage of residual soil moisture from southwest monsoon rains and crop will be grown as rainfed which coincides with northeast monsoon rainfall period. In Tamil Nadu State, North-East Monsoon (NEM) rainfall is a predominant rainy period (October - December), therefore sowing of blackgram during the second fortnight of September results in higher yield.

A.2. Peas

Peas is a winter crop and it is well adapted to agro-climate with mild winter. It is able to tolerate frost during vegetative period, but susceptible to frost during flowering and pod formation stages causes heavy loss of pod setting as well as deformation and discolouration of seeds leads to low yield with poor grain quality. To subdue this unfavourable climatic problem, sowing of peas during January month is a traditional practice in Tamil Nadu and this sowing period is very favourable for better crop performance. If peas sown on earlier than January month, which may lead to poor crop establishment and development and thereby low yield.

B. Nutrient management

Redgram possess deep root system (>150 cm) with well-developed lateral roots and it is capable of absorbing the nutrients from the deeper layers of soil. Under certain condition, root depth may be goes to more than 2 m which mainly depends upon the date of sowing and availability of nutrients in the soil profile.

Lakshmana (2000) reported that farmers in Andhra Pradesh never apply fertilizers to redgram crop and they believed that the crops possess deep root system, therefore it can able to uptake required nutrients from the soil.

C. Pest management

C.1. Insect-Pest in the field level

Generally, pulse crops are infested with several pests *viz*., pod borer, whitefly, aphid etc. throughout the cropping season. Farmers were adopted the different indigenous practices for the management of insect-pest in the field level.

C.1.1. Redgram

According to Gupta and Patel (2002), farmers in Gujarat state were used the leaf extract of *Ipomoea fistulosa* for controlling the insect pests in redgram field. Some farmers were used tobacco waste decoction to control the caterpillars and sucking pests. The materials required for preparation of tobacco waste decoction are (i). Tobacco waste - 5kg and (ii). Cow urine - 5 litres.

Procedure for tobacco waste decoction preparation and recommendation

- Collect 5kg of tobacco waste and cut into small pieces
- Then, it must be soaked in 5 litre of cow urine for 7 days
- After soaking period, it has to be filtered by using muslin cloth/strainer and collect the filtrate
- Add 150g of soap and 250 litres of water to the filtered tobacco waste

- It is usually recommended at the rate of 50 ml/litre of spraying solution
- It must be sprayed to control the caterpillars and sucking pests only

C.1.2. Bengalgram

Farmers are managing the pod borer in gram by using whey (buttermilk), *Aloe barbadensis* and *Nicotiana tabacum.* This will be prepared by adding 200g of tobacco powder and 2 leaves of *Aloe barbadensis* in 2 litre of whey. These combined materials are kept in 15 litre of water as such for 15 days. After that, it has to be filtered by using muslin cloth and the filtrate is to be applied as foliar spray over the infested crops at an interval of 2-3 weeks based on the insect pest infestation.

C.2. Disease management

Pulse crops are affected by several diseases such as powdery mildew, yellow mosaic, dry root rot, wilt disease etc. which limit the pulse production. Farmers were adopted the several indigenous practices for the management of diseases in pulse crops.

C.2.1. Redgram

Gupta and Patel (1992) documented that farmers were using dried fish powder to control the wilt disease through broadcasting method of application.

C.2.2. Blackgram

Traditional practice of spraying of neem oil @ 6 litre/acre is used to control the powdery mildew disease.

C.2.3. Greengram and cowpea

Fermented curd/ buttermilk is used to control the whitefly incidence, which act as vector/carrying agent for spreading of yellow mosaic virus disease.

D. Processing

D.1. Soaking and drying

This method is followed in the rural areas of Andhra Pradesh and reported by Reddy (2006). The grains of pulses are soaked in fresh water for about 8-14 hours and it is sundried for 3-4 days and after that milling process is carried out. The soaking action makes the grain swell and subsequent sun drying results in loss of moisture from the grain. This makes a gap/space between the cotyledons and therefore, *dal* is obtained in very simple way, besides it also facilitated easy husking and removal of powdered materials. This method of processing yields more percentage of *dal*.

D.2. Soaking and mixing with red earth

As per the report of the Reddy (2006), cleaned pulses are soaked in water for 8-10 hours and then it is thoroughly mixed with red earth. After that to reduce the moisture content, the treated pulses are sun dried for 4-6 days, and followed by milling and winnowing process are carried out to remove separate the grain and husk. Farmers believed that this method improves the de-husking process and reduce the losses of *dal*. This method also having a disadvantage of presence of impurities such as fine dust particles in the milled *dal* even after the cleaning process. This method is predominantly followed by farmers in Andhra Pradesh.

D.3. Pitting and wetting

Pitting and wetting method is being adopted by farmers in Andhra Pradesh Reddy (2006). After cleaning the pulse grains, it is fed through the machine for scratching the seed coat. The grain thus obtained is mixed with edible oil @ 0.3% and it is to be dried under bright sunlight for 2-3 days. In some areas, beside edible oil water is also added along with it. This technique makes the cotyledons loose by passing of oil and water through the crack made by scratching process. Grains thus obtained after drying are milled and de-husked properly. For complete de-husking, dried grains have to be passed through 2-3 times and the techniques yields *dal* with better quality with good percentage of recovery (nearly 75%).

D.4. Pitting, oil application and roasting

Outer coat of pulse grains (redgram and blackgram) is scratched by passing the grains through machine and then grains are treated with small quantity of edible oil and kept as such for 2 days. The conditioned grains are kept in iron pan, which is containing sand or ash for roasting. After that, grains are milled and processed.

D.5. Splitting and oil application

Pulse grains (blackgram and greengram) are milled after proper cleaning. The un-husked *dal* is thoroughly mixed with edible oil followed by sun drying. Then, de-husking is carried out by either passing through the machine or by hand pounding and it is followed by removal of husk & broken *dal*. This method is vastly practiced in some areas of Andhra Pradesh.

D.6. Scratching, wetting and drying

After cleaning of chickpea grains, it is passed through the machine to scratch the seed coat. The grains thus obtained is added with water and followed by tempering for 4-8 hours. Then, tempered grains are dried under bright sunshine and milling is done. When comparing the soaking and drying method, this method yields good quality *dal*. This is one of the traditional practices in some areas of Andhra Pradesh (Reddy, 2006).

D.7. Puffed legumes

Initially, pulse grains (chickpea) are heated in a gentle manner and followed by moistened the grains with 2-4% fresh/salt water. Then, the grains are roasted for 3-5 minutes in iron pan containing sand.

D.8. Splitting of pulse grains

Before storage, pulse grains are split by using indigenous milling tool called Ural (Fig. 1). This indigenous practice is carried in different parts of Tamil Nadu. It is only effective for consumption purpose and it control the storage pests such as bruchid beetles and pod borer. Generally, these pests prefer whole grains than the split one and therefore, it is very effective (Karthikeyan *et al.*, 2006). According to the report of Lakra *et al*. (2010), tribal farmers in Jharkhand were carried out trashing operation by hand beating and winnowing process by using bamboo made device.

Table 1: *Dal* recovery of different traditional methods which are practiced in Andhra Pradesh (Reddy, 2006)

Sr.No.	Name of the processing method	Crop	*Dal* recovery (%)
1.	Soaking and drying	Redgram	60-70
2.	Soaking and mixing with red earth	Redgram	60-70
3.	Pitting and wetting	Redgram	70-75
4.	Pitting, oil application and roasting	Greengram and blackgram	65-70
5.	Splitting and oil application	Redgram, greengram and blackgram	70-75
6.	Scratching, wetting and drying	Chickpea	74-80
7.	Puffed legumes	Chickpea	90-95

Figure 1: Ural - Pulses splitting tool

E. Storage structures

Different types of storage structures were used by the people for safe storage of pulse grains in various parts of India.

E.1. *Sandaka/ pettige*

Sandaka is a box like structure made up of wood which is used for storage of pulses and it is having a storage capacity of 3-12 quintals. After grain filling in this structure, a big lid is used to place on the box and this lid consists of small outlet provision to take the grains from the *sandaka*. At the bottom of box, it consists of legs of 0.3408 m to protect the grains from moisture at the ground level. This structure was common in all households of Dharwad district of Karnataka (Nagnur *et al.*, 2006).

E.2. *Matka*

Matka is a pot like structure made up of earthen material (Fig. 2), especially for storing the pulse grains like lentil (*Lentil esculenta*). Pulse grains were treated with cow urine and dried under sunlight. After that dried grain is filled in matka and its opening was sealed with the help of cow dung, cow urine and clay to make air tight (Thakur, 2011). Southern India, especially in Andhra Pradesh, people were used *matka* like structures for storage of lentil (Reddy, 2006).

Figure 2: *Matka* - Storage structure

E. 3. *Khatti*

Khatti is an underground storage structure which locally called as *khassa* or *bhuidhara*, which was used for storage of pulse grains for both consumption and seed purpose. These are the large underground storage structures having the measurement of 10-12 feet deep and 6-8 feet wide. Storage structures were filled with wheat straw or stubbles of linseed for 1 m height. Then, palas made from *Butea monosperma* leaves placed on all four sides. After the grain filling in the structure, small opening at the top was closed with wooden plank or stone and after that, it was plastered with cow dung for safe storage (Sah *et al.*, 2014).

E.4. *Munda*

Munda is a method of storage on false ceiling and it was used to store for small quantities of pulse grains. Grains had been stored in this structure in the month of May - June and it opened after cessation of rains i.e., during October. This storage structure is very specific to Baberu block in Uttar Pradesh (Sah *et al.*, 2014).

E.5. Earthen Pot

Figure 3: Storage of pulse grains in earthen pot

Figure 4: Pulse grains stored in gunny bags

Sah *et al.* (2014) also reported that farmers were using earthen pot (Fig. 3) for storing all pulses in general and more specifically for storing greengram, balckgram and pigeonpea in the Bundelkhand region of Uttar Pradesh.

Farmers in the Bundelkhand region of Uttar Pradesh were storing their pulse grains such as bengalgram, redgram and greengram in the gunny bag (Fig. 4) and they believed that guuny bags provides good aeration to maintain the seed quality (Sah *et al.*, 2014).

F. Storage pest management

While storing pulse grains, farmers have to store it in a controlled condition or otherwise storage pest infestation will occur. Generally, pulse grains are more susceptible to storage pest infestation and it ranges from 30-70% of the grain. Post-harvest losses of pulses in India accounts 9.5% of total pulse production and during storage only accounts maximum loss of 7.5%. The major storage pests of pulses are pulse beetle (*Callosobruchus chinensis, C. maculatus*), *Acanthoscelides obtectus* (in rajmash), red flour beetle (*Tribolium castaneum*), *Zabrotus subfasciatus*, *Bruchus lentis* etc. The various ITKs have been documented by various scientists in various parts of India for managing the pulse storage pest.

F.1. Sun drying and packing

Farmers are usually dry the harvested grains on the floor during the bright sunshine hours. By doing this, larvae and adults of storage insect pests are killed due to exposure to the sunlight. Storage pests can be killed by exposing the infested grains to sunlight in the months of May and June (Atwal and Dhaliwal, 2005). The practice of periodical sun drying of pulse grains eliminates the storage pest infestation. In Andhra Pradesh, pulse grains were dried under sunlight and stored in gunny bags. This was frequently done and mostly carried out during full moon day (Reddy, 2006).

Figure 5: Sun drying of Redgram

F.2. Mixing with other crop grains and packing

In this practice, smaller cereal grains were mixed with pulse grains to arrest the movement of pulse pests and limit the air circulation inside the storage grain. This method is simple if amount of grain is small for storage or otherwise, it is tedious one for storing large amount of pulse grains. It is also difficult to separate the pulse grains from cereal grains and also there is no grader available for separation of grains. In this method, pulse grains were stored or packed in double gunny bag for reducing the insect movement.

Redgram and chickpea seeds were mixed with small millets such as pearl millet or finger millet or foxtail millet @ 1kg for 5kg pulse seed and stored in an earthen pot. Cow dung was smeared over the earthen pot to made airtight (Mathad *et al.*, 2013). The coarse surface of small millets absorbs the moisture and provides better storage.

F.3. Mixing of different materials with the pulse grains

During storage, pulses grains were mixed with any one of the materials such as cow dung ash, wood ash, cow urine, leaves of neem tree (*Azadirachta indica*), pungam tree (*Pongamia sp*ecies), *Eucalyptus* tree, mint, *Juglans regia (*Walnut), chilli powder, castor seeds etc. (Nagnur *et al.*, 2006; Karthikeyan et *al.*, 2006). Farmers believed that materials used with storage grains may be act as anti-feedant, pest repellant and ovi-position deterrents. This traditional practice protects the pulse grains from storage pests up to few months. Storage pest infestation will occur, if once effectiveness of such materials gets lost. It has been reported that walnut, mint leaves possess antimicrobial and pesticidal properties and it also reduces the pest infestation.

Traditional practice of mixing of neem leaves with storage grains has been adopted by the farmers of different agro-climatic zones of Tamil Nadu and it is highly feasible one (Karthikeyan *et al.*, 2006). Ash was obtained by combined burning of the wood and cow dung after that, ash was mixed with storage grains in the ratio of 1:1 then allowed for sun drying for few hours and filled in gunny bags which is airtight in nature. This indigenous practice is adopted by 60% of farmers in Kaliyamuthur village of Tamil Nadu State. This practice drastically reduces the storage loss up to 80% (Karthikeyan *et al.*, 2006).

According to the documentation of Karthikeyan *et al*. (2006), before storing of pulse grain it should be cleaned properly and then sundried for removing the excess moisture present in the grains. To repel the storage insect pests, the dried grains should be mixed with dried chilli fruits and the indigenous weed species called Naithulasi (*Ocimum sp.*). Due to strong odour of *Ocimum species* and astringent smell of dried chilli fruits, which facilitates repelling the storage pests *viz*., flour beetles, pulse beetle, etc. This ITK practice controls the storage pests to a level of 60% and improves the shelf-life of storage grains up to 2 years. This technology has been in practice among the pulse growing farmers of Devarayapuram village of Coimbatore District Tamil Nadu. Somasundaram (1995) reported that farmers in Tamil Nadu were storing the redgram seeds after mixing with vasambu (*Acorus calamus*).

Karthikeyan *et al.* (2006) also revealed that farmers of Kaliyamuthur village in Tamil Nadu adopted the indigenous practice of mixing the greengram with ash in the ratio of 1:1 and then sun dried and stored in gunny bag. Farmers in the Bundelkhand region of Uttar Pradesh were storing the chickpea mixed with dried onions @ 250g/quintal for safe storage and for storing of field pea; one kg of dried onion/quintal was randomly mixed while filling in the gunny bags for safe storage (Sah *et al.*, 2014).

Chickpea grains were mixed with chickpea leaves and stored and this practice prevents the change of grain colour and storage pest infestation (Nagnur *et al.*, 2006). Farmers in

Kolgadhahivya village of Uttar Pradesh state were crushed the fenugreek plants and allowed to dry under solar radiation then it was mixed with pulse seeds @ 1kg for 10g of seed for safe storage (Sah *et al.*, 2014). Similarly, farmers in Karvi block of Uttar Pradesh were mixing the fine wheat husk along with chickpea seeds or grains @ 2kg per 50kg of seed for safe storage (Sah *et al.*, 2014). Seeds of greengram were stored in the pot with the layer of ash, after that the pot was smeared with cow dung paste. This practice makes the pest inside the seed to suffocate & die and also it helps for longer storage of pulse grains (Mathad *et al.*, 2013).

In the region of Bundelkhand in Uttar Pradesh state, farmers were practicing the safe storage of chickpea seeds by using Asafetida. It was mixed with required quantity of water and sprinkled over the grains. After thorough mixing, it was stored (Sah *et al.*, 2014).

According to the report of Mathad *et al.* (2013), farmers of the North-eastern region of Karnataka, were mixing the greengram seeds with 250g of chilli powder and one kg of finger millet flour for 10kg of greengram seeds for safe storage. Similarly, farmers were mixing the redgram seeds with horsegram seeds and plant dust in an air tight container for storage. The principle behind this practice is dust particles absorbed the excess moisture from seed and it paved the way for the long-term storage. Redgram seeds were kept with drumstick seed extract or bitter gourd powder for 3-6 months. The toxic effect of drumstick and seeds of bitter gourd are not only repelling the pest and also prevents the pathogen infection during the storage period.

F.4. Oil coating to pulse grains

In this traditional practice, pulse grains were coated with oil *viz*., neem oil, karanja oil as a thin film over the grain and for this process both edible and non-edible oils were used. This provides a long term protection from storage pest infestation and such practice reduces the adult emergence from the stored grains. This method greatly reduces the storage loss of pulse grains.

In the North-eastern region of Karnataka, redgram and chickpea seeds were treated with citronella leaf oil, castor oil, cotton seed oil, soybean oil @ 500 ml for 100kg of seeds which repels the pest because of its strong odour (Mathad et *al.*, 2013). In experiment conducted by Kumar *et al*. (2018), revealed the effects of various seed protectants at different doses on weight loss in blackgram by pulse beetle (*Callosobruchus chinensis*). It was found that neem oil and olive oil treatment recorded the lower percentage of grain weight loss when compared to the other treatment.

Hossain *et al.* (2010) conducted the experiment on efficacy of indigenous plant extracts (*Swietenia megahoni, Azadirachta indica, Crotalaria juncea, Aphanamixis polystachya, Polygonum hydropiper, Nicotiana tabacum, Annona squamosal, Ricinus communis, Trigonella foenum-graecum, Jathropus curcas, Linium usitatissimum* and *Tagetes erecta* with different solvents such as acetone, ethanol, n-hexane, petroleum ether and water) as grain protectant in bengalgram against *Callosobruchus chinensis.* It was found that neem extract treatment with different solvent recorded the low percentage of pest infestation and also weight loss caused by the storage insect-pest.

Farmers of Malamanoor village in Tamil Nadu adopted the indigenous practice of oil coating to pulse grains. Pulse grains mainly blackgarm, greengram were coated with coconut oil and stored. For one kg of pulse grains, about 50 ml of oil has required for oil coating. This prevents the storage pulse grains from pest infestation for nearly 6-8 months. This method becomes very effective if oil treated grains are exposed to sun once in five months (Karthikeyan *et al.*, 2006). Whereas in the Bundelkhand region of Uttar Pradesh, farmers were treated the pulse grains such as chickpea, blackgram, field pea and greengram with kerosene oil @ 50 ml per 5kg of seeds. This method was not used for storing the pulse grains for consumption and used only for seed purpose. This method protects the seeds from bruchid infestation during storage (Sah *et al., 2014*).

Table 2: Effects of various seed protectants at different doses on weight loss in blackgram by *Callosobruchus chinensis* (Kumar *et al.*, 2018)

Sr.No.	Treatments	Lower dose/kg of seed	% weight of loss	Higher dose/kg of seed	% weight of loss
1	Neem oil	3 ml	3.00 (9.97)	5 ml	1.33 (6.62)
2	Castor oil	3 ml	3.66 (11.02)	5 ml	2.00 (8.13)
3	olive oil	3 ml	3.00 (9.97)	5 ml	1.33 (6.62)
4	Camphor	1g	4.00 (11.53)	2g	2.33 (8.78)
5	Anola fruit powder	10g	4.66 (12.46)	15g	3.00 (9.97)
6	*Lantana camera* leaf powder	5g	4.66 (12.46)	10g	3.33 (10.51)
7	Neem leaf extract	5 ml	6.33 (14.57)	10 ml	2.00 (8.13)
8	Control	-	8.33 (16.77)	-	8.66 (17.11)
	SE (d)		1.02		1.24
	C.D		2.16		2.62

F.5. Heating and packing

This traditional practice involves heating the pulse grains after mixed with sand or wood ash or cow dung ash and stored in new earthen pot structure. The principle behind this practice is mixing of sand or ash with grains makes mechanical wounds and dehydration to the insects and results in killing of storage insect-pest. This method having an advantage of eliminating the storage pests from grains before storage and it provides safe storage for long term i.e. up to one year.

F.6. Treatment with turmeric and chilli

Pulse grains were treated with turmeric paste before storage and it reduced the pest infestation. Turmeric paste was prepared by mixing the turmeric powder with mustard oil. Likewise, during storage, farmers were used the chilli (*Capsicum annuum*) fruits and kept in pulse grains during storage. Due to stringent smell of chilli, it repels the various pests namely flour beetle, pulse beetle, etc. Similarly, Nagnur *et al*. (2006) reported many traditional techniques of adding materials with pulse grains during storage.

In the Chopal district of Himachal Pradesh, for repelling the ants from grains, farmers are making turmeric paste with mustard oil and make a line by using this paste around the storage grain (Atwal and Dhaliwal, 2005).

F.7. Use of table salt

Table salt was used for short term safe storage of redgram (*Cajanus cajan*) and common bean (*Phaseolus vulgaris*). It provides protection against the storage pests with an average period of 6-8 months. For one kg of pulse grains, 200g of table salt was used and it mixed with pulse grains thoroughly. The principle behind this practice is abrasive action of table salt prevents the pest movement inside the grains. Similarly, the farmers of Bundelkhand region in Uttar Pradesh were mixing the lentil and chickpea seeds or grains with salt @ one kg for 100kg of seeds or grains for safe storage (Sah *et al*., 2004).

F.8. Treatment with cow urine

After thorough cleaning, pulse grains especially Lentil (*Lens esculenta*) were sun dried after that it was treated with cow urine and dried it again under sunlight for long-term storage. Farmers believed that cow urine having antimicrobial and pesticidal property which gives protection from storage pests.

F.9. Frying of pulse grains

Karthikeyan *et al*. (2006) reported that, pulse grains especially greengram and blackgram were roasted in the iron pan for 3-4 minutes. This makes the seed coat of grains become hard and reduces the grain borer infestation up to 80%. This practice is adopted by 60% of the farmers residing in a village of Melathulukkankulam, Tamil Nadu state.

F.10. Storage of pulse grains with sand

After cleaning of pulse grains, it was keeping in the cow-dung pasted bamboo basket with an alternate layer arrangement of pulses gain and river sand respectively. By this practice, condition prevailing in the bamboo basket due to presence of sand will not favour for the pest infestation. It is adopted by about 40% of farmers in Vattamalai village of Tamil Nadu state (Karthikeyan *et al.*, 2006). This indigenous practice also improves the shelf-life of stored grains. Similarly, the tribal farmers in Andhra Pradesh were storing the redgram seeds with sand as layer by layer in an earthen pot to prevent the storage pest infestation (Kella *et al*., 2007)

F.11. Red earth treatment

This indigenous technique involves treating the seeds with red earth. To treat one kg of redgram, one kg of red earth is required (at the ratio of 1:1 ratio). After treated with red earth, it must be sun dried for 1-2 days and stored for seed purpose. This indigenous technology is predominantly practiced by the farmers (90%) of Viraliyur village, Coimbatore District, Tamil Nadu. The principle behind this concept is that small gravel present in the red earth scratches on the body of storage pests and the storage insect-pest will die. It is very cheap and effective method in terms of storage pest management (Karthikeyan *et al.*, 2006).

Conclusion:

Organic farming provides the solution to the various agricultural problems in a sustained way and it has very least / no harmful effect on the environment. In pulse production, organic produce provides healthy food to human beings and also it fetches the premium price to the farmers. ITKs are generally based on eco-friendly concept and it is also economically feasible. In the different regions of India, various ITKs were documented by the different scientists and some of it is the location as well as crop specific. By adopting ITKs in pulse production from sowing to storage, there may be huge possibilities to alleviate the various constraints in pulse production technology in general and post-harvest losses specific. Therefore, practicing of different known indigenous practices in various operations of pulse cultivation make it very effective at very low cost along with minimum risk, which also promote the cultivation in an organic way.

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INTEGRATED APPROACH FOR MANAGEMENT OF PLANT PARASITIC NEMATODES IN VEGETABLE CROPS

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Abstract:

The production of vegetable crops is hindered by different pests and diseases out of which plant parasitic nematodes have emerged as a serious limiting factor. It causes considerable yield loss in vegetable crops throughout the world. Generally chemical nematicides are used for control of these nematodes but many of them has been drastically restricted for their negative effect on environment as they kill the beneficial microorganisms in soil, contaminate ground water and create health problems to human and animals from its residual effects. So far management of plant parasitic nematodes integrated approach is the way to success.

Keywords: Plant Parasitic Nematodes, Vegetable, *Meloidogyne incognita*, Plant Growth Promoting Rhizobacteria (PGPR)

Introduction:

Nematodes are the most awesome creature on earth, commonly found in soil or water, even in oceans. Some nematodes are parasites of plants and animals. Plant parasitic nematodes are non-segmented, pseudocoelomic, bilaterally symmetrical microscopic, eel-like round worms. Nematode life cycle consists of an egg, four pre adult stages (juveniles) and an adult. Life cycle depends on the species and the temperature.

Vegetables are an essential component of our daily diet which are important sources of many nutrients like potassium, magnesium, iron, dietary fibre, folate, vitamin A, vitamin C, vitamin K, antioxidant etc. The nematodes that most commonly cause problems on vegetable crops are root-knot, lesion, dagger, stunt, spiral, stubby-root, lance, pin, cyst, stem, and needle nematodes. These nematodes are varied in their geographic distributions and host ranges. A study was conducted on 17 vegetable crops during 2012 to 2015 and resulted in 23.70 percent production losses due to nematode in Western UP. Maximum yield loss of 43 percent was observed in eggplant followed by 40% in tomato, 38 percent in okra, 35 percent in bottle gourd and 32 percent in potato. Bitter gourd and cabbage were found to have insignificant yield losses of only 4 percent and 6 percent respectively (Singh and Kumar, 2015).

Integrated approach

Root feeding nematodes damage root tissues by disrupting normal root functions. The above ground symptoms of nematode infections are stunting, yellowing, and wilting which are the result of reduced translocation of water and nutrients. The symptomsof nematode infection can be subtle, and are often undetected or overlooked. Accurate diagnosis requires an evaluation of colonized tissues, specific symptoms and the presence of the nematodes.

For effective management of plant parasitic nematodes several methods are integrated. These are cultural method, physical method, host resistance, biological control, biotechnological approaches and chemical control.

1. Cultural method of nematode management

Once plant parasitic nematodes are present in a field, it is almost impossible to eradicate. Therefore, as a first management strategy we should avoid fields with a history of nematode problems and undertake efforts to prevent spread of the same from infested to non-infested fields. Plant pathogenic nematodes generally cannot move far on their own, (usually, less than six inches per year).Sanitation of field equipment and planting non-infected seedlings will limit the spread of the nematodes (Mulrooney, 2014). They are usually transported over long distance through machinery, nursery stock, transplant, seeds or by animals.

Secondly, since plant parasitic nematodes are obligate in nature, rotation with non-host crops can help to reduce population levels of the nematodes in the soil. Crop rotation with garlic, onion, asparagus, corn, cahaba white vetch, nova white vetch not only helps to reduce the infestation of Meloidogyne spp., but also helps to prevent the plant from diseases and insect pest. Furthermore, some nematode species have wide range of hosts, including weed species that can survive as eggs in the absence of a susceptible host for several years. If cover crops are included in the rotation, it must be non-hosts or poor hosts (Mulrooney, 2014). Cover crops like *Mucuna pruriens, Crotolaria spectabilis* show the resistance against three species of PPNs viz. *Meloidogyne arenaria, M. javanica, M. incognita* (Bernard *et al.*, 2017). If sudan grass and sorghum are included as cover crop allelochemical like dhurrin is produced which are then converted to hydrogen cyanide and used as powerful nematicide (ATTRA, 2003). Organic matter amendments and green manuring crop have been shown to reduce nematode populations in some cases. Butryric acid released from decomposition of rye and timothy-grass and isothiocyanates released from Brassica crops can lower nematode populations to a great extent.All the nematodes donot respond to soil amendments in the same manner as for example rapeseed amendments can suppress dagger nematodes but not lesion nematodes (Shrestha *et al.*, 2014).

2. Physical method of nematode management

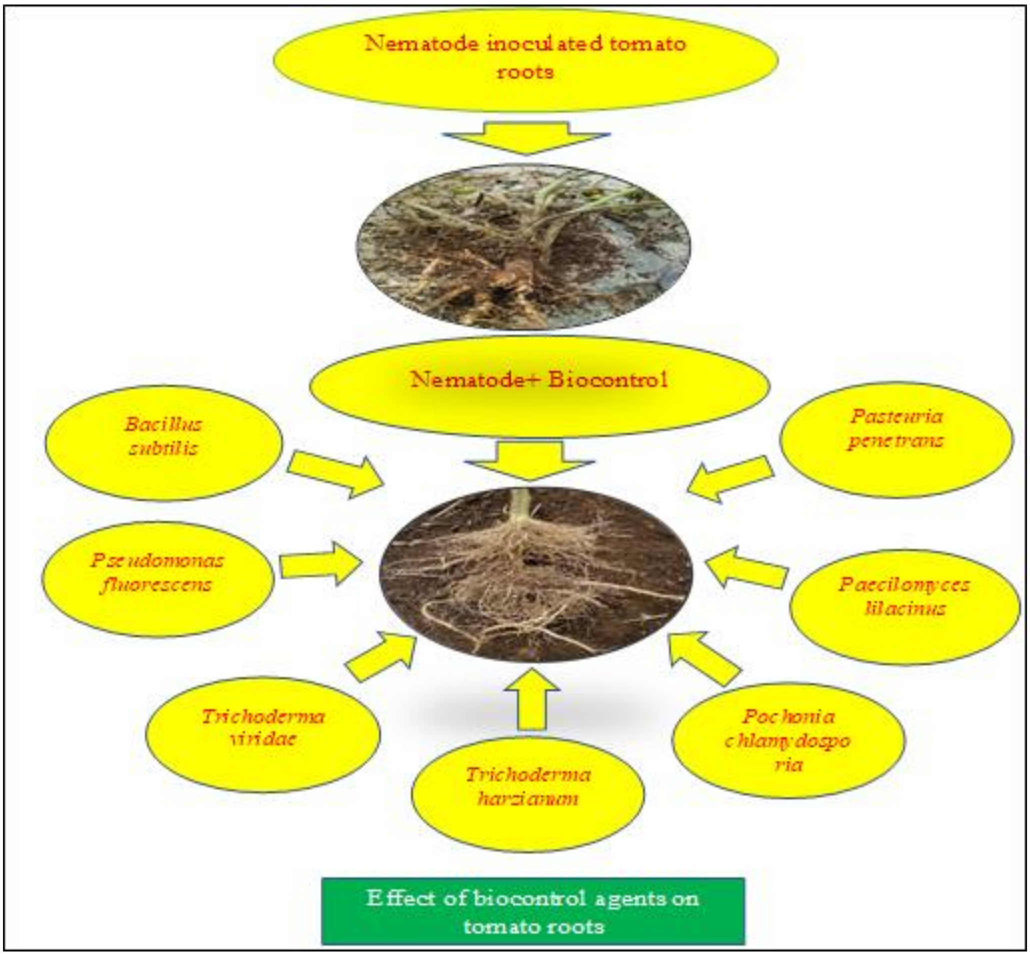
The use of physical methods, such as the application of heat, steam, and flooding can be used to lower nematode populations, especially in greenhouse cultivation. Heating soil with steam to a temperature of 158°F for 20 minutes to a depth of 14 inches has been shown as effective management of nematode problems, but this practice requires special equipment, and the logistics of application may not be practical (Kokalis-Burelle *et al.,* 2014). If the planting material is dipped in hot water it will effectively eliminate nematodes from plant material provided thermal tolerance of the nematode is less than that of the plant material. There are some specific temperature requirements to achieve lethal conditions for nematodes without causing damage to the plant materials eg. *Pratylenchus vulnus* can be killed by immersing grape roots in water at 51.50 C for 5 minute and *Ditylenchus dipsaci* can be killed in bulbs by immersing at 440 C for 1 hour. Anaerobic soil disinfestations (ASD) is a process in which low oxygen conditions are induced by adding quickly decomposable organic matter to soil, covering the amended soil with plastic mulch and irrigation of the soil to the point of saturation. The organic matter used is often a material that is inexpensive and readily available in the area, such as rice bran, rapeseed cake, chicken litter, and molasses (Kokalis-Burelle *et al.*, 2014).

3. Host resistance to some nematode species

Different types of natural genes are used for developing plant resistance to nematode. Mainly two types of resistance work between host plant and nematode resistance. These are active and passive resistance, active resistance is related to histological change which forms the necrosis around the nematode leading to death of the nematode (Giebel, 1982) whereas passive resistance is anatomical, physiological and chemical barrier which hinders nematode infestation.This type of resistance is available in some commercial vegetable varieties. For example, resistance to root-knot nematode is available in varieties of pepper, tomato, and sweet potato (Mulrooney, 2014). Grafting of susceptible varieties with a nematode resistant root stocks has also been shown to control nematode problems in some vegetable crops including tomato, pepper, muskmelon, watermelon, cucumber, and eggplant (Kokalis-Burelle *et al.*, 2014).

4. Biological control

It can be defined as the use of living organisms, some natural resources and/or their different products to suppress the negative effects on the plants and enhances positive effects. Some bacterial bio control agents against plant parasitic nematode include *Bacillus subtilis, Pasteuria penetrans, Pseudomonas fluorescens*, etc. and some fungal bio control agents are *Trichoderma viridae, T. harzianum, Pochonia chlamydosporia, Paecilomyces lilacinus* etc. For example *Bacillus subtilis* has effect on nematode multiplication, *Pasteuria penetrans* reduce infection as well as fecundity of plant parasitic nematodes, *Paecilomyces lilacinus* causes severe attack on eggs of different plant parasitic nematodes. Plant growth-promoting rhizobacteria (PGPR)s enhance plant growth by colonizing the plant root system. Some of them show nematicidal activity against plant-parasitic nematodes. Secondary metabolites produced by *Pseudomonas fluorescens* CHA0 that induce mortality of nematode eggs and second-stage infective juveniles (J2s) is the good example of it (Siddiqui and Shaukat 2003). Zhao and his co-workers (2018) conducted a study where he collected 860 strains of bacteria from the rhizosphere, out of which 5 (*Bacillus cereus, B. subtilis*, *Pseudomonas putida, P. fluorescens*, and *Serratia proteamaculans)* showed high efficacy as bio control agents against *M. javanica*.



Thus, PGPRs besides helping in growth promotion have great potential as a bio control agent against pathogens such as nematodes. Nowadays, a wide variety of organisms are used as biocontrol agents against plant-parasitic nematodes besides fungi and bacteria. These are viruses, protists, predatory nematodes and other invertebrates. Predatory nematodes not only act as bio control agents against plant-parasitic nematodes, it also plays a main role in stimulating cycling of plant nutrients, which helps plants to defend themselves more effectively against the attack of pathogens. There are many such nematodes as for example, *Odontopharynx longicaudata* effective against *M. incognita* and *M. Javanica* and *M. gaugleri* effective against *Heterodera oryzae* and *M. incognita* (Khan and Kim, 2007).

5. Biotechnological approaches

It aims either to exploit natural resistance present in genes of a particular crop species and their relatives or to employ synthetic form of resistance. In order to show up their synthetic form of resistance, they destroy their feeding cells and insert the toxic compound in the nematode invading cells (Nyarko & Jones 2015). To exploit natural resistance, large scale screening of germplasm is often recommended along with molecular markers and/or positional cloning to identify resistance genes or metabolites that provide resistance against that particular nematodes in a wide range of germplasm of crop plants and their wild relatives. After that identified source of resistance are introduced into the desired germplasm.

Following tools are used for identification and then management of plant parasitic nematodes:

a. **Isozyme electrophoresis and antibodies:** Through this tool it is easy to diagonise different species of nematodes such as root knot nematode, cyst nematode which are sometimes difficult to identify based on their morphology.

b. Polymerase chain reaction (PCR): It is used for species and strain identification of major plant parasitic nematodes.

c. Randomly amplified polymorphic DNA (RAPD): It is a Polymerase chain reaction (PCR) based technique for identification of genetic variation.

d. Restriction fragment length polymerase (RFLP): It helps to know the evolutionary relationship, characterization and development of nematode species (Shah and Mir, 2015).

6. Chemical control

When all the above approaches are not successful we have to go for chemical control as a last weapon. There are two main categories of chemical nematicides based on their volatility namely, fumigants and non fumigants. Fumigant nematicides are composed of small, volatile molecules and become gases after application and disperse through air spaces in the soil. Fumigants can be applied to the vegetable crops or in the strips under the plastic-mulched planting beds. For effective performance of the fumigants, emphasis should be given to proper soil conditions including temperature, moisture, and seedbed preparation. Fumigants commonly used for nematode control include 1,3-dichloropropene (Telone® II Soil Fumigant, Telone® C-17 Soil Fungicide) and sodium methyldithiocarbamate (Metam 426, Vapam® Soil Fumigant Solution for All Crops, Sectagon-42 Agricultural Fumigant). Registrations and use restriction of use of these chemicals may vary from state to state and can change from year to year. Therefore, it is important to carefully read the most current product labels and strictly follow these instructions as many nematicides are toxic and volatile in nature which adversely affects the human and animal health as well as environment causing ozone layer depletion and ground water contamination (Hussain *et al.*, 2017)

Non-fumigant nematicides do not volatilize in the soil and generally have a narrower spectrum of activity. Generally these chemicals may be applied at or after planting. Organophosphates and carbamates are generally categorized into non fumigants which directly have the systematic action on phyto-nematodes and are more effective at low doses (Ebone *et al.*, 2019)

Conclusion:

Through effective management of plant parasitic nematodes in vegetable crops food security can be achieved to a great extent to global agriculture. Since complete elimination of plant parasitic nematodes is not possible so our aim should be to manage their population keeping it below damaging level. For effective management, first we have to go for proper diagnosis of the plant parasitic nematodes and then select appropriate management measures those should be very effective and environment friendly. Cultural methods can be applied in an integrated way. In case of chemical nematicides, chemicals those are less harmful to human, animal and environment and more specific to plant parasitic nematodes should be applied. Use of nematode resistant varieties and bio control agents can be used for proper management. The integration of conventional and molecular methods can be applied as sustainable nematode management measures for control of plant parasitic nematodes in near future.

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DEVELOPMENT OF PLANT FROM ORGANOGENESIS IN PLANT TISSUE CULTURE

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Organogenesis:

Organogenesis refers to the process whereby the explants, tissue cells can be induced to form root, shoots, buds, leaves and embryos like structures.

Organogenesis means the development of adventitious organs or primordial from undifferentiated cell mass in tissue culture by the process of differentiation. In tissue culture, the formation of shoot and root is generally known as organogenesis. Thus organogenesis is of two types i.e.

1. Rhizogenesis(only root formation when the ratio of kinetin to auxin is lower)
2. Caulogenesis(only shoot formation when the ratio of kinetin to auxin is high)

Rhizogenesis:

Definition: The process of root formation from the callus is called rhizogenesis.

Root initiation is a type of organogenesis which occurs most frequently first in the cultured tissues. The root initiation begins after the formation of small buds on the callus.

Caulogenesis

Definition: The process of shoot formation from the callus is called caulogenesis.

1. The historical study of shoot organogenesis from the embryo like structure derived from the callus shows that the leaf primordial originate within minute indentations on the surface of callus. Normal leaf primordial is then formed around these indentations.
2. When the culturing the callus is transferred to shoot induction medium, the shoot organogenesis can be observed within three days.
3. Within 9 days, procambial and provascular tissues become visible become stratified and meristematic. Leaf primordial develops from this meristematic layer.
4. The organogenesis in tissue culture starts with the stimulation by certain chemicals present in the culture medium, substances carried over from original explants and the endogenous compounds produced by the callus. Thus organogenesis is chemically controlled process.

5. Normally, root and shoot initiation begins after the addition of some growth hormones to the culture medium, this regulation of organogenesis depends upon the balanced proportion between the growth substances like Auxin and Cytokinin.
6. The hypothesis of organogenesis was advanced by Torrey (1966) who suggested that organogenesis in callus starts with the development of group of cells called meristemoid (cell which are looking like the meristmatic cell called meristmoid).
7. These cells respond the factors present in the tissue culture system to initiate the primordium of the specific organ inducing either from root, shoot or embryoids.

Root culture

1. Generally excised (cut out from the plant body) root piece is cultured in the liquid culture medium.
2. White (1934) for the first time reported successful culture of excised tomato roots that developed into whole plantlets.
3. Subsequently, root of several Gymnosperms and Angiosperms have been cultured to obtain plantlets.
4. The technique of root culture in liquid medium has several advantages over the culturing on solid medium.
5. This technique give certain important information such as
   a) Nutritional requirement of a particular plant species
   b) Infection by rhizobium and subsequent nodulation in the root system of developing plantlet.
   c) Physiological activities of the roots such as production of secondary metabolites like alkaloids.

Shoot culture:

1. In shoot culture apical meristem from the shoot of the plant is utilized for culturing this is the shoot apex which is 8 to 10 millimeter in length this is known as meristem culture.
2. The shoot apex culturing is extensively used in horticulture, agriculture and forestry to develop need plants.
3. More (1960) for the first time started the shoot apex culturing of Orchid plant cambium for clonal multiplication.
4. Murashige contributed the establishment to development of micro-propagation technique by shoot apex culture leading to further biotechnological application

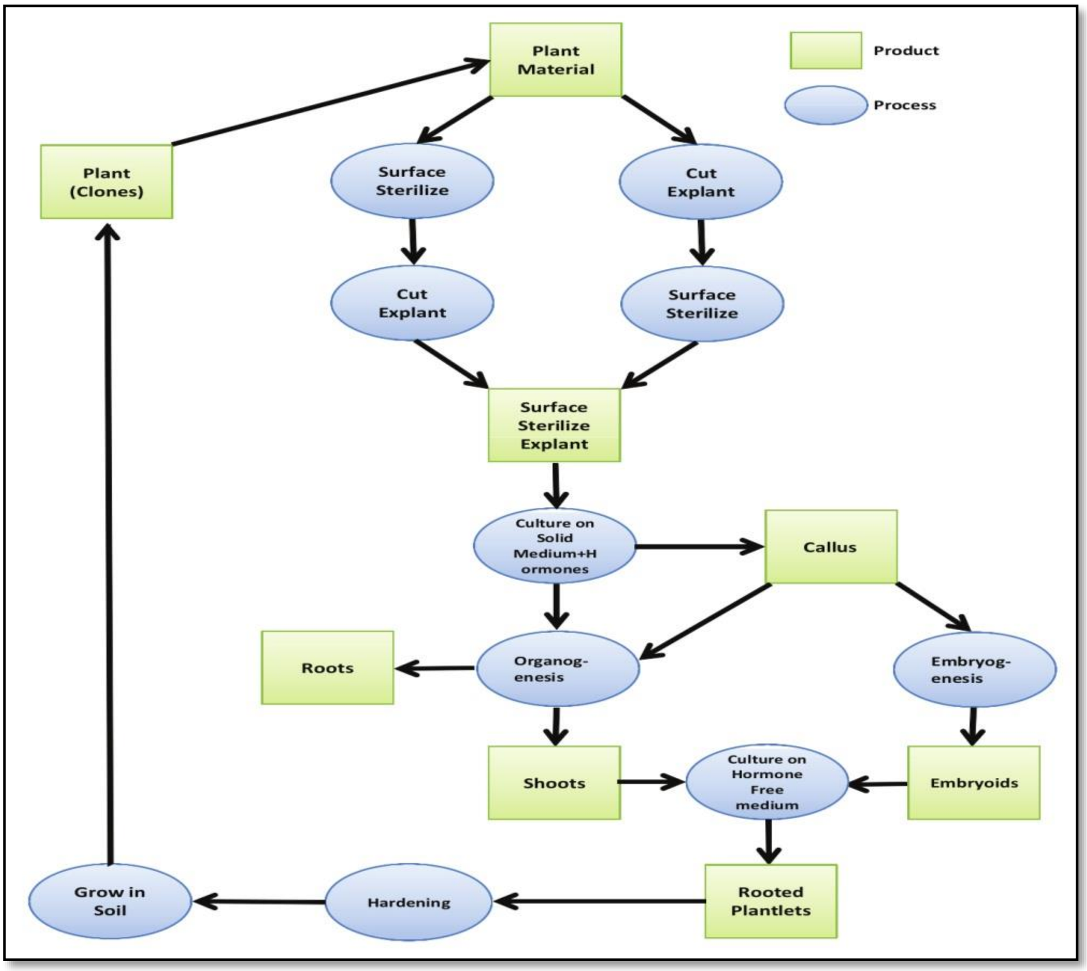

Figure 1: Organogenesis

Factors controlling organogenesis:

Vitro organogenesis is controlled by a number of factors. Such factors are discussed below:

1. Size of Explant
2. Source of Explant
3. Age of the Explant
4. Growth regulators
5. Light
6. Temperature
7. Culture medium
8. Agar – Agar
9. pH of the medium
10. Age of culture
11. Seasonal variation
12. Oxygen Gradient

1**. Size of explant**

i. Organogenesis is generally dependent upon the size of the explants.

ii. The large explants consisting of parenchyma, vascular tissue and cambium have greater regenerative ability than the smaller plant. A remarkable capacity to regenerate shoot buds in vitro is displayed by certain ferns such as *Davallia, Platycerium*.

2**. Source of explant**

i. The source of explant cultured is important in determining the potential of organogenesis.

ii. The most suitable part of the plant for starting culture will depend on the species leaves and leaf fragments of many plant species like *Begonia, Solanum, Nicotiana, Crepis*, etc. have shown the capacity to regenerate shoot buds. Root of sections of convolvulus sp. and *Ipomea* sp. etc. produce shoot buds in culture.

1. **Age of the explant**

i. The physiological age of the plant is another factor which often plays an important role in organogenetic phenomenon. Regeneration of adventitious shoot bud is only noted in case of *Nicotina* sp. If the leaf explants are collected from the negative phase i.e., prior to flowering. Leaf explants of *Echeveria* species (ornamental garden plants.) that use collected from young leaves produce only root, whereas older leaf initiates only shoot buds and leaves of medium age produce both shoots and roots.

2. **Growth regulators**

i. Relative ratios of Auxin and Cytokinin of play important role in the organogenesis.

ii. In case of tobacco pith tissue cultures, high ratio of Auxin to cytokininfavours root formation in the callus while high concentration of cytokinins to Auxin favours shoot formation.

iii. However, equal concentration of both hormones causes the callus to grow in an unorganized manner; this hormonal regulation is now applicable to most of the plant species.

iv. In some cases, it has been observed that Auxin promote root formation where as rhizogenesis is inhibited in other cases if exogenous Auxins are added to the medium.

v. In tobacco, bud formation could be separated by supplementing the medium with IAA and NAA (Nypthalin acetic acid) or where as bud formation in the callus of purines, adenine and adenosine in the culture medium.

vi. Endogenously occurring gibberlin like compounds in explants are reported to be involved in shoot initiation in callus.

3. Light

i. High light intensity inhibits shoot bud formation on the callus.

ii. The callus growing under continuous light becomes whitish and does not show organogenesis.

iii. In Pelargonium plant shoot formation takes place only when the callus is kept in under alternating light and dark periods.

iv. Quality of light also affects organogenisis. Red light promotes root formation where as blue light stimulates shoot initiation in the callus.

4. Temperature

i. The growth of callus increases with the rise in temperature up to 33 ^{0}C. For the formation of shoot optimum temperature is 18 ^{0}C for some cultivator of *Allium* and *Nareissue.* In linseed, however, short initiation is better at 30 ^{0}C.

5. Culture medium

i. The essential components of plant cell culture medium are the macro or major salts and micro or minor salts. Besides these, vitamins, amino acids, carbohydrates, etc., are also required for in vitro growth and development of plant cells.

ii. In addition, nitrogen is found in such important molecules as purines, pyrimidines and coenzymes.

iii. Phosphate is found in plants as a constituent of nucleic acids, the co-enzymes NAD and NADP and most important as a constituent of ATP.

iv. One well known role played by calcium in the plant cell is the function as a constituent of cell walls in the formation of calcium pectate. Similarly, iron, zinc and molybdenum are parts of certain enzymes.

v. The organic supplements required in plant culture medium include a carbon source of Vitamins.

6. Agar – Agar:

i. Agar- agar is not an essential component of the culture medium.

ii. In plant tissue culture, the culture medium is gelled with agar. The quantity of agar is a factor that may have a determining role in organogenesis; commercially available agar contains impurities “Difco” or Bacto-agar containing fewer impurities are generally used in plant tissue culture medium. So the concentration of agar also plays a role in organogenesis.

7. pH of the medium

The pH of the culture medium is generally adjusted between 5.6 to 5.8 before sterilization. The pH is another factor that may have a determining role in organogenesis.

8. Age of culture

Age of culture often exercises on influences on organ formation. A young culture frequently produces organs but the organogenic potential may decrease and ultimately disappear in old culture.

Importance of organogenesis

i. The invention of callus culture a large number of plant species including economically important plants , medicinal plants, timber yielding plants etc. have been successfully regenerated from the callus culture through organogenesis.
ii. Large number of production of haploids from microspores and the possibility of raising triploids from endosperm cell culture play a vital role of organogenesis in genetics and plant breeding.
iii. Chromosome number variation of cells i.e. polyploids have also been observed in callus culture. So that through the organogenesis a wide range of aneuploid plant produced from tissue culture.
iv. Variability of chromosome number if not associated with depression of yield, which is mainly valuable in vegetatively propagated medicinal plants and agricultural crops.
v. Cryopreservation of cell culture of many species and regeneration of plant from them after a desirable time period is an another importance of organogenesis. That is too much helpful for the conservation of endangered plant species.
vi. Regeneration of whole plant from the process of organogenesis is also helpful in mutagenic studies.
vii. The application of *in vitro* methods for the improvement of the genetically potential plants for the production of primary and secondary compounds, there generation of plants from cell and tissue cultures give special significance. Therefore, the success of all invitro cellular and molecular technique for the improvement of plants depends upon the ability to regenerate plants from single cells or callus culture via organogenesis.
viii. The organogenesis is very useful in mutation breeding of both sexually and vegetatively reproducing plants.
ix. Crop plants improvements through manipulation at the cellular level such as the vegetative hybridization by the fusion of isolated protoplast of the plant , the transformation of foreign genetic material in protoplast is happen when the somatic cells are able to give rise the whole plant. A plant breeder is interested in modified plants than modified cells.

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