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Contents

1. SOIL SCIENCE

Scientific Agriculture – A Solution for Carbon Sequestration

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Introduction:

Since the late 1800s, global surface temperatures have risen by 0.4 to 0.8 ° C. (0.6 to 0.2 ° C). Since 1976, the pace of rise has been 0.15 °C each decade, with the largest warming occurring in the Northern Hemisphere winter and spring, with some warming occurring in the summer (Baede 2001).

Greenhouse gas (GHG) emissions and anthropogenic activity are both blamed for the observed climate change. CO_2 concentrations have grown by 31% from 280 ppmv in 1850 to 380 ppmv in 2004, and have been growing at a pace of 1.5 ppmv/yr (0.4 percent/yr) since 1980. CH_4 and N_2Oconcentrations in the atmosphere have progressively grown as a result of anthropogenic activity, similar to CO_2 (Etheridge et al. 1998; IPCC 2001; Prather and Ehalt 2001)

The latter includes an estimated release of 78±12 Pg from global soils as a result of human soil organic carbon depletion (Lal 1999). Since 1980, fossil fuel combustion has accounted for the majority of emissions, with land use change or tropical deforestation accounting for 10 to 30% of total emissions.

Carbon sequestration: In the agricultural sector, carbon sequestration refers to the ability of agricultural lands and forests to absorb carbon dioxide from the atmosphere. Trees, plants, and crops absorb carbon dioxide through photosynthesis and store it as carbon in biomass in tree trunks, branches, leaves, roots, and soils (EPA, 2008b). Carbon sinks include forests and stable grasslands, which can store enormous amounts of carbon in their vegetation and root systems for extended periods of time. The largest terrestrial carbon sink on the planet is soil.

Soils and the global carbon cycle

There are five principal global C pools, and the C circulates among these pools.

- The oceanic pool is the largest, estimated at 38,000 Pg of C.
- The geologic pool is the second largest, estimated at 5000 Pg of C and comprising three sub-pools including 4000 Pg of coal, 500 Pg of oil and 500 Pg of gas.
- The third largest pool is pedologic or the soil C pool, comprising two distinct components: SOC and soil inorganic carbon. The SOC pool is estimated at about 1220 to 1550 Pg to 1-m depth and 2376 to 2450 Pg to 2-m depth (Eswaran et al. 1995). The SIC pool is estimated at 695 to 748 Pg to 1-m depth (Batjes 1996).
- The atmospheric C pool is 760 Pg, and increasing at the rate of 3.3 Pg C/yr.
- The biologic pool, comprising C contained in all biota, is 560 Pg

Scientific agriculture- the solution:

Agriculture has a critical role to play in efforts to reduce climate change caused by CO_2 and other greenhouse gas concentrations in the atmosphere. Scientific agriculture, contrary to popular belief, may help with environmental difficulties, particularly slowing the rate of CO_2 enrichment in the atmosphere.

Conservational tillage: Ploughing is the primary source of SOC oxidation and CO_2 emissions into the atmosphere. Reduced or eliminated soil tillage, as well as increased cropping intensity and plant production efficiency, can influence microbial activity, which in turn affects SOC dynamics and stability. Soil mineralization can be reduced by reducing or eliminating soil tillage and increasing cropping intensity and plant production efficiency. In the event of no-tillage, litter builds at the soil surface,

reducing evaporation from the soil. Surface residues and similarly standing stubbles lower wind speed at the soil surface, resulting in less turbulent water and heat exchange. The use of surface mulches and no-till methods to reduce soil temperature is critical for preserving soil organic matter stocks, especially in tropical soils.

Crop rotations: The series of crops cultivated in regularly repeated successions on the same piece of land is referred to as crop rotations. Crop rotations, particularly the use of legume cover crops, which contain carbon compounds that are thought to be more resistant to microbial degradation, can help to stabilise soil carbon. Crop rotations that are suited for the soil and environmental circumstances can aid in carbon sequestration, which not only improves soil fertility but also reduces CO_2 emissions into the atmosphere and increases farmer revenue.

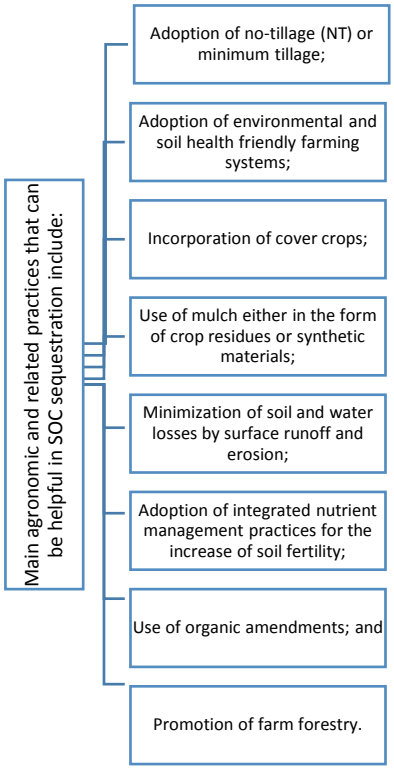
Crop residues: Crop leftovers serve a significant role in SOC management and soil quality enhancement. Mulching enhances soil moisture, minimises soil erosion, and reduces carbon loss from the soil and crop leftovers, which are absorbed into the soil to increase organic matter. As a result of higher carbon inputs and less soil disturbance, a direct seedling mulch-based farming strategy enhances soil organic matter. Mulch and crop leftovers can promote soil microbial activity, reduce heat stress, aid in water storage, and boost soil organic carbon.

Cover crop: The purpose of a cover crop is to help the soil rather than to increase crop output. Cover crops increase soil organic carbon through biomass, enhance soil aggregates and stability, and protect the soil from surface runoff, all of which improve soil quality. Green manuring, on the other hand, increases the biomass returned to the soil, resulting in a larger soil carbon sink. Cover crops, when chosen and planted correctly, can help to increase soil organic carbon.

Irrigation and water management Upgrades in water usage efficiency, such as mechanical improvements to irrigation systems combined with a reduction in working hours; drip irrigation technologies; and center-pivot irrigation systems, can significantly reduce the quantity of water and nitrogen applied to the cropping system. This minimises nitrous oxide emissions and water withdrawals, both of which are harmful to the environment.

Animal manure Animal manure is excreta collected from livestock farms and barnyards and used to improve the soil, whereas compost is a substance made primarily of decomposed organic waste that is used to fertilise and condition agricultural land. Manure application is vital for maintaining soil health and is a source of C, and its application to various agricultural fields has an impact on C content. Different organic wastes, such as municipal solid waste (MSW), farm yard manure (FYM), sugar industry waste (filter cake), and with a full or half dose of NPK mineral fertiliser, and it was discovered that adding organic wastes (filter cake or MSW) has the best potential for improving SOC retention, WUE

Chemical fertilizers Chemical fertilisers, particularly N2O, are a source of GHG emissions. Furthermore, fertiliser manufacturing and transportation are linked to GHG emissions. The use of fertilisers

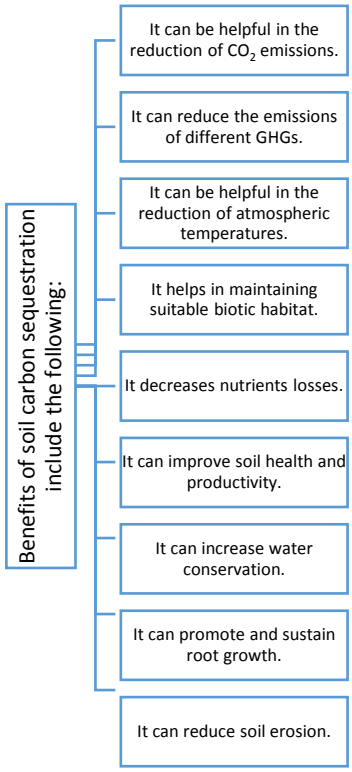


wisely boosts agricultural yields and profitability, and cultivated soils have supplied around 50 Pg CO_2 to the atmosphere through the mineralization of soil organic carbon(SOC). The proper use of fertilisers based on soil conditions can aid in carbon sequestration, crop productivity, and the reduction of various GHG emissions.

Conclusion:

Conversion from plough till to no-till, incorporation of cover crops and forages into the crop rotation, liberal use of crop residues and biosolids like mulch, integrated nutrient management including compost/manures and judicious fertiliser use, integrated pest management, and so on are all recommended management practises.

As a result, improving the efficiency with which these inputs are used is critical. SOC sequestration relies heavily on the restoration of damaged soils and ecosystems. The initial SOC pool has been lost in most degraded soils, but it can be restored by restorative techniques. On a worldwide scale, soil erosion by water and wind is the most common degradative



process, and conservation-effective strategies can reduce erosion-induced emissions and refill the depleted SOC pool.

The ability of soil C to be sequestered indefinitely is contingent on the implementation of prescribed procedures. Regular practises can deplete the SOC that has been sequestered. However, if suggested management methods are followed, sequestered carbon remains in the soil pool for a long period, slowing the rate of CO_2 enrichment in the atmosphere.

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2. AGRICULTURE

Herbicide Residue Estimation Techniques

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Introduction

When a herbicide is applied to soil it is subjected to various fates and an ideal fate of herbicide should be such that it should dissipate from the soil by the time of crop harvest. The quantity of the herbicide that is present in the soil is called herbicide residue. A residual herbicide maintains its phytotoxic effects in soil for considerable time after its application affecting the succeeding crops.

Herbicide Residue Estimation

Herbicide residues in the soil can be estimated by either by analytical method or bioassay method

I. Analytical method: It involves quantifying herbicide residues in any given sample chemically by using instruments like:

1. **Calorimetry or visible and ultraviolet spectrophotometry:** This method is based upon the measurement of the absorbency of the herbicides. The direct utility of a UV-visible spectroscopic method in pesticides residue analysis is limited because of its relatively low sensitivity.
2. **Thin layer chromatography (TLC):** TLC is one of the simplest, fastest, easiest and least expensive of several chromatographic techniques used in qualitative and quantitative analysis to separate organic compounds. It is an analytical technique that can be used to monitor reactions and for the qualitative analysis of complex mixtures and for the identification of unknown compounds. It is also important for determining the correct solvent system with which to run a column chromatography in. TLC is composed of two phases, a mobile and a solid phase. The solid phase is a thin solid support that usually consists of Alumina or Silica. The mobile phase is a solvent that moves through capillary action right through the solid phase. In general, the solid phase is usually polar while the mobile solvent is non polar relative to the solid phase. TLC is used mainly for confirmation of residues following initial screening and quantification. Extraction, cleanup and concentration steps normally precede TLC determination. Sensitivity ranges from about 5-500 ng for most herbicides detection methods
3. **Gas liquid chromatography (GLC or GC):** In spite of developments in spectroscopy and liquid chromatography, gas chromatography remains the most widely used separation tool in analytical chemistry and is likely to remain so far the foreseeable future. This technique has more resolving power and sensitivity for the separation and determination of volatile organic compounds than any other method in analytical chemistry.

   In herbicide analysis, GC has assumed a role of prime importance as compared to other methods. Because GC technique is capable of rapidly resolving complex herbicide mixtures and provides qualitative identification and precise quantitative analysis of the compounds. In multi-residue analysis, GC is the only method of choice.
4. **High performance liquid chromatography (HPLC):** High performance liquid chromatography has become increasingly important for separations and *insitu* quantitative analysis in the recent past. HPLC is carried out on 10 x l0 cm or 5x5cm layers of silica gel with a smaller particle size and a narrower particle size distribution than in conventional thin layer chromatography plates and thereby gives improved resolution and sensitivity of detection. Solvent development is carried out in the miniature glass rectangular chamber.

High resolution is achieved rapidly with short development distances.

High performance thin layer chromatography (HPTLC) or high-speed liquid chromatography (HSLC) or high-pressure liquid chromatography (HPLC) or high sensitivity liquid chromatography (HSLC) are the names used for this new liquid chromatography. The role of HPLC in pesticide residue analysis has been assessed by several authors and its potential is to be more fully explored.

II. Bioassay: Bioassay refers to the method of determining the level or amount of chemicals present in the soil by employing a highly sensitive biotic system. In spite of rapid developments in analytical methods, bioassay remains a major tool for qualitative and quantitative determination of herbicides. Bioassay may be a pot bioassay or field bioassay. Here, crop response is used as an indicator of the continued presence or absence of herbicide.

Table 1: Bioassay materials used for various groups of herbicides

Herbicides	Indicator species
Aliphatic halogenated acids (Dalapon)	Oats, millets, cucumber, barley, wheat, rice
Acetamides	Crab grass, oats, barley, rye grass, pig weed
Acetanilide (Alachlor, Metolachlor)	Cucumber, rye grass, crab grass
Benzoic acid	Cucumber, oats, foxtail, pig weed
Dicamba	Beans, sorghum, cucumber
Chlorpropham	Cucumber, oats, rye grass
Diphenyl ether	Cucumber, crab grass
Phennoxy derivative (2,4-D)	Cotton, pig weed, tomato, mustard
Substituted ureas (Diuron, Monuron)	Cucumber, rye grass, oats, barley, sorghum, millets
Thiocarbamates (EPTC)	Rye grass, oats
Dinitroanilines (Trifluralin, Fluchloralin)	Oats, sorghum, rice, cucumber
Triazines (Atrazine, Simazine)	Oats, cucumber, sugar beet

Advantages of bioassay over chemical method:

- It is simple and less costly.
- Toxic metabolites of the herbicide can be detected based on the crop response of the indicator plants.
- The sensitivity level of herbicides to the crops can be detected.

3. AGRICULTURE

Formulations of Biofertilizers

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Introduction

Biofertilizers are the substance which contains living microorganisms which, when applied to seed, plant surfaces or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Biofertilizer formulation is a substance that comprises aids to preserve the organism and to deliver them to their target fields and thereby to improve their activities. Etymologically formula is the diminutive of the Latin word *forma*, meaning shape. Formulation is created according to the standard for the product.

Different Formulations of biofertilizers:

- Liquid formulations
- Carrier based formulations
- Granular formulations

- Encapsulated formulations

1. Liquid Biofertilizers:

These are special liquid formulation containing not only desired microorganisms and their nutrients, but also special cell protectants or substances that encourage formation of resting spores or cysts for longer shelf life and tolerance to adverse conditions.

Liquid inoculants are based on aqueous (broth cultures), mineral or organic oils, oil-in-water or polymer-based suspensions.

Production technology

- Isolate and select efficient and competitive strains.
- Prepare media for broth culture.
- Multiply mother culture in the appropriate broth.
- Select and prepare broth material for mass production.
- Mass production and packing of the liquid biofertilizers.
- Storage and dispatch to farmers.

Aapplication: liquid biofertilizers are applied by seed treatment, root dipping or by soil application

Dosage:

- Pulses: Rhizobium at 200 ml/acre by seed treatment
- Cereals : Azotobacter/Azospirillum @ 200ml/acre
- Oil seeds :Azotobacter @ 200 ml/acre
- Tobacco, Tea, Rubber: Azotobacter @400 ml/acre through soil treatment

Advantages of liquid biofertilizers:

- Longer shelf life (12-24 months).
- No contamination.
- Low effect of high temperature.
- No loss of properties due to storage up to 45^{o} C.
- Greater potentials to fight with native population.
- High population can be maintained (more than 10^{9} cells/ml) up to 12-24 months.
- Cost saving on carrier material, pulverization, neutralization, sterilization, packing and transport.
- Quality control protocol is easy and quick.
- Better survival on seeds and soil.
- No need for running biofertilizers production units throughout the year.
- Dosage is 10 times less.
- Very much easy to use by the farmers.

Disadvantages of liquid biofertilizers:

- Lack carrier protection: low viability during storage and on seeds.
- Cool temperatures for storage (4 °C).
- More sensitive to stressful conditions.

2. Carrier based formulations:

Various types of material are used as carrier for seed or soil inoculation. For preparation of seed inoculant, the carrier material is fine powder with particle size of 10-40 μm.

According to the "Handbook for Rhizobia", the properties of a good carrier material for seed inoculation is:

- Non–toxic to inoculant bacteria strain and plant.
- Good moisture absorption capacity.
- Easy to process and free of lump-forming material.
- Easy to sterilize by autoclaving or gamma-irradiation.
- Good adhesion to seed.
- Good pH buffering capacity.
- Be abundant locally at a reasonable cost and able to sterilize.
- These properties only indicate the potential for a good carrier, while final selection for carrier must be based on microbial multiplication and survival during storage and general method of planting, equipment used for planting.

Types of carriers:

- **Soil** : peat, coal, lignite, inorganic soil
- **Plant waste materials**: charcoal, compost, FYM, press mud
- **Inert materials**: vermiculite, perlite, ground rock phosphate

Advantages:

- Suitable to wide range of microorganisms: AMF, Bacteria, Ecto-mychorrhiza.
- Protective nutritive environment.
- Moisture content can be adjusted to optimize growth and survival of bacteria during curing, storage, inoculation.
- Storage buffering capacity.

Disadvantages:

- Shorter shelf life (3-6 months).
- Sensitivity to temperature.
- More chances of contamination.
- Unavailability of good carrier in local area.
- Bulk sterilization problems in terms of economy and facilities.
- Poor moisture retention capacity.
- Labour intensive.
- High transport cost.
- Takes more time for quality control.
- Dosage contradictory to farmers.

3. Granular Biofertilizer:

Granules are made of peat prill or small marble, calcite or silica grains that are wetted with an adhesive and mixed with a powder-type inoculum. The granules are coated or impregnated with the target microorganisms. The inoculant is placed in a furrow near to the seed to facilitate lateral–root interactions but is not in direct contact with the chemicals or pesticides potentially toxic for the microorganisms.

Characters:

- Exhibited good physical characteristics.
- High water solubility.
- Optimal viscosity (good spray).

Advantages:

- Easy to store, handle, apply.
- Less dusty than others.
- Efficient under stressful environment condition.
- Soil application: no direct contact with other chemicals (no toxicity).

Disadvantages:

- Bulky in nature.
- High transport and storage cost.
- Higher application rates.

4. Encapsulated Formulations:

These formulations encapsulate the living cells of the microorganisms against many environmental stresses and release them to the soil, gradually but in large quantities. The encapsulation of microorganisms into a polymer matrix is still experimental in the field of bacterial-inoculation technology. At present there is no commercial bacterial product using this technology. Alginate is the material most commonly used for encapsulation of microorganisms.

For better contact of micro organisms with carrier material stickers or additives are added.

Stickers: Sticking agents are mainly incorporated to peat to enhance its uniformity of coverage on seed. The adhesives used in current agricultural practices are essentially polymers and include polysaccharides (such as gum arabic or carboxy methyl cellulose), polyalcohol derivatives, or caseinate salts. They should be nontoxic to seed or microorganisms, dispersible in water,

Additives: These are the materials added to the formulations to increase their efficiency in application. The objective is to provide a protective and/or a nutrient source to improve the inoculant quality through a better adhesion to seed, a stabilization of the product, an inactivation of the toxins or an enhancement of the strain survival during storage and after exposure to extreme environmental conditions (high temperature, desiccation) after inoculation and offer a better adhesion and survival to microorganisms on seed. They include macro and micronutrients, carbon or mineral sources, hormones etc. In liquid formulations addition of PEG, Glycerol improves survival of the microorganisms by holding considerable amounts of water, thus protecting cells from desiccation by reducing the drying rate.

4. AGRICULTURE PHYSIOLOGY

Role of Ethylene in Plants during Abiotic Stress

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Introduction

Stress is usually defined as an external factor that exerts a disadvantageous influence on the plant. Under both natural and agricultural conditions, plants are exposed to unfavourable environments that result in some degree of stress. Water deficit, chilling and freezing, heat stress and heat shock, salinity, oxygen deficiency, and air pollution are major stress factors restricting plant growth. Some of the effects of abiotic stress on the physiological growth of the plant are as follows,

Relative water content

The relative water content and leaf water potential as the two major components of water relations in plants, which characterize the water status of plants. The function of the metabolic processes and their rate in plants are mostly related to leaf water status. RWC is considered an important measure of plant water status since it reflects the metabolic activity of the tissues and lethal leaf water stress. Those genotypes that maintained a higher per cent of RWC may be due to a lower transpiration rate. High RWC under moisture stress denotes the ability of plants to drought tolerance.

Leaf gas exchange parameters

The availability of photosynthates decides the sink size and, in turn, crop yield. Photosynthesis is the most susceptible component to high temperature stress. The effect of temperature on photosynthesis and gas exchange in many plants has been studied. The photosynthetic rate increases with temperature until an optimum range, after which an increase in temperature results in a decreased rate of photosynthesis. A variation exists among plant species but, generally, photosynthesis is inhibited at 35° to 40°C. In many crops there is usually an optimum temperature for photosynthesis.

Under field and greenhouse conditions, an increase in temperature usually is accompanied by an increase in VPG (Vapour Pressure Gradient), which may affect transpiration, leaf water potential and stomatal diffusive resistance. Thus, high temperatures may play an important role in the CO_2 fixation rate.

Membrane and organellar damage

Membrane disruption is the first symptom of heat stress and membrane integrity is needed for thermo tolerance. High-temperature stress causes damage to the organelle membranes such as nuclear membrane, endoplasmic reticulum (ER), mitochondrial membrane and chloroplast membrane.

An important harmful effect of different abiotic stresses at the cellular level is the alteration of membrane permeability leading to leakage of ions and other important solutes. Permeability can be assessed by measurement of the rate of leakage of solutes, including ions, amino acids, sugars and pigments from tissues to the medium of measurement of UV-absorbing substances or uptake of ions.

Chlorophyll stability index (CSI)

The first change observed in plants suffering from drought is the wilting of the leaves and gradual fading of colour. When the colour reached some critical point, no longer recovery was possible. A high CSI value means that the stress did not have much effect on chlorophyll content of plants. This leads to increased photosynthetic rate, more dry matter production and higher productivity.

Ethylene

Plant hormones are not only involved in cell division and cell differentiation, but there is also a wealth of information about many other processes, including induced gene expression and biochemical changes. As a consequence of these environmental stresses, plants typically synthesize increased levels of the phytohormone ethylene and are often unable to grow and proliferate to any great extent, at least until the

stress is removed and the ethylene level is lowered.

The increase in ethylene under stress is of adaptive significance as it helps plants to cope with stress by reducing water loss through increased senescence of fruits/leaves and reduced growth. The magnitude of ethylene increase under stress depends upon growth stage, stress intensity, and stress duration and higher stress levels tend to reduce ethylene concentration.

Drought

ET has been implicated in both stomatal opening and closure. ET inhibits ABA-induced stomatal closure, and the ET overproducing mutant eto1 closes its stomata slower than wild type plants during drought stress. On the other hand, ET promotes stomatal closure by promoting NADPH oxidase-mediated ROS production in stomatal guard cells. ET-mediated production of antioxidant flavanols, which accumulate in guard cells under stress conditions The increase in ethylene in response to stress is depicted primarily by an increased synthesis of ACC.

Salinity

Salt stress positively influences ethylene biosynthesis, which helps in promoting salt tolerance by enhancing Na/K homeostasis. Ethylene overproducing (eto1) mutant under salinity exhibits reduced root Na influx and low root Stelar and xylem-sap Na concentrations, leading to restricted root-to-shoot delivery of Na+, along with high xylem-sap K+ concentrations. It alters salt tolerance by interfering with other hormone pathways and NO signalling. It also stimulates H+-ATPase activity to modulate ion homeostasis and salt tolerance.

Cod stress

Cold stress alters ethylene levels in plants and the enhanced ethylene level contributes to cold tolerance However, tolerance responses of ethylene are variable and species-dependent (High-temperature stress (35/25^{o}C) in capsicum increased abscission of reproductive organs, which is due to an increase in ethylene concentration by accumulation in ACC and induction in ACC-oxidase activity in flower buds and flowers reported that in vitro-grown Arabidopsis seedlings treated with the ACC and mutant overproducing ethylene, eto1, show reduced freezing tolerance, in contrast to increased freezing tolerance by aminoethoxy vinyl glycine (AVG), an ACC biosynthesis inhibitor.

Flooding

Ethylene is also considered important plant's adaptation to flooding. Under flooding, the lack of oxygen in flooded roots triggers the ACC synthesis, which upon transportation upward in the plants gets oxidized to ethylene to cause nastic movements of the leaves and promote aerenchyma formation. The biochemical mechanism that provokes ethylene biosynthesis under stress is still not clearly understood, and some reports also show variations in ethylene responses. Greater availability of methionine as a result of the increased rate of protein breakdown under stress which leads to elevated ethylene levels. The increased production of free radicals under water stress facilitates the greater conversion of ACC to ethylene.

Heavy metals

Plants exposed to toxic levels of heavy metals show several macroscopic consequences such as reduced growth (of both roots and above grounds parts), leaf chlorosis and necrosis, loss of turgor, and a decreased seed germination rate cell and plant death. In addition, independent of the varying amounts of heavy metal mobilization and accumulation, the presence of heavy metals raises plant ethylene levels, leading to subsequent inhibition of root elongation and a stress/senescence response.

Conclusion

Importantly, the effects of plant hormones on abiotic stress path-way are intimately linked through secondary signals such as Ca^{2+} and ROS. ET regulate various developmental and physiological processes that may be associated with abiotic stress tolerance. Inherent ethylene production is necessary for the establishment of salt acclimation, and ethylene signalling is indispensable for plant self-adjustment in rapid response to salinity stress and better adaptation to the stress condition.

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5. PLANT PATHOLOGY

Mycotoxins in Agricultural Commodities and Their Management

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Introduction

A toxin can be defined as a microbial metabolite excreted (exotoxin) or released by lysed cell (endotoxin) which in very low concentration is directly toxic to cell of the suscept (Singh, 1990). Toxin produced by pathogen is two types, first one is toxins affecting plant health and second one is toxins affecting both plant and human health. Pathotoxin, vivotoxin and phytotoxin are affecting plant health. The word mycotoxin derived from Greek word *mykes* or *mukos* means "fungus" and Latin word *toxicum* means "poison". Some major mycotoxins are Aspergillus toxins, Cleviceps toxins, Fusarium toxins, Penicillum toxins, Alternaria toxins, and Mushroom toxins. Fumonisin B_1 and aflatoxin B_1 found in sorghum, incidence of *A. flavus* was highest in groundnut seeds followed by cotton, sesame and castor. Also the contamination of aflatoxin occurs in coconut and lowest contamination occurs in raisin.

Economic impact of mycotoxin: About 25% of the world's crops are affected by mycotoxins for every year, with annual losses of around 1 billion metric tons of foods and food products. Exports of peanuts from Sub-Sahara African countries have declined by as much as 20% owing to mycotoxins contamination. This clearly poses a serious hurdle to international trade. Due to mycotoxin effect, 90,000 tons imported wheat declared unfit for human consumption in Gujarat (Anon., 1982).

Factor responsible for mycotoxin production: The optimum limits for growth of *A. flavus* and *A. parasiticus* are 82-85% RH and temperature of 30-32°C. Moisture levels of the substrate ranged from 10 to 30% and pH value between 4 to 8. Plant origin substrates are better than animal origin for mycotoxin production. Late harvest or pre mature harvesting of crop, heavy and continuous rain at harvest, mechanical damage at the time of harvesting, threshing and processing of crop, storage stress like storage product contain more than 90% moisture, wet and humid condition during drying, crop presence and rotation, monocultures or planting of closely related crops one after the other will enhance the risk of mycotoxin formation. Crop varieties that are more resistant to fungal foliar diseases reduce fungal infection and thus mycotoxin formation. Ploughing practices harbors harvest residues will reduce spore contamination of the subsequent crop and thus reduce fungal infestation and mycotoxin formation, no tillage systems will enhance the risk.

Management

Cultural method

- **Time of season:** They reported aflatoxin contamination during *kharif* season occur high as compare to *rabi* season in groundnut. Reason behind this is dry weather during *rabi* season and crop taken in irrigation condition, lack of rain at the time of harvesting so, pod wetting not found. They also reported that highest aflatoxin contamination occurs during *kharif* season which is due to low rainfall (297 mm) with two prolonged dry spell during pod development stage in this season.
- **Time of pod removal after uprooting:** Waliyar *et al.* (2010) reported that if delay pod removal after uprooting, aflatoxin contamination is increased immediately while pod removal after uprooting found low in aflatoxin contamination.
- **Resistant cultivar:** Nakrani (2011) studied twenty varieties of groundnut among them, he found lowest aflatoxin content in J-11 variety was 955.79 ppb and moderate level was 1052.84 ppb in TAG-24 variety of groundnut.

Physical method:

Mansur *et al.* (2014) studied effect of gamma irradiation on the reduction of *Fusarium moniliforme* population on corn for 7 weeks at normal and optimal condition with 6 different doses of gamma iiradiation, out of them *F. moniliforme* growth was ND at 30KGy irradiation in both condition and after one week *F.moniliforme* gowth was significantly higher in optimal condition than the normal condition at 1 to 20 KGy gamma irradiation.

Biological method

Reddy *et al.* (2010) reported *Rhodococcus erythropolish*, a bacterial bio agent completely inhibit growth of *A. flavus* and aflatoxin production. Result revealed that one isolate each of *T. viride* (Tv 20), *T. harzianum* (Th 13), *Trichoderma sp.* (T 28) and *P. fluorescens* (Pf 2) provided greater protection to kernel infection by *A flavus* than others.

Chemical method

Benzoic acid, propionic acid, sodium benzoate and formic acid completely inhibit the production of fumonisin B_2 while benzoic acid only found effective for checking production of fumonisin B_1 production. Fungus growth and fumonisins B_1 contamination controlled by propionic acid and formic acid application. Seed treatment of tebuconazole @ 2 g/kg seed and foliar spray of tebuconazole 25.9 EC @ 20 ml 10 L^{-1}, significantly reduced the infection of fumonisins in maize. The concentration of cyprodinil @ 10 µg mL^{-1}, gave 90% inhibition, followed by Fludioxonil @ 10 µg mL^{-1} concentration gave 80-86% inhibition for *A. flavus* mycelium growth.

Decontamination and Detoxification

Cooking of rice on gas significantly reduced aflatoxin contamination as compare to other cooking method. Ozone treatment for mycotoxins degradation in various products in citrus industries results in reduction of 24-98%.

Integrated disease management:

Lowest contamination of aflatoxins in groundnut through summer ploughing, use resistant varieties, gave seed treatment with Diathene M45 @ 3g/kg or carbandezim @ 2g/kg before planting, *Trichoderma viride* @ 2.5 kg/ha mix with 500 kg castor cake / FYM than apply in furrow at the time of sowing, seed drying, *etc* (Basu, 2004). Seed infection, seed colonization, and level of aflatoxin is decreases in integrated management plot, pod yield and haulm yield is increased in integrated management plot (Kumar *et al.*, 2009).

Conclusion:

Mycotoxins are diverse secondary fungal toxic metabolites. Food safety is an important issue in food trade and therefore it has become a prime concern throughout the globe. Mycotoxin can be manage at satisfactory level by integration of all possible methods like cultural practices, resistant cultivars, timely fungicides application, use of bio agents, as well as harvesting at proper stage and drying by appropriate methods. Mycotoxin free agriculture trades requires awareness among cultivators and traders.

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6. AGRICULTURAL ENTOMOLOGY

Magnetic Field: A Future Pest Management Component

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Introduction

The geomagnetic field is an abiotic component, which interacts permanently with living beings and has been present since the emergence of life on Earth. Animals can use the direction of the geomagnetic field vector as a compass during homing or migratory activities. Magnetoreception has been observed in several animals, from insects to mammals. In case of insects, the studies have been concentrated on some bees, especially honeybees, one wasp species, migratory butterflies and ants. The few studies regarding magnetoreception in ants have focused on the relation between the magnetic field direction and spatial orientation. On the other hand, other studies have shown that several species of ants are able to use the geomagnetic field as an orientation cue. Whereas, the studies in relation to the influence of magnetic field over pests and their management are very less. So, this article provides information pertaining to the effect of magnetic field on insects.

There are several physical components of pest management such as temperature, light, humidity and few energies like Radio-frequencies (200 μm -10cm), Infrared radiation (770-200nm), Visible light and UV (380-770nm), and Ionizing radiation (X and γ rays) (0.01Å-100nm) were discussed widely and plenty of research activities carried out. But magnetic field being the major component of earth which is highly important for all life forms on the earth its importance in pest management is unnoticed and cut short which led to put forth this article.

Effect of magnetic field on Insects

- **Migration in monarch butterflies:** Monarch butterflies from across the central and eastern United States and Canada converge yearly on overwintering sites in central Mexico. On clear days the directional orientation of migrating monarchs is guided by the use of a sun compass. Polarized light perception and orientation may also be incorporated into this compass. However, even on completely overcast

days, when the sun's position and related celestial cues are unavailable, monarchs maintain a normal south-westerly orientation. Therefore, in addition to a sun compass, monarchs must have a backup mechanism of orientation such as a magnetic compass that can be used when the sun is hidden.

- Perez *et al.* (1999) tested the butterflies' sensitivity to magnetic fields, a requirement of any magnetic compass orientation, by exposing subjects to a strong magnetic field about 15,000 times the strength of the earth's magnetic field and measured their subsequent flight direction. Which showed that the experimental butterflies were completely disoriented by the magnetic treatment.
- **Alters the behaviour, physiology and stress protein levels on desert locusts:** Locusts are posing a real threat to the Indian farmers. During plague years, desert locusts can cause widespread damage to crops, as they are highly mobile and feed on large quantities of any kind of green vegetation, including crops, pasture, and fodder. A typical swarm can be made up of 150 million locusts per km^2 and fly in the direction of the prevailing wind, up to 150 km in one day. Even a very small, 1-km^2 locust swarm can eat the same amount of food in a day as about 35,000 people. Wyszkowska *et al.* (2016) during their studies on effect of magnetic field on locusts have reported that, the magnetic field negatively influenced the movement of the desert locust.
- **Utilization of magnetic field as pest management:** Magnetism and using magnetic field seem to be promising physical method in pest control (Hussein *et al.* 2014). Recently scientists are showing some focus lights on magnetism and the effect of electro-magnetic waves on the different biological aspects of insects. Hussein *et al.* (2014) during their research over effect of magnetic field on storage pests *i.e.,* eggs of *Sitotroga ceralella*, (Gelechiidae: Lepidoptera), *Trichogramma evanescens* (Trichogramatidae: Hymenoptera), *Spodoptera littoralis* and *Spodoptesa* exigua (Noctuidae: Lepidoptera) showed that, *S. ceralella* eggs were highly affected and most sensitive as the comparison between hatchability percentage in control (without MF) recorded 90%. Which clearly projects that, magnetic field led to disturbance in egg cells components as a result of the high temperature resulted from the magnetic power lines in the magnetic field. Further, Hozayn *et al.* (2016) also reported that, when whaet grains are physically treated from maganetic field that lead to the reduction of storage pests such as rice weevil, *Sitophilus oryzae* (L.) and lesser grain borer, *Rizopertha dominica* F. similarly, Zein and Hussein (2019) also proved that, exposing wheat grains to the maganetic field that lead to the reduction of two stored grain insects, *Tribolium casteneum* adults and *Trogoderma granarium* larvae.

Advantages of magnetic fields

Investigations on the influence of magnetic fields on seeds and plants over many years suggest that they lead to better plant growth and yield than chemical fertilizers and contributed to the improvement of the crop productivity and protection. In addition, there have been developed magnetic technologies in several countries that are ecologically friendly and nonpolluting to the soil and are potentially attractive as being affordable to farmers.

- Magnetic Fields (MFs) at the same time not dangerous to the environment and not expensive than many radiation sources. They have attracted the attention of researchers due to their biological effects.
- Most of the studies about MFs' effects have focused on vertebrates and relatively fewer studies have been done

on insects and their stored-product environment.

- MFs have been shown to affect the orientation, oviposition and development, fecundity and behavior of a wide variety of insects.

Disadvantages of magnetic fields over bees

- Increased motor activity
- Abnormal propalisation
- Reduced weight gain of hive
- Queen loss
- Impaired production of queen cell
- Decreased sealed brood
- Poor winter survival

Conclusion

Each and every organism on the earth is surrounded by earth's magnetic field and it has specific influence on organisms. From this article it is being confirmed that, magnetic fields not only influence an organism towards specific path or orientation but also in its high frequency it may be lethal. There are only fewer studies on importance of magnetic field as pest management component but there is a need to peruse plenty of work.

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7. AGRONOMY

Role of Allelopathy on Weed Management

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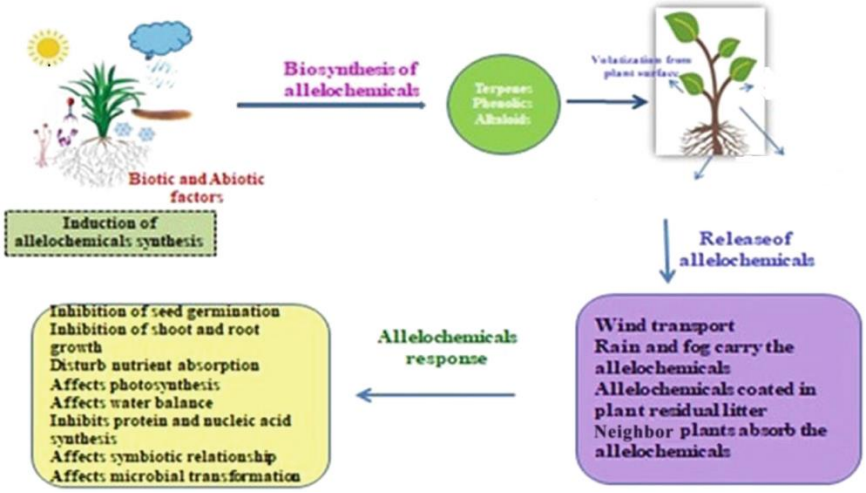
At present weed management plays a major role in crop productivity. It involves cultural, chemical and biological control. Due to labour shortage and increased cost of cultivation, farmers are practicing chemical weed management. But chemical weed management develops herbicide resistant weeds and environment pollution. In this situation eco friendly way of weed management is very much essential.

Allelopathy is any direct or indirect effect by one plant, including micro-organisms, on another through production of chemical compounds that escapes into the environment to influence the growth and development of neighbouring plants. Allelopathy is described as the beneficial and deleterious biochemical interaction between plants and microorganisms. The bio-chemicals that are released by plant parts, which have inhibitory (negative allelopathy) or stimulatory (positive allelopathy), effect on each other (Palanivel *et al*., 2021)



Crop on weeds

Crops	Effect on	**Cause/source**	**Effect**
Coffee	Spiny amaranth (*Amaranthus spinosus*)	1,3,7-trimethylxanthin	Inhibit germination
Maize	Associated weeds	Increased Catalase and Peroxidase activity by root extract	Inhibit growth
Oat, wheat, pea	Lams quarter (*Chenopodium album*)	Root exudates	Suppress growth

Weeds on crop

Weeds	Effect on	Cause/source	Effect
Quack grass (*Agropyron repens*)	Maize, potato	Ethylene produced by the activity of microorganism on rhizomes	Decrease uptake of manures (N, K) followed by yield reduction
Wild oat (*Avena fatua*)	Wheat, barley, oat	Root exudates	Growth of leaves and roots of wheat
Bermuda grass (*Cynodon dactylon*)	Barley	Decayed grass residues	Seed germination, root and op growth
Johnson grass (*Sorghum halepense*)	Sugarcane, maize, soybean	Root exudates and decaying residues	Root and shoot growth

Dahiya *et al.* (2017)

Allelopathic potentiality of crop plant

Crops	Allelochemicals
Rice	Phenolic acids
Wheat	Hydroxamic acids
Black mustard	Allyl isothiocyanate
Oat	Phenolic acids and Scopoletin
Sorghum	Sorgoleone

Advantages

- It act as a natural herbicides and eco friendly nature with affecting the environment
- The selectively allelopathic plant will suppress certain weeds and will not disturb the growth of the main crop with increased crop productivity.
- Using allelochemicals to stimulate the suicidal germination of weed seeds reduces the number of dormant seeds in the soil.

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8. AGRICULTURE

Invasive Insect Pests reported as on now from India

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Introduction

Invasive pests are non-native or exotic organisms that occur outside their natural adapted habitat and dispersal potential. “Alien Invasive Species is one which becomes established in natural or semi natural ecosystems or habitat, and threatens native biological diversity”. International Union for Conservation of Nature and Natural Resources (IUCN). “Globalization” Increased international agricultural trade Movement of seeds and planting materials Risk of exotic pests into new areas Spread of invasive alien species (IAS).

Pathways of invasion

- Introduced as contaminants
- Living industry pathway
- Transportation related

Characteristics of an invasive species

- Very resilient
- Short life cycle
- Broad host range
- High dispersal ability
- Ability to withstand many environmental conditions
- High fecundity
- Voracious feeders
- Benefits from mutualist interaction

Effects of invasive species on ecosystem

- Disrupt natural food web
- Cause habitat loss
- Loss of species diversity

List of invasive pests in India

Year	Invasive Pest Name	Origin	Introduced from
1889	Woolly apple aphid	Eastern North America	China
1911	San Jose scale	Eastern Asia	China
1914	Diamond back moth	Europe	Europe
1915	Lantana bug	Sri Lanka	Sri Lanka or West Indies
1921	Cottony cushion	Australia	Australia

	scale		
1937	Potato tuber moth	Italy	Italy
1970	Pine woolly aphid/ Adalgid	Western and Central Europe	Australia, Europe, New Zealand
1988	Subabul psyllid	Central America & Caribbean islands	Sri Lanka
1990	American serpentine leaf miner	USA	California to Kenya
1990	Coffee berry borer beetle	Northeast Africa	Sri Lanka
1994	Spiralling white fly	Central America	Hawaii
1997	Coconut eriophyid mite	South America	South America
1999	Silver leaf whitefly	Kolar district, Karnataka	Kolar district, Karnataka, INDIA
2004	Cotton mealybug	North America	North America
2005	Lotus Lily midge	China	China
2006	Eucalyptus gall wasp	Australia	Australia
2006	Erythrina gall wasp	East African	Taiwan
2008	Papaya mealybug	Mexico / Central America	Mexico
2012	Banana mealybug	Neotropical region	Neotropical region
2012	Madeira mealybug	Neotropical region	Neotropical region
2014	Tomato Pinworm	South America	South America
2015	Western flower thrips	America	America
2016	Rugose spiralling whitefly	Central America	Central America
2018	Fall armyworm	America	America
2019	Neotropical whitefly	Neotropical region	Neotropical region

Management strategies against invasive insect pests

- There is need to study the biology and ecology of known insect pests and their management.
- Study the ecology and genetic makeup of the invasive insect pest.
- Tracking of geographical distribution of pests.
- Developing cultivars resistant to insect pests.
- Judicious use of insecticides to prevent resistance and resurgence development.
- To identify, conserve and augment natural enemies of invaded insect pests.
- Modify crop management practices.
- Develop suitable integrated pest management programmes.
- Strict phytosanitary regulations to prevent or limit the introduction of risky insect pests.

Conclusion

Globalisation helped to get connected to the neighbours but along there is a huge chance of pest trespass. Not only the globalization that contributed for the invasion of insect pest but also the rapid change of climate also favoured the survival of foreign pests. Managing the pest is not a big task until and unless we know which pest is that. In order manage a invasive pest, the information related to its biology, optimum conditions of its survival and more importantly its natural enemies are needed to be known for which there is a need of international management approach. Moreover, there should be a hierarchical setup recruiting expertise personnel having sound knowledge on insect identification, preliminary risk assessment and monitoring of insects and their eradication. Besides, several public awareness campaigns can be conducted to educate the common people which will definitely reduce the chances of an accidental invasion

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9. PLANT PATHOLOGY

Spiroplasma: An Emerging Threat to Crops

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Introduction

Spiroplasma was identified in 1971. Spiroplasmas are wall-less prokaryotes. Spiroplasma comes under mollicutes. It has a spiral shape. They grow well at 37°C. The impact of Spiroplasma diseases on agriculture is impressive and, at the present day, no effective curative strategy has been developed. Spiroplasmas are pathogens of agriculturally important plants like corn, citrus etc. It infects the phloem of the affected plant, causing fruit deformities.

Characters of Spiroplasma –

- Lack of cell wall.
- Helical
- Surrounded by a triple-layered unit membrane.
- Fried-egg colony morphology.
- They are mostly found in phloem tissues of plants.
- Cell of Phytoplasma are usually resistant to the antibiotics eg. Penicillin, cephaloridine, which act on cell wall, but sensitive to tetracyeline.
- Transmitted by vector like leaf hopper.

Systematic position of mycoplasma

Group	Prokaryotes
Class	Mollicutes
Order	Entomoplasmatales
Family	Spiroplasmataceae
Genera	Spiroplasma

Symptoms of Spiroplasma disease in plant

- Stunting.
- Numerous ear shoot develop
- Numerous tillers may also develop at the leaf axils and base of the plant, giving if a bushy appearance.

- On affected trees, fruits become small, crooked.

Important diseases caused by Spiroplasma

1. Stubborn *disease* in citrus.
2. Pear decline.
3. Corn stunt.
4. Grape Leaf roll.
5. Periwinkle yellow.

Some major plant diseases symptoms

- **Stubborn disease in citrus** – Causing agent *Spiroplasma citri*. The most common symptoms are different shape of fruits, effect on colour of fruits and fruit drop before maturity.

Figure 1

- **Grape Leaf roll** – Leaf tissue between the veins turns deep red to purple, with downward curling or cupping of the leaf margins.

Figure 2

- **Corn stunt -** The most characteristic symptoms of Corn stunt citrus discoloration panicle and twisting and distortion of inflorescence. Leaves – abnormal colours, abnormal forms, necrotic area, yellowed or dead. Witches broom and dwarfing.

Figure 3

- **Pear decline** - The most characteristic symptoms are Poor shoot and spur growth. Also dieback of shoots, premature reddening and upper rolling of leaves. Reduced leaf and fruit size, and premature leaf drop.

Figure 4

Common Management practices for control of spiroplasma caused diseases

- Rouging of infected plants.
- Adjustment of date in sowing.
- Use of pathogen-free bud and grafting materials.
- Remove replants infected with disease and replant with disease-free trees.

Vector controls are effective methods for the containment of spiroplasma-associated diseases. Spraying Monocrotophos, Cypermethrin, and demithoate will be effective for vector control.

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10. SOIL SCIENCE

Tank Silt – A Boon Manure for Farmers

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Organic manure application in soil is a traditional practice followed by farmers from long back to current days. Even though green revolution paves the advancement of chemical fertilizers introduced in cultivation, current generation people are highly concerned on health conscious and the export of organic products also increasing on one hand. Apart from farmyard manure, poultry and sheep manure, green and green leaf manures. application of tank silt appears as one of the best organic manure to the soil by increasing the yield, nutrient status and fertility of the soil by giving enormous benefits. But, fertilizer application, changes in traditional crop raising practices results in fading of applicaton of tank silt. to croplands

Tank Silt

Tank silt is nothing but fine soil present over the tanks and catchment areas. These are surface soils which are brought in to the catchment areas either by the soil erosion or surface runoff water or by leaching resulting in deposition over the tank areas. In general, surface soil was found to be rich in nutrients. As like, the tank silt was found to be rich in organic matter and it helps in maintaining the soil fertility by improving soil physical, chemical and biological properties. Deposition of silt in tank areas was a huge problem as it creates silt pan in the catchments that leads to decrease in water storagecapacity of the tanks, which affects eutrophication and ground water discharge. But in terms of nutrient value, tank silt was highly beneficial to soil.

Age old practice

Application of tank silt was a traditional practice followed by farmers from year old. Farmers from various states such as Karnataka, Andhra Pradesh, Tamil Nadu, Madhya Pradesh etc. are following this practice from long back. During the summer seasons, farmers in Karnataka usually collect the tank silt from the catchments and tanks using bullock carts and applied in their fields. In Tamil Nadu, Southern district farmers are also practicing the same. This collection of tank silt from tanks acts as a desilting practice which helps in restoring of water in the tanks. Hence it is considered as dual benefit as it improves soil fertility as well as tank restoration.

Tank silt collected from tanks through tractor

loads and applied in fields

Advantages and application

As tank silt is silty in nature, it is highly recommended to apply for sandy and sandy loam soils because it aggregates easily.Application of tank silt is suggested mostly for drylands and garden land areas as a fertilizer. Desilting of tanks improve ground water storage and causes increase in ground water table level hence irrigation availability is higher.It also increases the water holding capacity and moisture retention of the soil.Water stable aggregates were higher in numbers in silts than the soil which is beneficial. It is also used for the reclamation of soils.

Tank silt application was done once in two years or three years. While Ploughing before the sowing, the tank silt was applied to the field. For one hectare of an area, 25-50 tractor loads of tank silt was applied by farmers depends upon the availability and further they don't apply any fertilizers to the soil.

Impact on yield and quality

In an experiment with combined application of farmyard manure, Tank silt and recommended dose of fertilizer in soybean crop, it was found that, different levels of application of tank silt results in increased organic carbon, available nutrient status and maximum water holding capacity and moisture content of the soil. The treatment of 100% RDF + Tank silt @ 5 t/ha + FYM @ 2.5 t/ha was found to record higher yield and soil fertility improvement. This finding was similar in case of chilli crop were the same treatment records higher yield in an experiment.

Application of tank silt in paddy experiment suggests that, it increases the extra nitrogen in soil and also forms good aggregate with clays and loams. Comparison studies on fertilizer equivalent and costs incurred for collection and application of tank silt in farmer field found that, the fertilizer equivalent was higher than cost incurred in tank silt procurement and application.

Table 1. Increase in yield of various crops with and without addition of tank silt and the percent increase of yield by tank silt application

Crop	Crop Average yield (quintals per ha)		% Increase
	Without Tank Silt	With Tank Silt	
Groundnut (protective irrigation)	9.0	14.4	60
Ragi (Irrigated)	22	40	82
Ragi (Rainfed)	9	16.2	80
Maize (Irrigated)	30	53	77
Potato (Irrigated)	160	268	90
Tomato hybrid (Irrigated)	400	720	80
Mulberry leaf yield (Irrigated)	16	28	80

Source: Chatrakodihalli 1997

Table 2. Nutrient content of Tank silt

Nutrient (mg kg^{-1})	Content (mg kg^{-1})
Organic carbon (%)	0.4-2.0
Mineral Nitrogen (mg kg^{-1})	200-1400
Available P (mg kg^{-1})	8.0 – 35.2
Available K (mg kg^{-1})	400-600
Available S (mg kg^{-1})	12-50
Available Zn (mg kg^{-1})	0.7-2.2
Available B (mg kg^{-1})	0.3-1.0

Srinivasa rao *et al.*, (2013)

Calculation of Silt requirement

A simple formula is used to calculate the silt requirement in terms of Nitrogen equivalent. Generally, the tank silt was collected in tractor so the recommended amount was calculated in terms of tractor loads. The formula is

$$N = X / 25*Y$$

Where, N is the number of tractor loads required per hectare

X is the nutrient required by the crop

Y is the nutrient content of tank silt in %

The quantity of tank silt required to meet the nutrient equivalent depends upon the nutrient

content of the tank silt. If the tank silt contains higher nitrogen content, then lesser amount of tank silt is enough to meet the nutrient equivalent.

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11. HORTICULTURE

An Underutilized Potential Indigenous Vegetable "*Tupistra nutans*"

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Abstract

Tupistra nutans is an evergreen indigenous herb belonging to family Asparagaceae. Nakima has increased popularity due to its antioxidant rich properties and therapeutic value. The local market demand has been rapidly increased which can boost up farmers income. To commercialize this indigenous vegetable research should be done on collection of germplasm and multiple trials in different regions which helps in avoiding over exploitation. Consumption of Nakima has several health benefits like preventing oxidative stress-related degenerative diseases, lowers blood sugar, blood pressure, constipation, controls diabetes and snake bite. Apart from consumption, it has future scope in pharmaceutical and processing industries.

Introduction

Tupistra nutans locally known as Nakima belongs to the family Asparagaceae (Liliaceae) and found in Sikkim and hilly region of West Bengal i.e., Kalimpong and Darjeeling (Pradheep *et al.*, 2019). It is also found in Eastern part of Nepal, Meghalaya and Arunachal Pradesh (Bhaumik and Gogoi 2008; Tanaka 2010). Nakima is an indigenous perennial vegetable crop which requires cool climate for growth and floral bud development. It is commonly found in steep slopes of forest and mostly confined to moist and shady areas. The common method of propagation is by suckers (Gurung *et al.*,2018). With rise in demand and better price in the market, farmers has started cultivating *Tupsitra nutans* as a sole crop or mixed farming in backyard of household. It is consumed as a cooked vegetable, pickles and soup. Crop is the rich source of antioxidant and gaining popularity due to its medicinal properties. The root powder and floral buds are used by locals as a tonic to ease pain and controlling diabetes. The edible part is purple-green inflorescence with no aroma and blanching removes the bitterness.

Botanical description

Genus *Tupistra* belonging to the family Asparagaceae are distributed in South and South East Asia comprising of 27 species (Tanaka 2010; Roy and Mao 2018). *Tupistra nutans* is a perennial herb having thick rhizomes sometimes tuberous, woody and roots are fleshy (Liang and Tamura, 2000). Nakima grows up to a height of 90cm, 4-6cm leaf width, 1-2m length , peduncle are purplish-greenish ,3-4 times longer than the spike length, concealing anthers, 6-11 flowers are loosely arranged on rachis, perianth lobes

are yellowish/greenish with purple tinge and stigma is purple/white in color. Fruits are single seeded berry, globose in shape and turgid seeds (Kubitzki, 1998). Flowering occurs in the month of September- October and inflorescence are attractive in color and having longer shelf life.

Figure 1: Inflorescence of Tupistra Nutans

Figure 2: Fruits of Tupistra Nutans

Cultivation

Tupistra nutans (Nakima) is a temperate crop which requires partial shade, high rainfall and moist environment. Crop grows well in loamy soil rich in organic matter content with good drainage facilities. Incorporation of inorganic fertilizers or pesticides are not required and grown organically. Suckers and dormant rhizomes are used as a planting material and cultivated as sole crops, mixed farming and intercropping. No incidence of pest and diseases has been recorded so far. The crop requires two years to reach a flowering stage when propagated through suckers. Nakima reach a marketable stage after 10 days from inflorescence emergence. Inflorescence are harvested in the month of September - October and can extends upto November depending upon the cultivation. Bearing stage can extend up to 10-15 years and each year one clump gives a yield of 1-1.5kg (Pradheep *et al.*, 2020).

Figure 3: 4 year old *Tupsitra nutans* grown in backyard of home (Rumtek, East Sikkim)

Figure 4: Inflorescence emerging from a single clump

Figure 5: Harvested inflorescence

Nutritional composition

Tupsitra nutans nutritional composition comprises , 91.5% moisture, minerals (mg/100 g) such as, sodium (3.1) and potassium (292.1), calcium (200.6), 2.1% carbohydrate, 2.4% protein, 2.9% fat, 1.1% ash and nutritive value (kcal/100 g) as 44.0 (Rai *et. al.*, 2005).

On the basis of dry weight Khatoon *et al.* 2018, mentioned significantly higher nutritional content with 41.70% carbohydrate, 0.44% ascorbic acid , 21.32% crude fat ,0.34% crude protein, 6.25% crude fibre and 3.66% ash.

Medicinal uses

Tupsitra nutans is a rich source of secondary metabolites like Polyphenols, Minerals, Vitamins and Flavonoids. Polyphenols like salicylic acid and p-coumaric acid are mostly found in root extract of *Tupistra nutans* which shows defense mechanism against various diseases like cancer, cardiovascular diseases and diabetes (Chung *et al.*, 2019). The essential elements (mg/100g of dry weight) like potassium (561.61), phosphorus (110.88), magnesium(86.82), calcium (11.30) and iron (42.33) are found in extract of flower bud and root wall. The most abundant Vitamin present is Ascorbic acid that protect the cells from the damage caused by free radicals (Onyeike *et al.*, 1995; Lui *et al.*, 2008). Floral bud or inflorescence contains Flavonoid known as Quercetin (Verma and Nath 2016).

It is a good source of natural antioxidant which can be used as a medicinal agent and prevents oxidative stress related degenerative diseases (Chhetri *et al.*, 2020). Traditionally, the root brew of *Tupistra nutans* is consumed to control urinary infection, food poisoning, rheumatism pain and bowel movement (Lepcha *et al.*, 2019).

Commercial opportunities

Tupsitra nutans is a crucial part of Himalayan traditional cuisine due to its antioxidant and medicinal properties. Initially Nakima was collected from forest and sell in the market.. Due to its increased demand in the market, farmers have taken up commercial farming and fetch a better price. The cultivation practices are not labor intensive as it does not require intercultural operations and management of pest and diseases. There is no use of inorganic fertilizers during cultivation and regarded as organically grown. In 2004, the cost price of inflorescence was Rs 60/kg (Sudriyal and Sundriyal, 2004) and increased to Rs. 270-380/kg in towns like Kalimpong and Gangtok and other areas Rs. 100-200/kg (Pradheep *et al.*, 2019). Inflorescence are short duration for marketable stage and available from mid September where the market price is the highest and continues up to last week of September. It also has high scope in pharmaceutical companies due to its therapeutic properties.

Conclusion

Tupsitra nutans can be regarded as a future crop due to its high antioxidant and therapeutic value. The market demand is increasing to a great extend even with the high price. This indigenous vegetable is distributed only in few regions of India and still underutilized. To popularize this indigenous vegetable, research should conduct on collection of germplasm ,identification of superior genotypes, conservation, multiplication , standardization of cultivation practices, distribution and post harvest handling .

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12. HORTICULTURE: VEGETABLE SCIENCE

Nano Urea: A Liquid Nitrogen Fertilizer

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Introduction

Nitrogen is one of the major plant nutrients required for plant growth. It is essential for the synthesis of protein, which is the constituent of protoplasm, and chloroplast reported that nitrogen has a positive influence on yield and yield components of rice. The important role of nitrogen fertilizers in increasing rice yield has been widely recognized particularly after the development of modern varieties. The efficiency of applied nitrogen use by the rice plant is also low. Farmers of the country usually do not apply nitrogen in their fields properly and timely. It is estimated that only about 25% of the added nitrogen is recovered by the crops and the rest 75% is lost due to leaching, surface runoff, NH_3 volatilization, denitrification, and other processes.

The Nano Urea Liquid has been found effective and efficient for plant nutrition which increases the production with improved nutritional quality. It will also have a huge positive impact on the quality of underground water, a very significant reduction in global warming with an impact on climate change and sustainable development. The Nano Urea Liquid has been developed to replace conventional Urea and it can curtail its requirement by at least 50 percent. It contains 40,000 ppm of Nitrogen in a 500 ml bottle which is equivalent to the impact of nitrogen nutrients provided by one bag of conventional Urea. The Nano Urea has been priced at ₹240 per 500 ml bottle for the farmers which are 10 percent cheaper than the cost of a bag of conventional Urea. However, while

conventional urea is effective just for 30-50 percent in delivering nitrogen to plants, the effectiveness of the nano urea liquid is over 80 percent. A major reason for this increase in efficiency is the fact that nanotechnology, which is the base of this new form of urea, enables designing ultra-small particles that offer higher surface-mass ratios, and help in the controlled delivery of plant nutrients. The size of one nano urea liquid particle is 30 nano meters and compared to the conventional granular urea it has about 10,000 times more surface area to volume size. Due to the ultra-small size and surface properties, the nano urea liquid gets absorbed by plants more effectively when sprayed on their leaves. Furthermore, aside from improving yield, soil health, and nutritional quality of the crop, nano urea has also been tested for biosafety and toxicity according to norms followed in India and the international guidelines developed by OECD, which are adopted and accepted globally.

Characteristics of Nano Urea

1. It contains 4.0 % total nitrogen (w/v) evenly dispersed in water.
2. Nano nitrogen particles size varies from 20-50 nm.

Benefits

1. It effectively fulfills crop nitrogen requirement, increases leaf photosynthesis, root biomass, effective tillers and branches,
2. Enhances Farmer's income by an increase in crop productivity and reduction in input cost.
3. Because of higher efficiency, it can reduce the requirement of conventional Urea by 50 % or more.
4. Farmers can easily store or handle one bottle (500 ml) of Nano Urea
5. It helps conserve soil, air, and water quality.

Application Rate, Time, and Methods

1. Mix 2-4 ml of Nano urea in one liter of water and spray on crop leaves at active growth stages.
2. For best results apply two foliar sprays: -
   a. 1st spray at active tillering / branching stage (30-35 Days after Germination or 20-25 Days after Transplanting)
   b. 2nd spray 20-25 days after 1st spray or before flowering in the crop.

Application Instructions

1. Shake well the bottle before use
2. Use a flat fan or cut nozzles for spraying on the leaves.
3. Spray during morning or evening hours avoiding dew.
4. If rain occurs within 12 hours of the spray of Nano urea, it is advised to repeat the spray.
5. Nano Urea can easily be mixed with bio-stimulants, 100 % water-soluble fertilizers, and agrochemicals.
6. It is always advised to go for a jar test before mixing and spraying for compatibility.
7. For better results, Nano urea should be used within 2 years from the date of its manufacturing.

Safety & Precautions

1. Nano urea is safe for the user; safe for flora and fauna and is non-toxic, however, it is recommended to use a face mask and gloves while spraying on the crop.
2. Store in a dry place avoiding high temperature and keeping away from the reach of children and pets.

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13. HORTICULTURE

Green Leafy Vegetables: Towards Nutritional Security of India

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Introduction

Malnutrition is defined as "a state where adequate nutrients are not delivered to the cells for its optimal functioning."

- About 46.6 million children in India are suffering from stunting and 51 per cent women of reproductive age are suffering from anaemia in India (National Family Health Survey, 2015-16).
- Leafy vegetables are also called pot herbs, greens, vegetable greens, leafy greens or salad greens are the plant leaves eaten as a vegetable.
- Leafy vegetables are rich sources of vitamins, minerals and fibers.
- They have multipurpose uses like some are used as spices, condiment and also for medicinal purpose.
- The Indian Council of Medical Research (ICMR) recommended a daily intake of 125g of leafy vegetables in the human diet.

Special features of leafy vegetables

- Quick growing
- Short duration
- Grown throughout the year
- Cheapest source of minerals and vitamins
- Having medicinal properties
- Can be grown even in partial shady places
- Best suited in kitchen garden
- Best suited as intercrop
- Per unit area yield is high
- Usually harvested in multiple cuttings

Important leafy vegetables

Drumstick

It is known as Miracle tree as it is small and fast growth habit, providing high nutrients along with many health benefits. It's known to increase milk production and also helps in treating anaemia which are common in lactating women. Leaves can be used in the diet of the obese. It contains Anti-cancerous agents like glucosinolates which helps in preventing the cancer. (Berkovich, 2013).Moringa powder can be used as a substitute for protein and iron tablets.

Amaranthus

The word Amaranths is basically derived from the Greek word "Anthos" which means everlasting or unwilting.An high genetic diversity of about 400 *spp*. are distributed throughout the world, and among 20 species are found cultivated/wild in India .It acts as Blood purification, Excellent source for reducing vitaminas deficiency and it is popularly used as multi mineral provider (Shukla *et al*., 2006)

Spinach

Spinach has a high nutritional value and is extremely rich in antioxidants, especially when fresh and even after steamed or quickly boiled.Its rich in many minerals like magnesium, calcium, phosphorus, iron and zinc. It contains different carotenoids like lutein and ß-carotene, and also contains high amount of vitamins like A, C and K. It has various biological activities like virus inhibitor and reducing risk of breast cancer Its use prevents from some of diseases like osteoporosis, and anaemia.Its consumption reported in reducing Antidiabetic effects and Anti-inflammatory activity (Patricia *et al*., 2014)

Curry leaf

Its green leaves, dried leaf powder, and essential leaf oil are used for flavoring soups, curries and also in food preparations, such as dal, sambar, and chutney.The leaves provides major nutrients like N, P, K and S along with protein

Leaves also provide an excellent source of micro nutrients like calcium, iron, and phosphorus.Health benefits of curry leaves namely Nephroprotective, Hypoglycemic effects, Antimicrobial activity, Anti obese activity, Antipyretic activity and Anti-inflammatory.

Anti-nutritional Factors in Green Leafy Vegetables

- This are the undesirable chemical substance present in both cultivated and wild plant species. These anti-nutrients are also referred to as "Allelochemicals"
- Commonly found anti-nutrients in leafy vegetables are, Nitrate, Oxalates, Phytates, Cyanogenic glycosides.

Effect of anti-nutritional factors on human health

- Nitrate concentration in leafy vegetables is found higher than other groups of vegetables such as root and fruits vegetables
- The presence of nitrates in infants' causes very serious disease called methemo globinemia or 'blue baby syndrome' leading to suffocation and death
- Oxalic acid in combination with its salts or minerals form oxalates.
- The insoluble calcium oxalate in the crystal form is stored in the kidney causing serious health-related problem called kidney stone
- Phytic acid is a natural substance that acts as a major storage of phosphorus in all leafy vegetables
- It has negative impact on the activity of digestive enzymes and act through chelation of mineral cofactors or interaction with protein
- Cyanogenic glycosides are derivatives of amino acids, and a group of secondary metabolites present plant species

Methods to reduce anti-nutrients

- Heat treatment is the most effective method to reduce the anti-nutrition factors present in green leafy vegetables
- Cooking and blanching helps in the removal of anti-nutrients through rupturing the plant cell wall followed by leaching out of soluble compounds into the blanching medium.
- Phytic acid and oxalic acid can be effectively reduced by cooking and blanching methods whereas oxalic acid content was reduced by both blanching and cooking

Constraints in India for growing leafy vegetable

- Lack of awareness about health benefits of leafy vegetables among people
- Presence of anti-nutritional factors makes them non-preference vegetables
- Lack of availability of suitable varieties which are low in anti-nutritional factor and high yielder
- Very less crop improvement work has been done on this vegetables
- Lack of standardization of cultivation and post-harvest management practices
- Poor transportation
- Absence of storage facility

Conclusion

Growing human population making us to depend on major crops like cereals and pulses which lead to increasing malnutrition and various health problems among the people. Diversification of food and utilization of Leafy vegetables in daily diet is the best way to achieve the nutritional security.

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Fig 1: Drumstick leaves and pods


fig.2: Leafy type of Amaranthus Spp.


Fig.3: Spinach leaves


Fig.4 Curry leaves

14. SOIL SCIENCE

Millets: a way to overcome agricultural and nutritional challenges

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The world is faced with agronomic and dietary issues. We need to focus on dry lands to enhance grain output because agricultural fields with irrigation systems have been fully exploited. The use of arid soils to produce sufficient quality crops is difficult due to low

fertility. Millets, as climate-resilient crops, outperform other grains such as wheat and rice in terms of growth circumstances and nutritional value. Vitamins, minerals, vital fatty acids, phytochemicals, and antioxidants are all found in these nutri-cereals, which can assist to eliminate a variety of nutritional deficiency disorders. Millets can help to maintain dry lands productive and ensure food and nutritional security in the future.

Millets, a popular superfood, recently got their Cinderella moment. Nirmala Sitharaman, India's Finance Minister, announced 2022-23 to be the "International Year of Millets" in her Union Budget speech. "Support will be provided for post-harvest value addition, increased domestic consumption, and millet product branding both nationally and internationally," she stated. Earlier this year, the country declared 2018 the 'National Year of Millets,' with the goal of increasing production of the nutrient-dense crop.

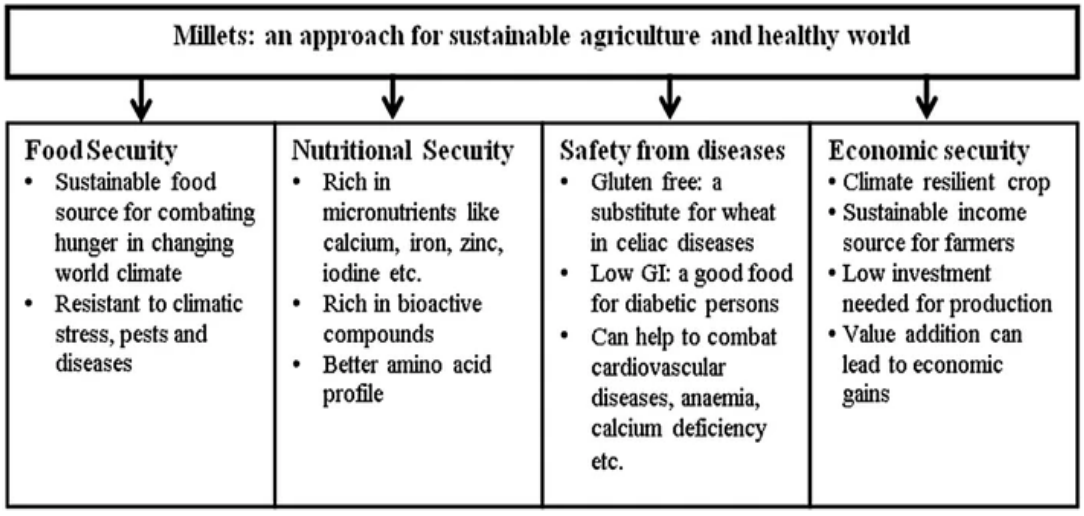
Millets are a fantastic source of nutrients. Traditional and rural societies across the country, as well as agricultural specialists in the Indian government's upper echelons, have long recognised this. However, it took 70 years for free India to recognise millets as "Nutri-Cereals" in 2018, which was also designated as "The Year of Millets" on a national level.

"Millets can help confront health difficulties including as obesity, diabetes, and lifestyle disorders because they are gluten-free, have a low glycemic index, and are high in dietary fibre and antioxidants," according to a note prepared by the Union Agriculture Ministry. "Millets are nutritionally superior than wheat and rice because of their higher quantities of protein with a more balanced amino acid profile, crude fibre, and minerals including iron, zinc, and phosphorus," the paper continues (Eduru *et.al*., 2021)

The millet revolution is gradually gaining traction, with products like millet crackers, chaklis, and even cookies being added to the menus of all new-age health cafés and healthy FMCG products. Millets come in a variety of shapes and sizes. "Some of the types are pearl millet (bajra), sorghum millet (jowar), buckwheat (kuttu), amaranth (rajgira), finger millet (nachni /ragi), foxtail millet (kangni), tiny millet (samai), kodo millet (kodon), barnyard millet (sanwa), and proso millet (chena) are some of the types.

Millets available in a variety of varieties, each with its own set of health benefits, and it's becoming fashionable to cook with them. “Millets are one of the earliest foods known to mankind. They are quickly replacing rice and refined flour, and you may be as creative as you want with them”.

Benefits of millets in a nutshell



(Kumar et.al., 2018)

Food as Status Symbol

While the government currently faces delays, private enterprises are successfully selling millets. At posh food stores, not only whole millets and millet flour, but also ready-to-eat foods manufactured from them, are in high demand, which many consider "abnormal." "At first, I was startled to see foreigners and high-profile Indians asking for stuff made from desi things like ragi and jhangora, which I thought were very coarse. According to Senior Scientist at the Indian Council of Agriculture Research (ICAR), Indian Agriculture Research Institute, Delhi, Dr. R S Bana, the young population of traditional and tribal societies has an “inferiority complex” about millets and need to be educated about their nutritional value. They perceive rice and wheat as superior foods, he says, an observation that is endorsed by researchers. However, the scene has changed over the last decade.

Popular Dishes

Barnyard Millet flour is frequently used in south India to prepare local dishes such as idli and dosa. It is blended with milk and sugar/jaggery to manufacture madirakikheer, a sweet delicacy, and with buttermilk to make paleu in the north, particularly in Uttarakhand. In many parts of India, mixed millets khichdi is popular, and millet cookies, puffs, flakes, and laddus are popular items in high-end organic food stores across the country. Millets in general, and Barnyard Millet in particular, have a high nutritional value, according to research.

"The nutritive value of Barnyard Millet is superior to that of other major and minor millets," according to a 2019 research paper by V. G. Ranganathan and others of the Tamil Nadu Agriculture University, Madurai, titled "Barnyard Millet for Food and Nutritional Security: Current Status and Future Research," published in Frontiers in Genetic Nutrigenomics on June 23, 2020. Calcium, protein, magnesium, lipids, vitamins, and several important amino acids are all abundant in it."

According to the study, Barnyard Millet has a carbohydrate content of 51.5 to 62.9 grammes per 100 grammes, which is lower than other millets; its fibre content, which ranges from 8.1 to 16.3 percent, is higher than any other cereal; and its protein content, which ranges from 11.2 to 12.7 percent, is higher than other millets and cereals. "The high carbohydrate-to-crude-fiber ratio ensures a slower release of sugar in the blood, assisting in blood sugar control."

The agriculture ministry advocated including millets in the Public Distribution System (PDS) to provide nutritional support because of their nutritious worth, but the proposal did not catch on. Only Karnataka, Odisha, and Uttarakhand have included millets in their PDS, owing to the millets' short shelf life and lack of storage facilities. Millets have not been included in mid-day meal schemes, which are one of the most significant places for the government's millets plan to be implemented, for the same reasons.

Conclusions

Millets survive in extreme environments such as drought, and some wild kinds may even grow in flooded places and swampy regions. These have a low glycaemic index, contain gluten-free protein, and are high in minerals, B vitamins, and antioxidants (calcium, iron, copper, magnesium). These exceptional characteristics make them nutrient-dense and climate-resilient crops. These can be used not only as a source of income for farmers, but also to improve the overall health of the community. Scientific interventions can overcome existing restrictions, such as the existence of anti-nutritional components and low sensory acceptance of millet-based products. Processing procedures like as heating, roasting, germination, and fermentation can inactivate anti-nutritional elements.

Mixing millet flours with other high-acceptance flours and making composite foods can improve the sensory acceptability of millet-based goods. Farmers will be encouraged to plant millets as a result of the usage of millets in commercial/packaged foods, which will provide new opportunities and revive the farmers. Incorporating millet-based foods into international, national, and state-level feeding programmers will aid in the alleviation of protein, calcium, and iron deficits in underdeveloped countries.

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15. HORTICULTURE

Hydroponics

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Hydroponics

Hydroponics is a type of horticulture and a subset of hydroculture which involves growing plants without soil, by using mineral nutrient solutions in an aqueous solvent. Hydroponics is simply the growing of plants without soil. In hydroponics, plants are grown in an inert medium such as rocks or coco coir fiber, and they are fed a solution containing a perfected mix of primary, secondary and micro-nutrients. Almost any kind of plant can be grown hydroponically, including veggies, herbs, fruits and flowers.

Growing medias:

The growing medias are used to provide a substrate that anchors the plants and assists in delivering water, nutrient, and oxygen to the plant roots. As soil is not used in these systems, medias role become very important for crop growth. Some medias used are: Rockwool, Glasswool, Styrofoam sheets, coir pith, Peat, Sawdust, Perlite, Vermiculite and Coarse Sand.

Quality of nutrient solution:

Libia *et al.,* (2012) compiled data about quality of nutrient solution and the fertilizers to supply nutrients. Temperature has a direct relationship to the amount of oxygen consumed by the plant and reverse relationship with dissolved oxygen from the nutrient solution. (Table 1)

Table 1: Solubility of oxygen in pure water at various temperatures at 760 mm Hg of atmospheric pressure

Temperature, ^{o}C	Oxygen solubility, mg L^{-1} of pure water
10	11.29
15	10.08
20	9.09
25	8.26
30	7.56
35	6.95
40	6.41
45	5.93

Table 2: Concentration level (mg l^{-1}) of various solutions according to different authors

Nutrient	Hoagland & Arnon (1938)	Hewitt (1966)	Cooper (1979)	Steiner (1984)
N	210	168	200-236	168
P	31	41	60	31
K	234	156	300	273
Ca	160	160	170-185	180
Mg	34	36	50	48
S	64	48	68	336
Fe	2.5	2.8	12	2-4
Cu	0.02	0.064	0.1	0.02
Zn	0.05	0.065	0.1	0.11
Mn	0.5	0.54	2.0	0.62
B	0.5	0.54	0.3	0.44
Mo	0.01	0.04	0.2	Not considered

Fertilizers: Calcium nitrate, potassium nitrate, magnesium nitrate, ammonium nitrate, monopotassium phosphate, monoammonium phosphate, potassium sulphate, magnesium sulphate, ammonium sulphate and potassium chloride

Crop suitable: Lettuce, tomatoes,

strawberry, spinach, cucumbers, basil, coloured peppers, radish, chives, celery, chard, potatoes, carrot etc.

Types of hydroponics:

1. **Nutrient film technique (NFT):** The nutrient film technique is recirculated design to run highly oxygenated dissolved nutrients continuously over the roots of plants through a set of channels, typically grown in baskets hanging in a PVC pipe. The solution is pumped from a holding tank, through irrigators at the top of every sloping pipe and the run-off from the bottom of the channels is returned to the tank. Thus, the nutrient solution is continuously recycled
2. **Water culture or deep water culture (DWC):** It is the straight forward form of hydroponics systems. Plants are floating by float platform on a bath of hydroponic nutrient solution. Oxygen is supplied by an air pump that runs continuously. The most convenient plants in this system are lettuce, strawberries, and herbs grow particularly well in this system.
3. **Wick system:** The wick system is the simplest of all types of hydroponic systems. However, the wick is the connecting part between the potted plant and food solution in the existing reservoir. Because it doesn't need electricity to work, it's also quite useful in places where electricity can't be uses, or is unreliable.
4. **Drip system:** Drip hydroponic system is at least two containers, one on top or higher than the other. Plants are located in the top container, while the nutrient solution is in the bottom container. The nutrient solution is pumped up to drips located by the stem of each plant with a water pump, and an aquarium air stone is used to oxygenate the water. The nutrients filter down to the plant roots and are passed back to the bottom container. Plants with large root balls are particularly suited to drip systems.
5. **Ebb and flow systems:** Ebb and flow system is another inexpensive type of hydroponic setup. The setup is very similar to the drip system. An overflow pipe determines the height of the nutrients, typically to where the roots begin, with excess liquid being recirculated through the overflow pipe back to the bottom container. With ebb and flow system, the pump is switched on and off intermittently (perhaps 30 mins on, 15 mins off). When the pump is switched off, all the nutrients are siphoned out of the grow tray via the pump line. The emptying period allows for oxygen to reach the roots, and for this reason an air stone is not absolutely required.

Conclusion

The hydroponics is the single word which depicts the use of water in cultivation of crops. It plays an important role, when we think of area, resource, need and management between these. The hydroponics also become important for creating an atmosphere for cultivation of exotic ones. The need of these is extending with improvement of these methods in different aspects and fields. This article provides the knowledge about this innovative technology.

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16. CROP PROTECTION

Laser Technology: Its Application in Crop Protection

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Introduction

Agriculture in the 21st century is facing many challenges which include demand for food, scarcity of water, climate change and loss of cultivable land to urbanization (Harnadez *et al.,* 2010). Use of chemicals pesticides and herbicides caused an adverse impact on the environment by resurgence of the crop pest. Therefore, introducing a novel, non- chemical techniques to the crop protection is highly desired (Krawiec *et al.,* 2018).

It is known that light comes from a source as a result of radiations coming out from the billions of atoms present in the source. The radiations coming out of these atoms differ in phase, in direction of emission and in the state of polarizations. There are some devices which are coherent in phase but also in direction of emission and state of polarization. Such device is known as Laser.

A laser is an amplifier of light. When the laser is suitably excited by optical or electrical energy, the light of proper frequency entering the laser cavity is amplified in a such a manner that laser output wave is in a phase without input(.

Types of Laser:

Laser technology has been developed very rapidly since 1960 there are many types of Laser which includes: 1) Solid laser (Ruby laser) 2) Gas laser 3) Semi conductor laser 4) Gas dynamic laser 5) Dye laser 6) Excrime laser 7) Free electron laser 8) Colour centre laser and 9)Chemical laser.

The basic features of solid state (ruby) and gas laser are detailed as under:

1. Ruby laser: In 1960, T.H.Maiman demonstrated first laser by using ruby crystals. Rubiu is made of aluminium (Saphire) AL2O3 with a small percentage of Cr+3 (0.05) replacing Al+3. This is done by adding small amounts of Cr2O3 in the melt of highly purified AL2O3. The chromium ions imparts pink colour to the ruby. The chromium ions are responsible for the emission of light by ruby.
2. Helium- Neon gas laser: The active medium in He-Ne gas laser in a mixture of 5 parts helium to each part of neon at a pressure of about 3 torr. The mixture is contained in quartz tube. The one end of the tube is perfect reflector while the other end is partial reflector.
3. He- Ne laser is electrically pumped continuously usually with D.C. power supply. He-Ne laser is a typical examples of gas laser because of the facts that it can oscillate at three wavelengths.

Advantages of Gas laser over ruby laser:

1. In gas laser the light produced as a continuous beam rather than in ultra short pulses as in ruby laser.
2. In this case crystal and other imperfections in the solid which lead to slight beam divergence and slight spread of wavelengths are avoided.

Application of Laser in Crop protection:

Uses in biological process:

- Lasers are use in the studies of photosynthesis, phototaxis, vision and light activated bacteria.
- Laser spectroscopic are used to study the structures of many biological systems.
- A biological system is disturbed from equilibrium by means of light pulses, and the subsequent recovery of the system is followed by laser spectroscopy.
- Laser irridations has shown a promising in overcoming hard seedness which

limits germination of almost all members of legume family.

Uses in entomological studies:

- The biological studies of the laser exposure were studied on adults of stored products pest i.e., *Tribolium confusum, T. castaneum, Sitophilus zeamais, Prastiphanus truncates* and *Oryzephilus surinamensis* with or without their rearing medium consisting of maize grains or maize or wheat flour.
- The exposure resulted in the shortening of life span, slight immobility, anorexia and degradation followed by changes in behaviour, melanisation and sclerotization.
- The exposure also led to changes in the duration of development, partial sterilization and reduction in the size of F1 generation which were found sterile.
- The nutritive value and germinability of the exposed grain remains unaffected.

Use in plant pathological studies:

- Laser technology has shown promising effect in tracking viruliferous aphids in following the movement of the pathogens in the atmosphere.
- The elimination or inactivation of pathogens including viruses in their early stages, from valuable genetic stock, through the action of laser, requires judicious selection of the type of laser, intensity of radiation, exposure time and other factors for differential interaction with host tissue and pathogen tissue.

Conclusion

It is concluded from the above discussion that laser based techniques have a great potential to offer non destructive solutions for many problems. Laser based techniques have shown a great promising effect in all the stages of crop protection. Research is needed to be done for introducing low cost automated systems for field applications. Awareness about laser technology should be given to the farmers.

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