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1. SEED SCIENCE AND TECHNOLOGY

Organic Seed Certification

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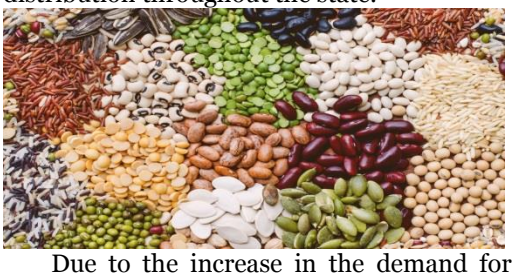
Introduction

Organic seed certification is a legally sanctioned label denoting the product have all the organic production standards and issued by a certification body or authority. APEDA, Agricultural and Processed food products Exports Development Authority, developed in the year 2002, regulates organic certification under NPOP (National Programme for Organic Production) standards of the produce, recognized by all European countries and Switzerland. Even though organic seed certification and production were initiated in 2002, established in Tamil Nadu in the year 2007. TNOCD, Tamil Nadu Organic Certification Department regulates and provides certification based on the NPOP standards under APEDA, New Delhi under the ministry of commerce and industry. TNOCD play a major role in training the volunteers about organic production standards both organic certifications nationally and in Tamil Nadu. They ensure quality seed production and distribution throughout the state.



Due to the increase in the demand for organic produces, organic certification of seeds is getting more important. Organic seeds undergo double certification, by seed certification offer an organic certification and monitoring team. Certification ensures the quality of the seeds, as it provides written assurance of the produce under NPOP standards.

Requirements for organic certification:

- Avoidance of chemical inputs like fertilizers, pesticides, weedicides etc.... and genetically modified organisms
- Use of farmland under conversion period
- Maintaining buffer zone, the physical barriers between organic and inorganic field
- Continuous inspection of the field

Cultural practices for organic seed production:

1. Land requirement: land should be maintained organically, avoiding contamination by any means by maintaining buffer zones of at least 3 meters distance or live fences. Use of proper sanitized implements and equipment to ensure organic balance.
2. Conservation period: The period between organic management and organic certification, a minimum of 3 years required. Helps in the conversion of conventional land into organic land. Have to maintain a proper register of cultivation practices.
3. Seeds and planting materials: Either from organic certified sources or the seeds from conventional farming which are untreated. Genetically engineered seeds, transgenic seeds or pollen should not be used.
4. Soil conditioning or fertilizing: Use of biodegradable substances which maintains soil fertility and biological activities. Nutrient content of soil can be increased by legumes crops, green manures or any deep-rooted crops. Materials prepared inside the field (farmyard and poultry manure), produced outside the field (Epson salt, clay), microbial preparations (biofertilizers) are permitted for usage.

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5. Pest management: Removal of disease vectors, or disease vectors. Use of crops and varieties which are resistant to the pest and diseases prevailing in the location. Development and introduction of natural enemies of the pest, non-synthetic control measures like traps, repellents.
6. Weed management: This can be done by using mulches, livestock grazing, hand weeding and mechanical cultivation. Improved plastic and synthetic mulches to remove plant weeds.

Organic seed certification procedures in Tamil Nadu:

When a producer is producing seeds under NPOP standards and TNCOD standards for organic seed certification, he/she is willing to allow inspections in all the stages required including all the production and handling operations, areas, offices etc., by an organic seed certification officer and other officials from TNOCD and APEDA. These seeds can be certified as organic seeds.

Application for certification

An application should contain details of the producer, reason for application, information relating to the standards maintained. The registration fee, one-time inspection fee, one time travel cost should be paid by the producer with the application form to TNCOD. The standards specified in NPOP should be maintained.

Scheduling inspection

The initial inspection is done to inspect the field and the equipment's to be used for the production. Inspections are to be conducted in the presence of the producer. The number of inspections to be followed will be fixed based on the initial inspection and risk factors examined.

Granting of certificate

TNCOD issues the certificates like scope certificate, transaction certificate and product certificate to the eligible producers, who followed all the standards of NPOP and TNOCD based on the certification committee.

Denial of certification

When there are deviations from TNOCD standards, the producer will be initiated with the reason of denial. When a producer receives a notice of denial of certification, he/she can apply for recertification or go for an appeal to the appeal committee.

Recertification

The producer can renew the registration and submit the new report for the production and operations. Producers should submit a new certification with the notification of non-conformities issued by the previous certifier. The report should also contain the preventive measure taken to maintain the TNOCD standards. TNOCD again verifies all the facts and measures.

Appeal to the appeal committee

Producers who received the notice of denial of certification can appeal to the appeal committee headed by Director, TNCOD. It should be done in 30 days of notice, and the final certification decision will be taken by the committee.

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2. AGRICULTURAL SCIENCE

Immunization, Types or Resistance, Cross Protection or Pre-Immunization

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Cross Protection

Cross protection or pre-immunization is a phenomenon in which plant tissues infected with one strain (mild or avirulent) of the pathogen are protected from infection by other strains (severe) of the related species of pathogen. This has been reported mostly in viral, bacterial and fungal disease.

1. Virus Diseases

Mckinney (1929) was the first to report this phenomenon in Tobacco Mosaic Virus (TMV). He defined cross protection as a phenomenon in which plants systemically infected with one strain of a virus are protected from infection by second related strain of the same virus. This method is followed for the control of papaya ringsport virus (PRV), tomato mosaic virus, citrus tristeza virus (CTV), apple mosaic virus, cocoa swollen shoot, TMV in chilli, CMV in chilli and soybean mosaic virus.

The criteria to adopt cross protection technique in crop diseases are as follows.

1. The disease should be endemic and impossible to eradicate.
2. It should spread rapidly.
3. The loss by the disease should be very high.

In Tamil Nadu, Quick decline caused by citrus tristeza virus (CTV) is reported to be severe in acid lime gardens. This virus is transmitted by black citrus aphid (*Toxoptera citricidus*). The occurrence of both mild and severe strains has been reported. So, it is possible to inoculate the mile strain to the young acid lime seedlings to confer protection against the severe virulent strain. From 1976, over one lakh seedlings have been cross protected without any breakdown. In Karnataka, two mild strains, M1 and M2 are utilized effectively for this purpose.

Symptoms of Severe Strain

The infected trees do not show seasonal new flushes or growth. The leaves show chlorosis along the main and lateral veins with a number of vein flecks. Defoliation occurs from tip downwards and exhibit die-back symptoms and the twigs remain barren. Sudden death occurs within few months after infection. Some trees may produce sparse foliage and few smaller fruits of inferior quality. The severe strain also produces stem pitting symptoms. This is characterized by small, long depressions or groove/cavities in the wood of the branches and trunk. This is noticed after removing the bark. Plant dies when the disease is in advanced stage.

Symptoms of Mild Strain

On the leaves, only few flecks appear. On stem, less number of pits with smaller size develop. The affected tress survive for more than 30 years with chlorotic leaves, but their productivity is considerably reduced. These trees are used as a source of mild strains.

Pre-Immunization Technique

Acid lime seedlings are pre-immunized with mild strains of citurs tristeza virus by patch budding to protect the trees from severe virulent strains. The methodology for the same is as follows:

1. Select mild isolates, choosing symptomless trees in declining orchards and evaluate the isolate by vector transmission.
2. For inoculating the mild strains, 4 to 5 months old vigorously growing acid lime seedlings are selected for grafting.
3. Collect scion materials (rectangular bark piece of 5 x 2 mm size) from the trees with mild strains virus.
4. The scions collected are stored in cool box to prevent desiccation. The scions are then grafted on the seedlings within 36 h after collection.
5. In the acid lime seedlings to be cross protected a bark piece of 5 x 2 mm size is

removed and the bark piece of same size collected from mild strain infected tree is inserted and covered with a polythene strip.

6. The grafted seedlings are left undisturbed but watered at regular intervals for 15 days.
7. If the union remains green it indicates the successful establishment of the grafting. This observation confirms the entry of mild strain of the virus into the plant system. Such seedlings confer appreciable resistance against a virulent strain.
8. The resistance due to pre-immunization may be due to the fact that the mild strain occupies the whole plant system and prevents subsequent infection by the severe strain.

Mechanism of Cross Protection

- Utilization of essential metabolites required by the second virus by the mild strain.
- Production of protective substances similar to antibodies in animals.
- Virus specific multiplication sites in the cells are limited. If all are occupied by the first virus for its multiplication, the later virus can not have place.
- Aggregates of virus in cells already infected with a virus have specific adsorptive properties. An incoming related strain of a virus becomes absorbed in one of the aggregates already present.

Advantages

In the absence of resistant varieties, adoption of this technique is fairly an accepted method, because the cross protected trees give reasonably higher yields without affecting the quality of produce.

Limitations

The limitations are

- Protection may not be complete in certain situations. Super infection by severe strains in epidemic area causes breakdown of cross protection.
- The mild strain applied to one crop may spread and cause severe symptoms on other crops.
- Sometimes both severe strain and mild strain may multiply simultaneously often expressing severe symptoms, e.g., Tomato mosaic virus.
- Synergistic reaction may also occur when the cross protected plant is infected by unrelated virus, which leads to severe disease, e.g., PVX and PVY.
- The mild strain may mutate to severe form and damage the crop, e.g., TMV
- The cost of inoculating mild strains to annual crops is very high. Hence, this is not economical to annual crops.
- If tolerant varieties are available for a particular disease, this method is not economical.

3. AGRICULTURAL SCIENCES

Management of Papaya Stem Rot / Foot Rot

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Phytophthora blight has also been called soft foot rot, stem canker, soft fruit rot, and root rot. The pathogen, *Phytophthora palmivora* (E. J. Butler) E. J. Butler, was named in 1919. It was once classified as a fungus, but now *it is regarded as a pseudofungus in the stramenopiles. Several strains of P.* palmivora have been described due to considerable morphological and pathogenic variation in the species. The host Papaya is just one of many plants affected by this.

The host Papaya is just one of many plants affected by this pathogen worldwide. Other hosts include breadfruit (Artocarpus altilis), palms including the coconut (*Cocos nucifera*), Catteleya orchids, English ivy (Hedera helix), and cocoa (*Cacao sp*.). The disease occurs on papaya in the Philippines, Sri Lanka, Santo Domingo, India,

Indonesia, Malaysia, Hawai'i, Mauritius, Mexico, Australia, Brazil, Spain, Taiwan, and perhaps elsewhere. Symptoms on papaya Young fruits. Water-soaked lesions exude milky latex. Fruits may eventually mummify and fall. Mature fruits. Fruit rot initially appears as small, circular, water-soaked lesions about 3/16–3/8 inch (5–10 mm) in diameter. Large lesions, often forming first where the rangia. Fruits can rot, turn soft, and fall prematurely. Stems and foliage. The top portion of the fruit-bearing region of the stem is susceptible to infection during rainy periods. This can cause stem cankers to appear.

The infected plant may become more susceptible to wind damage. Older portions of stems are susceptible when wet after extended rainfall, or after injury. As lesions enlarge, infected areas of the stems way weaken, causing stem damage or breaking. Foliage on affected stems may collapse. Roots. Lateral roots of young plants (less than 3 months old) are most susceptible in poorly drained soils. Roots may become dark and rotten, causing stunting of plant growth and yellow, collapsed leaves. Severely infected plants may die. Plants with a heavy load of fruit may topple. Papaya plants with rotten roots are susceptible to drought stress. Morphology and life cycle of *P. palmivora* The most important developmental factor in *P. palmivora* is its ability to produce zoosporangia on diseased plant tissue when free water is present. The organism produces hyphae, zoosporangia containing zoospores, chlamydospores, and oospores. Two separate mating types (called A1 and A2) are required for the production of oospores. Oospores do not play a significant role in the disease cycle because the chance of both mating types occurring together naturally is low. Zoospores are motile and infective after their release from the zoosporangia. Chlamydospores are the principal long-term survival structures in soils. Chlamydospores may germinate in water to produce sporangia and release zoospores, which may be transported by wind-blown or splashing rain to susceptible plant tissues. Chlamydospores formed in fallen fruit can survive in soils and infect roots of papaya seedlings in subsequent plantings. The minimum temperature for growth of *P. palmivora* in culture is 52°F (11°C). The optimum temperature is 81.5–86°F (27.5–30°C), and the maximum growth temperature is near 95°F (35°C). Propagules of this pathogen are dispersed principally by wind-blown rain, splashing rain, slugs, ants, knives, clippers, rodents, soil, or plant growth media.

Pythium aphanidermatum **Symptoms:**

- Water soaked spot in the stem at the ground level which enlarge and griddle the stem.
- The diseased area turns brown or black and rot.
- Terminal leaves turn yellow droop off.
- The entire plant topples over and dies.

Favourable conditions

- The pathogen inhabits the soil. It is capable of growing and surviving on plant resides, but attacks living plants in the presence of a favourable host.
- Waterlogging is very conducive to disease development.

Management

- The disease can be avoided if plants are grown in well-drained soil.
- Affected plants should be carefully dug up and destroyed by burning.
- Replanting should not be done in the same pit where disease has once appeared.
- When trees are weeded, care should be taken so that no injury is caused to the base of the stem.
- Seed treatment with Thiram or Captan 4 g/kg of seed.

- Drenching with Copper oxychloride 2.5g/lit of water or Bordeaux mixture 1% or Metalaxyl 1g/lit of water.
- Control incipient rots (less than 24 hours old) of harvested fruit by dipping fruits in hot water held at 120°F (48°C) for 20 minutes.
- Avoid damage or injury to papaya stems during cultivation.
- Control African snails; they can vector the pathogen.

4. ENTOMOLOGY

Combating Mosquitoes in Green Way

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Introduction

Mosquitoes are one the deadliest insect in the world. Their ability to carry and spread diseases to human's cause millions of deaths every year (WHO, 2005). Several mosquito species belonging to the genera *Anopheles*, *Culex* and *Aedes* acts as vectors of many pathogenic organisms causing diseases like Malaria, Filariasis, Japanese Encephalitis, Dengue fever, yellow fever etc. A total of 404 species under 50 genera have been recorded in India (Tyagi *et al*., 2015). Every year, about 300–500 million people of the world are estimated to be affected by malaria, and this dreadful disease threatens about 2.4 billion of the world's population with a death rate of about 1.1–2.7 million (WHO, 2005).

Vector control strategies have traditionally focused on killing mosquitoes using a variety of insecticides. As insecticide resistance is now widespread in a number of mosquito species, there is a growing need for safe novel, cheap, and reliable mosquito control strategies (Benelli, 2015). The evolution of insecticide resistance in mosquitoes is threatening the effectiveness and sustainability of malaria control programs in various parts of the world. Biological methods provide promising alternatives to chemical control. They include natural organisms that kill mosquitoes, plant-based insecticides, releasing mosquitoes that are either sterile or unable to transmit disease as well as creating protective barriers against them.

Taxonomic position of mosquito: Kingdom-Animalia, Phylum-Arthropoda, Class-Insecta, Order-Diptera, Superfamily-Culicoidea, Family-Culicidae, Genera- *Anopheles*, *Aedes*, *Culex*, *Mansonia etc*...

Biology and life cycle

Life cycle is temperature-dependent from 1 to 20 days. There are four distinct stages in its life cycle: Egg: 2-3 days, larva: 8-9 days, pupa: 1-2 days, and adult 10 days. Adult is active and terrestrial, while larvae and pupae are aquatic and occur only in water.

Green Methods to Combat Mosquitoes

Biological Methods	
Role of pathogens	
i) Entomopathogenic bacteria	*Bacillus thuringiensis* (Bt) *Bacillus sphaericus* *Wolbachia*
ii) Entomopathogenic fungi	*bassiana* *Metarhizium anisopliae* *Lagenidium* Oomycetes (Watermolds) *Pythium* *Coelomomyces* *Conidiobolus*
Role of predators in mosquito control.	
Dipteran predators	*Toxorhynchites* spp. known as the "elephant mosquito" or "mosquito eater", is a large, cosmopolitan genus of mosquitoes that does not consume blood (Rawlins *et al*., 1991).
Coleopteran predators	Families Dytiscidae and Hydrophilidae have received attention as mosquito larvae predators. *Laccophilus, Agabus* and *Rhantus* were reported as

	potential biological control agents of mosquitoes (Aditya *et al.*, 2006).
Hemipteran predators	Belostomatidae, Nepidae and Notonectidae are the most important families of predaceous Hemipteran bugs.
Odonatan predators	Odonata larvae are voracious and important predators of mosquito larvae in freshwater ecosystems.
Larvivorous fishes	*Gambusia* and *Poecilia* (Poeciliidae) have been introduced in more than 60 countries for mosquito control purposes.
Frogs and toads	Tadpoles, with various life-history characteristics, actively prey upon the eggs of *Ae. aegypti.*
Crustacean predators	*Cyclops vernalis*, *Megacyclops formosanus*, have been reported as active predators of mosquito young instars (Marten *et al.*, 1989).
Role of botanical insecticides in mosquito control	
Lantana (*Lantanacamara* L.)	Lantana oil and crude extract are used as natural fumigants against many insects and mosquitoes.
Marigold (*Tagetes patula* Linn.)	The chemical constituents of *Tagetes* are β-karyophyllene, terpenes, hydrocarbons, alcohols, ethers, aldehydes, ketones, esters, carotenoids, flavonoids and thiophenes. They have insect repellent, antiseptic, diuretic, blood purifier and also cancer treatments.
Periwinkle (*Catharanthus roseus* L.)	Its leaves constitute two secondary metabolites viz. vincristine and vinblastine that has shown larvicidal activity against *culex* spp.
Agnimantha (***Clerodendrum phlomidis***)	*C. phlomidis* contains secondary metabolites like tannins, alkaloids, polyphenols, terpenoids, and essential oils etc.... that has shown larvicidal activity against mosquitoes.
Botanical formulations used for mosquito control	Neo-Innova® isa repellent that has a prolonged action. "NEO-PART®" (Prolonged Action Release Technology) is a formulation with 40% Citriodiol®. ME 750: *Smyrnium olusatrum* has isofuranodiene and essential oils with larvicidal activity.
Physical Methods	
Mosquito net	These nets are considered as more protective than coils and other repellents because their use does not cause any health problem.
Mosquito traps	These traps copy the various mosquito attractants such as body heat and exhaled carbon dioxide. They are powered by electricity so their use is safe.
Mechanical Methods	
Electric mosquito zipper	This device works by using the ultraviolet light and then killing of mosquito occurs when mosquito interact with the lethal charge of electric charge.
Mosquito Magnet	Its principle based on copying of mammal's properties such as giving off heat, moisture and carbon dioxide. When mosquito comes close to the device it drew in and suddenly dies.

Conclusion

Eco-friendly strategies for mosquito-control are needed to reduce the prolonged application of insecticides that is currently used as the primary method for mosquito control. Safe and sustainable methods using bioagents, predators, insect sterile techniques, physical and mechanical

methods should be developed to target various mosquitos' species in such a way that it is available to common man. Need based production of biocontrol formultaions in the form of tablets, capsules, icy granules etc. should be popularized.

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5. SOIL SCIENCE

Remediation of Heavy Metal Contaminated Sites by Green Technologies: Special Reference to Sustainable Remediation in Soil

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Introduction

Soil is non-renewable sources and nowadays the anthropogenic activities like manuring, fertiliser application and industrial waste leads to heavy metal contamination in soil as well the whole ecosystem in an earth.

Metals that have the specific density of > 5 g cm^{-3} are classified as heavy metals and specifically, Lead (Pb), Chromium (Cr), Arsenic (As), Zinc (Zn), Cadmium (Cd), Copper (Cu), Mercury (Hg) And Nickel (Ni) may be harmful to human as well Soil - Plant - Animal - Human continuum.

In America, Hg has used for mining of Gold and Ar in Wood Preservatives and tetraethyl lead remains a common additive to petrol and it may be emitted in to the environment while natural and anthropogenic activities. Also, soil reserve as a major source of heavy metal and it's not undergo a microbial chemical degradation like organic contaminants to carbon (IV) oxide hence metal persist in soil for long run.

Remediate the contaminated sites by using various available techniques like, immobilization, soil washing and phytoremediation. In developing countries like India, have the thickly populated and scares of funds to restore and reclaim the contaminated sites, low cost with ecologically sustainable remedial options are also be there for reducing the risk and enhance the soil health, environment sustainability, agricultural production and food security.

To overcome that, green and sustainable remediation strategies might have used for sustainable restoration of soil and human health. Techniques employed for remediation by Green and sustainable remediates are as follows;

1. Amendment for green remediation
   a. Biochar
   b. Industrial waste byproducts
   c. Natural Mines
   d. Metal Oxides
   e. Nano material from green synthesis method
2. Resource recovery strategies
   a. Phytomining

b. Soil Washing
3. Nature Based solutions
   a. Bioremediation (Microbes)
   b. Phytoremediation (Plants)
   c. Immobilization
   d. Stabilization
4. Energy Efficient Strategies
   a. Low-temperature thermal desorption
   b. Bio-electro kinetic remediation

Sustainable Remediation in Soil:

Remediation by using Amendments

Biochar (amorphous & high surface area), fused with nano particles leads to increases its potential for metal sorption. The principle of metal removal mechanism includes such as physical adsorption, ion exchange, surface complexion, co-precipitation (oxidation, reduction & surface precipitation), electrostatics attraction, donor acceptor interaction involved in soil. The advantages of using biochar is easy to fabricate (pyrolysis) from plant biomass and wood wastes, instead the charred products have polycyclic hydrocarbons that has polluted to the soil. Sustainability concerns, the application of modified biochar sequester the carbon in soil and the sorbed heavy metals where fixed in sorption sites by clay metal complexes.

Remediation by using Plants and microbes

Plants are widely used to extract, stabilize or volatilize the toxic metals in soil and the metallophytes could accumulation of metals in their tissues, which reflect the concentration in solid liquid interface in soil phase. In this method, proper handling has needed for various purpose such as bio-energy production, animal feeding and soil fertility improvement after harvesting. Familiar plants such as **castor, alfalfa, sunflower, corn, date palms, certain mustards; even willow and poplar trees** can be used to reclaim contaminated soil – a cheap, clean and sustainable process

Microbes such as bacterias like ureolytic bacteria could induce the Calcite precipitate, which favors the metals co- precipitate with $CaCO_3$ by $PbCO_3$, $CdCO_3$ and $CuCO_3$.this results the oxidation and reduction of toxic metalloids decreasing their toxicity (Mahbub et al, 2016).

Remediation by Resource Recovery Approach

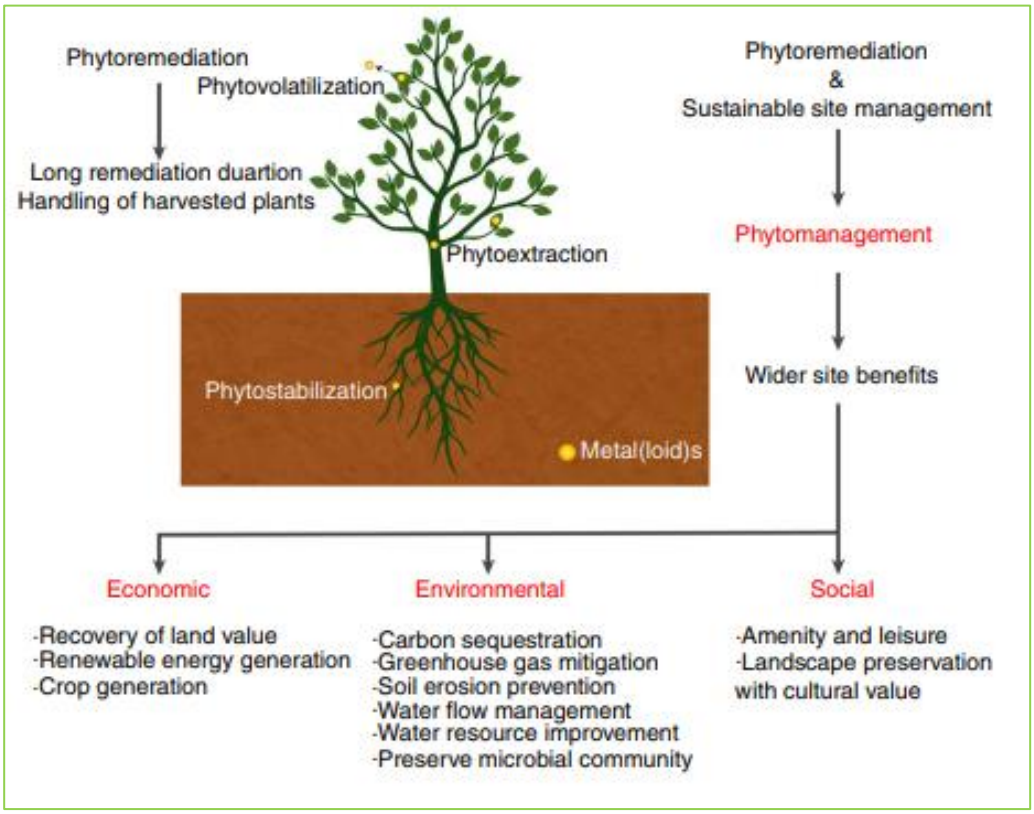
Phytomining can be used the plant covers to reduce the migration of pollutants from wind or percolation to water. Targeted metals are such as Ni, Ti, Co, Ag and Au instead the economic point of view Au, Ag, Pb and Pt are suitable for photo mining.

Soil washing is also a technique to wash the heavy metals thoroughly and rapidly from the soil by two process (dissolving or suspending and by concentrating them into smaller volume of soil through particle size distribution, gravity separation and attracting scrubbing) and the extractants such as strong acids and chelates are contaminant to soil.

Remediation by Energy Efficient Strategies

Low Temperature Thermal Desorption, the targeted metals is Hg and the soil treated at low temperature are used for agriculture because in low temperature desorption of metals from sorption site is low.

Bio- Electro Kinetic Remediation, all metals can removed by enhancing agents (citric acid, NaCl & EDTA) and properly sequestered but this technology has not commercialized because of problems like waste of current and short circuiting (Wang et al, 2020).



Conclusion

In the view to sustainable remediation strategies, phytoremediation, soil washing are being commercialize. Integration of green technologies like phytoremediation, microbial oxidation and reduction, energy efficient techniques such as low temperature thermal desorption and Bio- electro kinetic remediation which are employed for extract, stabilize and detoxification of metals in contaminated sites.

"BE THE SOLUTION TO SOIL POLLUTION"

Reference

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6. SEED SCIENCE AND TECHNOLOGY

Use of Liquid Waste (Human urine) as a Fertilizers Source for Aerobic Rice Cultivation

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In order to grow plants that supply our food, fertilizers containing nitrogen, phosphorus, potassium and other additional elements are needed. Today, chemical fertilizers account for the largest share of these nutrients but, at the present rate of use, the available resources will be rapidly depleted. Use of human excreta as fertilizer has been implemented only to a limited extent. Rather, they have been flushed out into the rivers, resulting in pollution of the aquatic bodies. These resources have also been polluted with pathogenic microorganisms to the extent that many large rivers have become virus infected more or less permanently. It is thus better to create a closed system, with no pollution from bacteria or viruses, where human fertilizers are harvested and used to feed the following year's crops. Nutrients are removed from fields with the harvested crops; in sustainable agriculture, therefore, the amount of nutrients removed from a field should be returned to it .Today, there is mainly an out flow of nutrients from farms to society. For a sustainable society, it is necessary to recycle these excreta back to the farm.

One of the best options in the present day context is to utilize human urine as a liquid fertilizer and cow urine to meet part of the nutrient requirement of crops in an integrated way. Based on a modest calculation it is estimated that even if 30 per cent of the urine produced by the Indian population is properly collected and used, approximately 7.8 million tonnes of nutrients (NPK) are recycled and this can help to narrow down the gap between the nutrient demand and supply.

The use of cow urine as a fertilizer has been understood and documented well. But to recommended human urine for direct application the protocol of dosage, timing, extend of dilution, schedule of application and crop suitability were not worked out till now. Early workers have documented clearly the high nutrient content of anthropogenic liquid waste (human urine) range of nitrogen percentage. In this background the research problem was identified to assess the potentiality of using human urine and cow urine directly for aerobic cultivation and its impact on crop growth

Methodology

I. Characterization of human and cattle urine

Human urine samples was collected from the different diet and age group person from boys hostel, University of Agricultural Sciences, GKVK at Bangalore and local area of Gauri Bindur , Bangalore. Care was taken for drawing the sample from pilot site. The samples were placed in sterilized white cans and subjected to analysis for its nutrients status as per standard procedures

Plate 1. Collection of Human urine samples and stored for characterization

Usually, human urine is treated with disgust. But lab tests conducted so far reveal that it contains no toxins. On the contrary, it is rich in nutrients such as nitrogen in large quantity, phosphorus and potassium in medium quantities, secondary nutrients in suffient range and micronutrients in small quantity. Hence it is considered as a liquid fertilizer (Table 1). In addition to nutrient elements it also has lots of sodium and sugar and may also have some plant growth promoting substances in small quantities.

Nutrient composition of urine and FYM used in experiment.

The nutrient composition of urine of differs from country to country and is basically based on diet. The composition of cow urine and FYM may also vary. Hence these were analysed. The

nutrient composition of human urine and cattle urine used for experiment are as below

Table 1. Initial nutrient content of Human urine, cow urine and FYM used for experiment

Sources	N (%)	P_2O_5 (%)	K_2O (%)
Human urine	0.3	0.12	0.08
Cow urine	0.2	0.08	0.11
FYM	1.6	1.40	1.84

The nitrogen and phosphorus content of human urine was slightly higher than that of cow urine while FYM was found to have much higher N, P and K than urine sample.

Research on use of urine as a liquid fertilizer for Aerobic rice cultivation

Crop Details

The details of crops, varieties, plot size, date of planting and harvest and the quantity of fertilizers, human urine and cattle urine are given in Table 2.

Table 2 : Crop details

Crops	Variety/ hybrid	Spacing (cm)	Plot size (m)	**DOS /DOP**	**DOH**	**RDF/Ha**	**HU (l/ha)**	**CU/ (l/ha)**
Aerobic rice	IR20	30x30	3.6x2.5	31/7/10	25/12/10	100:50:50	33,333	50,000

Grain and Straw yield

The results of grain yield and straw yield obtained are described in the following pages. The data on grain yield as influenced by various treatments of paddy is presented in Table 3.

Table 3. Effect of human urine, cattle urine, fertilizers and FYM on grain yield and straw yield (t ha^{-1}) of Aerobic rice

Treatments	Grain yield (t/ha)	Straw yield (t/ha)
T_1 Rec. N -Human urine (HU) @ 40% basal + 60 % in 3 splits without gypsum	2.60	4.31
T_2- Rec. N -Human urine (HU) @ 40% basal + 60 % in 3 splits with gypsum	2.63	4.35
T_3- Rec. N -Cow urine (CU) @ 40% basal + 60 % in 3 splits without gypsum	1.88	3.11
T_4- Rec. N -Cow urine (CU) @ 40% basal + 60 % in 3 splits with gypsum	1.92	3.18
T_5- 40% Rec. N through FYM basal+ 60% through human urine	2.74	3.52
T_6- 40% Rec. N through Chemical fertilizers basal + 60% through human urine	1.40	2.32
T_7- 40% Rec. N through FYM basal+ 60% through Cow urine	1.35	2.24
T_8- 40% Rec. N through CF basal + 60% through Cow urine	1.30	2.15
T_9- Absolute control	1.12	1.79
T_{10}- RDF	2.58	4.28
SEm ±	0.01	0.02
CD(P =0.05)	0.04	0.06

The different treatments tried in this experiment significantly influenced the Aerobic rice yield (Table 3). The aerobic rice yield (2.74 t ha^{-1}) was recorded in T_5 treatment which received 40% recommended dose of N through FYM as basal+ 60% through human urine, while the treatment which received 40% recommended dose of N through FYM as basal+ 60% through cow urine recorded (1.35 ha^{-1}). But all these treatments were significantly superior over absolute control. Similar trend of results was observed in straw yield. The treatment differences are clearly depicted in Plate 2.

Figure 1 Absolute control and Figure 2 Recommended dose of fertilizers

Figure 3 Human urine + gypsum and Figure 4 FYM + Human urine

Plate 2: Effect of human urine on Aerobic rice

Conclusion

From the research work conducted so far it can be concluded that human urine can be used as a liquid fertilizer and can be a supplement to fertilizers.

7. PLANT PATHOLOGY

Potato Fusarium Wilt Disease and Management

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Introduction

Potato (*Solanum tuberosum* L.) is the most important vegetable and known as 'poor man''s friend'. Globally, potato (Solanum tuberosum L.) is the fourth most important food crop after maize (Zea mays L.), rice (Oryza sativa L.), and wheat (Triticum aesitvum L.), and is the top non-grain food commodity (Bradshaw and Ramsay, 2009; Fiers *et al*., 2012).

Potato is affected by many diseases like fungal, bacterial, viral, and also parasitic nematode. In potato 16% losses in yield due to microbial diseases and out of this 70-80% due to fungal affects. Major fungal diseases in potato are late blight (*Phytophthora infestans*), early blight (*Alternaria solani*), *Fusarium* wilt of potato (*Fusarium oxysporum*), powdery mildew (*Erysiphe cichoracearum*) and *Curvularia* disease**.** In all Poatato wilt also one of the major disease in potato which responsible for yield reduction in India.

To control potato diseases many management strategies are use include applications of fungicides to potato tubers prior to storage and at planting, in-furrow applications of fungicides (Al-Mughrabi et al., 2007; Kirk et al., 2013), and the development of machinery for potato handling and storage (Finckh, 2008).

To control *Fusarium* wilt of potato many management practices are used like Cultural, biological, Use of resistant varieties and Chemical.

Symptoms

Fusarium wilt appeared as yellowing of the leaves, following by wilting, rolling or curling, sometimes affecting leaves on only one side of the plant. It typically begin on the lower part of the plant, eventually moving up the stem. The potatoes themselves may be blemished or decayed, often with sunken brown areas, especially at the stem end. Also plant growth stunted and developing of yellow leaves seeing in plant by Garibaldi *et al*. (2002).

Symptoms like Yellowing on one side of the plant or leaf. Yellowing begins with older, bottom leaves, followed by wilting, browning, and defoliation. Growth id typically stunted, and little or no tuber development. Brown, vascular tissue can be found when the infected stem is cut at its base. Infected plants often die before maturing.

Potato Wilt

Probable management strategies

Cultural management

- **Deep ploughing –** Deep ploughing very important cultural management practice for control of Fusarium wilt.

- **Remove infected plants from field –** Removal of infected plants will help limit the diseases spread. Soil sterilization or fumigation will eliminate wilt fungi from the soil.
- **Avoid over-application of high nitrogen fertilizers –** High soil nitrogen levels accompanied by low potassium levels can increase susceptibility to the pathogen.

Use of resistant variety

Saturna, Kufri Chandramukhi, Kufri pukhraj etc. Application of resistant variety is one of the most important management practices for manage of Fusarium wilt disease of potato crop.

Biological Management

For management of Fusarium wilt many Bio-control agents use but most imporatant bio-control agent is *Trichoderma harzianum* 10g/kg of tuber.

Trichoderma spp. was well-known biological agents that have significant antagonistic activity against several plant pathogenic fungi. *T. harzianum* used as a promising biological control agent against *Fusarium* spp. that cause diseases in various vegetables and crops reported by Meena et al. (2017).

Also *Trichoderma viride* is a biocontrol agent that has proven to control this disease in an environmentally firndly manner. It can also manage Fusarium wilt in cucumber, tomato, and various other crops.

Chemical management

There is no chemical control measure that completely eliminates a Fusarium infection, but some can stop an infection for up to a few by using various fungicides like prothioconazolen etc. Systemic and soil fungicides can also be used (Booth 1971).

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8. AGRICULTURE

Applications of Remote Sensing in Weed Management

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Introduction

Weed management is the application of certain principles and suitable methods that will improve the vigor and uniform stand of the crop and at the same time discourages the invasion and growth of weeds. It encompasses all the aspects of prevention, eradication and control by regulated use, restricting invasion, suppression of growth, prevention of seed production and complete destruction. Advanced weed management systems rely on an accurate detection of weeds and reliable discrimination between weeds and crop plants. Spatial distribution, severity of the infestation or herbicide resistance degree are considered key parameters for characterizing a weed infestation scenario. Remote sensing plays a key role in providing both accurate spatial and temporal information. The latest advances in remote sensing using very high resolution satellites are allowing the characterization and diagnosis of plant conditions based on reflectance data through visible, multispectral or hyperspectral sensing. Some of the applications of remote sensing in weed management are:

Site specific weed management

Site specific weed management is a method to limit the application of herbicides only to areas with weeds in precision farming. Site specific weed management has the potential to reduce herbicide use by 40-60 per cent. Accurate mapping of weeds is a pre requisite for SSWM. However, the use of satellite imagery for weed detection at the early stages of weed growth is limited by the lack of spatial and spectral resolution of the satellite sensors to detect small plants. Unmanned aerial vehicles (UAVs) or drones are an alternative means of collecting high spatial and temporal resolution Visible (VIS) and Near Infra-Red (NIR) imagery. Ground based hyper spectral remote sensing techniques can also be used for discriminating weeds and crop plants and to generate weed maps. Such weed maps provides information about the location and density of individual weeds and patches of weeds in the crop. Variable Rate Technology (VRT) uses these weed maps for site specific herbicide application.

Weed management in inaccessible areas

In inaccessible areas like forests, remote sensing is the only method for identification and spread of invasive weeds in forest that threaten the forest species diversity.

Detection of crop susceptibility to herbicides

Herbicides are intended to kill the weeds without harming the crop plants. However, few herbicides will affect the crop plants and causes crop injury. Ground based hyper spectral remote sensing techniques were developed for detection of crop injury from herbicides. Handheld hyper spectral radiometer is a portable and effective device for rapid, early detection of herbicide injury of crops. The spectral reflectance of the crop varies with the concentration of herbicide applied and the reflectance of herbicide treated plants is higher in visible region compared to control. NDVI values can be calculated and the percent reduction in NDVI indicates the degree of crop injury or susceptibility.

Monitoring of weed control practices

When weed control practices are taken under large farm holdings, it becomes difficult to assess the weed control efficiency of the whole farm manually. To know the efficiency of herbicide once applied to a field, imagery captured by sensors can be used. The images taken at respective intervals after herbicide application shows the reduction in weed cover by differential spectral reflectance and if at all there is no reduction in weed cover in a particular weed patch they were examined for herbicide

resistance.

Automated weeders (Robotic weeders)

Automated weed control, including weed detection and removal, has gained significant popularity in the community of precision farming over recent years, due to its great potential to improve the weeding efficiency while reducing the environmental and economic costs. Many robotic weed control systems have been proposed with focusing primarily on single tactics *i.e.*, selective chemical spraying, mechanical weeding and flaming. However, robotic weed control system with multiple weeding tools named integrated weed management system has also been developed aiming at maximizing the weed control efficiency and success rate using a combination of tactics. Such robotic weeders are capable of performing either chemical control with a precise spot spraying of herbicide or mechanical control with a stamper tool destroying the weeds. All the smart weeding machines (weeding robots) rely on the performance of the machine vision system to detect weeds. However, the environmental uncertainties, including illumination condition and color variance of leaves or soil, affect the performance of the machine vision system. Some of the automatic robots that are available in the market are: **Tertill (**solar powered weeding robot for home gardens**),** RIPPA (Robot for Intelligent Perception and Precision Application), Hortibot, SwagBot**,** ASTERIX, AgBot II, Blue River LettuceBot2 and EcoRobotix (fully autonomous and programmable via a smart phone).

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9. AGRONOMY

Vermicompost Preparation from Plant Debris by Using Earthworms

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Introduction

The increase in population causes an increase in the quantity and type of urban and rural wastes. Such wastes are undesirable pollutants to the environment and time could even be a health menace. As far as rural wastes are concerned, there are enormous quantities of organic materials that are not utilized. "Vermicomposting technology" is a fast growing one with its pollution free, cost effective and efficient nature. Since 2,350 years ago Aristotle was reported, vermiculture is basically the science of breeding and raising earthworms. It defines the thrilling potential for waste reduction, fertilizer production, as well as an assortment of possible uses for the future.[1]

Vermicomposting is the process of producing organic fertilizer or the vermicompost from bio-degradable materials with earthworms.

Benefits

- Composting with worms avoids the needless disposal of vegetative food wastes and enjoys the benefits of high quality compost.
- The earthworm is one of nature's pinnacle "soil scientists." Earthworms are liberated and cost effective farm relief.
- The worms are accountable for a variety of elements including turning common soil into superior quality.
- They break down organic matter and when they eat, they leave behind castings that are an exceptionally valuable type of fertilizer.[5]
- In recent years, *Julka* and *Smith* were reported earthworms have been identified as one of the major tools to process the biodegradable organic

materials.[3,2] The utilization of waste materials through the earthworm has given the concept of vermicomposting.

- The vermicompost technology approach utilizes waste management process by involving earthworms.[4]
- Improvement of soil through vermiculture has now become a popular part of organic farming. Vermicompost is accepted as humus biofertilizer, soil fertility booster, soil activator and soil conditioner with required plant nutrients of storage polysaccharides and structural polysaccharides, vitamins, enzymes, growth regulators and beneficial microorganisms like nitrogen fixing, phosphate solubilising, denitrifying, decomposing bacteria and methanogenic bacteria.[11,12]
- "The Green Revolution" that was promoted in early part of 20th century, was a boost to food production without foreseeing its ill effects. The recent realizations to maintain ecological balance for sustenance of agricultural production, farmers and scientists alike are aiming at finding an alternative to chemical agriculture. India has a long tradition of agriculture with a rich heritage of eco friendly agriculture technologies. In India the tropical climate prevailing is very congenial for farming. Talking in consideration such favorable environmental conditions, early farmers developed such technologies which were used to reap a big harvest throughout the ages.
- But after 1950, when green revolution was introduced, there was a sudden hike in consumption of chemical fertilizers, pesticides, insecticides and hybrid seeds. Unfortunately such extravagant use of these technologies and interference in natural processes in so called modern agricultural technologies seem to have failed in maintaining harmony with nature. As a result even sustainability of agriculture as a whole is at stake.
- Vermiculture is ecofriendly since earthworms feed on anything that is biodegradable, vermicomposting then partially aids in the garbage disposal problems. No imported inputs required, worms are now locally available and the materials for feeding are abundant in the locality as market wastes, grasses, used papers and farm wastes. It is also highly profitable, both the worms and castings are saleable.[5]
- Seanapatti and other co-workers developed applied use of earthworms in the breakdown of a wide range of organic residues, including sewage sludge, animal wastes, crop residues, and industrial refuse to produce vermicompost, has been recommended Hartenstein and Bisesi, 1988; Van Gestel *et al*., 1992; Dominguez and Edwards, 1997. The importance of the earthworms in waste management, environmental conservation, organic farming and sustainable agriculture has been highlighted by several workers.[6,7,8]
- Therefore an experiment was conducted during summer session from January 2016 to March 2016 with the objectives to find the best source of bedding material in relation to the nutrient status as well as the multiplication of earthworms and to find out the best species of earthworm vis-a-vis different bedding materials.

Materials and Procedure

- The cattle dung (15 days old) was procured from village dairy farm. The moisture content of the medium was maintained at about 50%.-80%, Plant waste and paper waste was procured from the different places. The procured paper was shredded before using by means of a paper shredder.
- Earthworms (*Eisenia fetida, Eudrilus eugeniae* and *Perionyx excavates*) were procured from GPC Biotech India, Kesarapalli, Krishna District, Andhra

Pradesh, India. For the present study, separate vermi-bed was made using 15 days old cattle dung, plant waste and paper waste for mass culture of *Eisenia fetida, Eudrilus eugeniae* and *Perionyx excavates*.

- The culture was constantly monitored throughout the period of study with time by time spraying of water. Mature clitellate worms for experimental purpose were taken from this stock culture.
- The experiments was conducted in to two parts as follows .The first part of pre-decomposition experiment in a ceramic tank of 50x45x35cm measurement was filled with a mixture (10kg) of cattle dung, plant debris and shredded paper, it was daily sprinkled with water so that it gets decomposed. Also this waste was turned up and down for proper aeration and decomposition.
- This experiment was continued for 10 days and second part of composting experiment was study plastic tubs were filled with the pre-decomposed mixture of cow dung and shredded paper. 50 numbers of each variety of adult, mature, clitellate worms were taken from the stock culture and were uniformly released on the top of the containers of all the three experimental containers along with plant waste. The experiments were conducted inside the vermicompost shed located in green fields.
- The ratio of carbon and nitrogen and values phosphorus and potassium increased over 60 days of vermicomposting. Excellent values of total nitrogen (0.79%), phosphorus (2.50%) and potassium (1.40%) were compared with control (0day). . Garg *et al.,* (2006) while working growth and reproduction of *E. foetida* in animal wastes also opined that pre-composting is very essential to avoid the mortality of worms[11].
- It clearly indicates that vermibiotechnology reduces the amount of waste and also increased the nutrient content of the product (vermicompost) to be used as a biofertilizer in agricultural practices. Weight loss were found in three material of plant debris, cattle dung and paper waste by *Eisenia fetida* (61%) *Eudrilus eugeniae* (72%) and *Perionyx excavates* (60%).
- The increase in earthworm population might be related with the decrease in C: N ratio with the advancement of time.

Conclusion

The results from the casting analysis had revealed that the organic waste of plant debris, cattle dung and paper waste can be converted into usable form with its excellent nutrient release. Though there may not be a great increase in nutrient, the small change in nutrient value and the reduction in C:N ratio make the plant to uptake. The castings which are rich in microorganism enhance the plant growth hormones. The result showed the increase in three types of Earthworm population in three substrate of paper waste, cattle dung and plant debris. The vermicompost is a eco friendly and cost effective methods. It is an ideal method for the management and development of solid waste. To conclude hold promise to play a significant role in protecting environment as it uses waste as raw material and in building up of soil fertility and improving soil health for sustainable agriculture practices.

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10. HORTICULTURE-VEGETABLE SCIENCE

Exotic Vegetable: Importance and Uses

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Anything of foreign origin, something not of native growth, as a plant is called exotic. Exotic vegetable are the species introduced to a country or location, globally important source of cash income for small holders in India. The diverse climate of India ensures the availability of all varieties of fresh vegetables. India is the second largest producer of vegetables in the World, after China. Globalization has brought many changes in developing nations such as India. We now have an improved lifestyle and living standards. The introduction of big food chains has brought international cuisines to our dinner tables. It has also resulted in a changed food preference, especially among the younger generation. Vegetables help us to be fit and healthy due to the abundance of proteins, vitamins, and other essential nutrients found in them. Surveys show that almost 42 % of India's population consists of vegetarians. Indians always love to have at least 1-2 types of vegetables along with their meals.

Importance of Exotic Vegetables:

1. As a Nutritional and medicinal value: Essential for balanced diet and good health provide micronutrients & phytochemicals. Reduce the risk of obesity, diabetes, cardiovascular diseases and cancer. Correct cooking improve the nutritional value of exotic vegetables
2. As a economic sources: Important source of cash income for farmers. Public and private sector supplies seeds to farmers at reasonable prices.
3. For commercial purpose: Lend themselves well to small scale and part time farming operation. Commercial production and marketing requires knowledge.
4. As a home garden: Growing organically at a home makes exotic vegetable excellent choice.

Uniqueness of Exotic Vegetables:

1. High price in retail market
2. Eaten raw/ semi cooked
3. Mostly health conscious people eat
4. Farming efforts are same as normal vegetables
5. Super healthy food proven scientifically

Opportunities:

1. Vegetables considered under super healthy food category
2. The open area for exotic vegetable cultivation is negligible
3. Exotic vegetables market demand has increased five fold in India
4. Only 10 % polyhouse are doing cultivation of exotic vegetables

Most Famous Exotic Vegetables

Cherry tomatoes: These are small and round. These are called cherry tomatoes since they are the size of cherries. These tomatoes, although small in size, taste the same as normal tomatoes. Cherry tomato are rich in lycopene, which is great at fighting free radicals that cause disease. Lycopene also limit UV damage to skin from sun exposure and promote better heart health. They are used in a variety of dishes such as salads and curries and can be eaten raw too. These are quite expensive and are mostly available at supermarkets.

Broccoli: Broccoli is one of the most nutritious vegetables in the list of exotic vegetables and is rather exotic with dark green,

crisp, and sturdy florets. Broccoli ranks as the world's fifth-most famous vegetable. Some of the popular broccoli dishes are baked broccoli, broccoli salad with French dressing, buttermilk chicken with chargrilled broccoli, chatpati broccoli, broccoli and cheddar crepes, broccoli soup, broccoli pasta, salmon with broccoli, roasted bell pepper with broccoli salad, broccoli soup with wasabi, broccoli, baby corn, and colourful pasta. Broccoli contains rich source of Sulphoraphane compound associate with reducing risk of cancer. It contain Glucoraphinanin having anti cancer property.

Coloured capsicum: Red, Green, Yellow or Orange, they all are essentially, just green capsicum that have been allowed to ripe. The different colours are simply caused by the fruit ripening. Capsicums are rich in vitamins, help in the formation of collagen, and improves skin health. They also increase our metabolic rate. Capsicums can be eaten raw in salads or marinated and tossed into pasta, pizza, fried rice and noodles. They can also be grilled and eaten with chicken and fish or other vegetables such as zucchini, onions, and tomatoes and served as a vegetable platter. They are also perfect for stuffing due to their hollow shape.

Baby corn: Baby corn also known as young corn, cornlets or baby sweetcorn. Along with used in Italian and Chinese dishes, baby corn is also the solo star of various starters like baby corn fritters and chili baby corn, it can also be teamed up with other ingredients in a salad, stir fry, pizza, roll or wrap such as double layered cheese veggie crunch pizza and cheesy vegetable dices. It is a very common ingredient in many Chinese dishes such as Schezuan fried rice, starters, gravies, and Manchurians.

Lettuce: It is hard to imagine having a salad without lettuce in it or biting on a burger without a crunch of lettuce to add to the texture. This crisp and crunchy green leafy vegetable is one of the most common and widely used vegetables among the list of exotic vegetables. Lettuce is a source of vitamin A, which plays a role in improved vision of eye. Extracts of multiple lettuce types have also been shown to promote sleep.

Celery: It is one of the most expensive vegetables in the list of exotic vegetables. It is a salad green that has a range of health benefits. It prevents inflammation and cancer, regulates blood pressure, and controls liver diseases, gout, asthma, psoriasis, and fever. It can be eaten both raw as well as cooked.

Zucchini: Zucchini is a summer squash in the Cucurbitaceae plant family and falls in the same category as cucumbers, melons, and spaghetti squash. This extremely healthy vegetable is a source of iron, calcium, zinc, and several vitamins. Cooked zucchini especially

contains a high amount of vitamin A compared to raw zucchini, which contains slightly fewer vitamins. They have health benefits such as helping reduce blood sugar levels, aid in healthy digestion, improve heart health, and strengthen vision

Asparagus: The Asparagus is one of the must delicate, wholesome and luscious perennial plant of the garden. This tops the list of exotic vegetables due to their health benefits. Asparagus is low in calories, neutralized stomach acids and packed with essential vitamins, minerals, and antioxidants. It comes in a variety of colors, including green, white, and purple. It is popularly used in dishes worldwide, including frittatas, pasta, salads, and stir-fries.

Parsley: Parsley is one of the most versatile herbs used in Middle Eastern cooking and is popularly used as a spice. It is also used as a garnish on several dishes. Parsley is one of the foreign vegetables that is used as a garnish and sprinkled in soups, hummus, or mixed with ground meat.

Red cabbage: It belongs to the Brassica genus of plants. Although it tastes similar to green cabbage, it is richer in beneficial plant compounds that have been linked to health benefits such as stronger bones and a healthier heart. It lowers inflammation and protects against various kinds of cancers. It is an incredibly versatile vegetable that can be eaten raw, cooked, or fermented and added to a variety of dishes.

Pak-Choy: It is a type of Chinese cabbage, which used as food. Pak-Choy is a leafy vegetable that is delicious added to stir fries. Originally from China, it has become popular in European food and is now imported to India. Its structure looks like squat celery with white or very pale green, short, or chunky stalks and glossy deep green leaves. Its flavour is somewhat a mix of mild cabbage and spinach.

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11. AGRICULTURE

Effect of Sodium Fluoride on Certain Enzymes of Nitrogen: Metabolism in *Paspalum* leaves

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Summary

Sodium fluoride inhibits several physiological and biochemical reactions. Fluoride has been known to act as inhibitor of an enzymes activities. Several studies have been conducted attempting to explain how fluorides affect enzyme activities. The present investigation was aimed to study the effects of sodium fluoride on the enzymes of nitrogen metabolism in *Paspalum scrobiculatum* grasses grown *in vivo* (field condition). Sodium fluoride, in general increased the activity of nitrate reductase and GS activity. On the other hand, NaF inhibited soluble protein content and GDH activity.

Key words: *Paspalumscrobiculatum*, Soluble protein, Nitrate reductase, Glutamine Synthetase(GS), Glutamate Dehydrogenase (GDH), Sodium fluoride (NaF).

Introduction

Salinity generally depresses nutrient uptake and causes nutrient deficiency or disorders in plants (Ashraf et al. 2017). Salinity stress generally results in the elevated level of NH4 C content in plants due to rapid proteolysis (Wang et al. 2007). Fluoride is one of the strong electronegative element present in the environment, occurs in soil, air, water and the vegetation (Jha*et al* 2009). High concentration of fluoride caused various changes in mineral content in plants which are important for physiological and biochemical reactions (Elloumietal., 2005). The general symptoms of fluoride injury are necrotic lesion, chlorosis and burning firstly appear in the leaf tips and margins (Elloumi et al., 2005; Mcnulty and Newman 1961; Miller et al., 1999). High level of fluoride is inhibitor for seed germination and growth in many plants (Gupta etal., 2009 ; Elloumietal., 2005;). Fluoride reduces germination by lowering the enzymatic activity and growth by slow the rate of cellular division and expansion (Chang and Thompson 1966; Shumway andBrockbank 1988). Various physiological processes such as water transport, photosynthesis, respiration, metabolism of hydrocarbons and lipids are inhibited by fluoride (Kamaluddin and Zwiazek 2003; Miller et al., 1993; Rakowski 1997.)Fluoride is one of the most toxic atmospheric pollutants affecting germination and early seedling growth of plants (Gupta *et al.* 2009). (Gadi*et al* ., 2012; Ram *et al.,* 2014; Baunthiyal,*et al.,*2014). According to Meng et al. (2016), the GS and GOGAT activities are responsible for NH4 C absorption, and generally the GS activity is higher than GOGAT under normal conditions. However, salinity stress inhibits the activities of both enzymes and GOGAT is found to be more sensitive to salt effects, particularly at higher salt concentration suggesting that the latter enzyme is the more limiting factor in NH4 C assimilation under salinity stress.

Salinity interfers with plants growth as result of both physiological drought and ion toxicity [(Tester et al., 2003) Redondo - Gomez.et al., 2007].In the present study an attempt has been made to investigate the effect of sodium fluoride on the activites of certain key enzymes of nitrogen metabolism. Proteins, being one of the important organic nitrogenous constituents of plants, play a vital role in the compensatory metabolism of a plant species during stress conditions. The increase in protein content may be due to a synergistic effect of fluoride with nitrogen as protein synthesis is directly related to the nitrogen concentration. (Oh, et al., 2008 ; Esposito et al., 2005)

Material and Methods

For the present investigation *Pasplumscrobiculatum* grass was selected as experimental material. Plant belongs to family Poaceae. It is commonly called as *kodomillet*,*kodo*in Hindi,*khoddi*in Urdu,*arugu*in

Telugu, and*Varagu*in Tamil language(Botanik, 1937).

The kodo millet is a food grain crop of minor importance. The husked grain, which is white in colour, is cooked and used as rice. For in vivo studies seeds were sown in earthenware pots. After thinning five to six plants of uniform size were maintained in each pot. Different concentrations of salts were given to three week old plants. The concentrations of NaF used were:-NaF - 10^{-3} , 10^{-2} , 10^{-1} M. Pots treated with water served as controls. Leaf samples were collected after 4 days of the third treatment for biochemical analysis.

Plant material (leaves) werehomogenised using appropriate buffers in pre-chilled pestle-mortar and centrifuged at 10,000 rpm for 20 minutes. The supernatent was dialysed and ammonium sulphatefractination was used. Soluble proteins were estimated by the method of Bradford (1976). Wray and Filner's (1970) method was used for the assay of nitrate reductase in vitro. GS was assayed using a modification of the Elliot (1995) as described by Boland etal., (1978) and GDH was assayed according to the method given by Boland etal.(1978).

Results and Discussion

Results relating to the effect of Sodium fluoride on the soluble protein content have been represented in (fig 01). It is clear that with an increase in the concentration of NaF, there is a decrease in the protein content. Similarly Purohit (1993) reported NaF decrease in levels of soluble protein in *Pennisetum*grasss. In contrast, Asthir and Tak (2017) observed increasing content of soluble protein under fluoride treatment in comparison to control in shoot and root of *Triticumaestivum*. An increase in the fluoride concentration has resulted in a significant increase in the amino acid content in Oleaeuropaea L. (olive). (Zouari, et al., 2016).Protein and energy contents were studied after harvesting in 100-200 ppm concentrations of NaF were found toxic to wheat and chickpea. (Chaudhry ,et al., 2008). The present study indicated (fig 02) the increase in NR activity was recorded with increasing concentration, in contrast, NR-activity was decreased with respect to control in NaF treated plants. Similar result was reported in leaves of *Phaseolusaconitifolius*seedling (Sankhla and Huber, 1975). On the other hand, Bora (1997) reported nitrate reductase activity decreased NR activity in *Cenchrussetigerus*.NaF treated *P. scrobiculatum* hunts showed increased as GS activity (fig 03) with respect to control a drastic increased was noticed at 10^{-3}M NaF concentration. In contrast, a decrease GS activity was reported in *Cenchrussetigerus* (Bora 1997). Paspalum grown in the presence of NaF recorded an increase in GDH activity over the control (fig 04). In contrast, Bora, (1997) reported NaF retarded GDH activity in *Cenchrussetigerus*grasss. Hatata (1982) reported that under low saline condition GDH activity increases which may by a consequence of increased ammonia and amide levels which accumulated under these conditions. Khadri et al. 2001 and Kawakami et al. (2013) have also reported that salinity-induced inhibition of NADH-GOGAT is more responsible for limiting the NH4 C assimilation in plants.

Fig.–[01] Effect of NaF on activity of Protein in *Paspalum scrobiculatum*

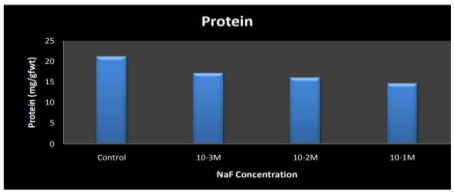


Fig. – [02] Effect of NaF on activity of Nitrate Reductase in *Paspalum scrobiculatum*

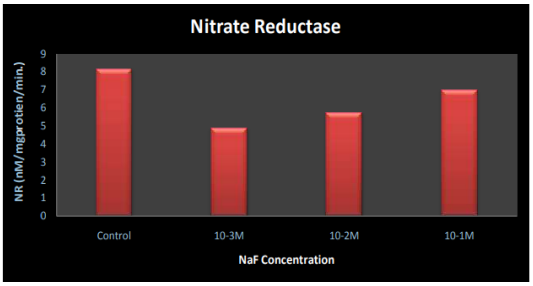


Fig.- [03]Effect of NaF on activity of Glutamine Synthetase (GS) in *Paspalumscrobiculatum*

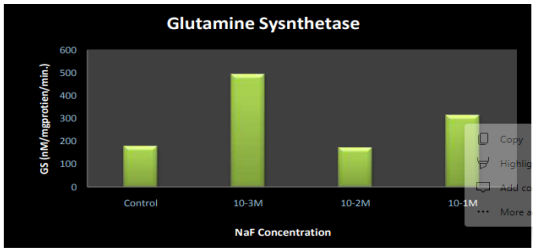
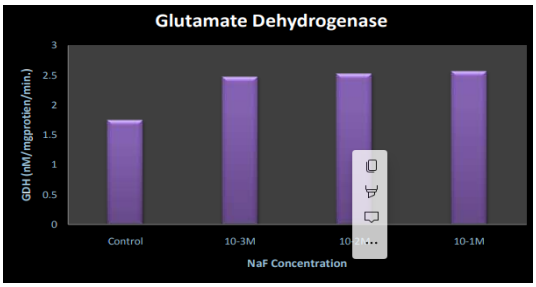


Fig.–[04] Effect of NaF on activity of Glutamate Dehydrogenase in *Paspalum scrobiculatum*



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12. HORTICULTURE: VEGETABLE SCIENCE

Bio-Fortification in Vegetable Crops to Increase the Micronutrient Content

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Abstract

Micronutrients malnutrition is a global health challenge affecting almost half of the global population, which cause mental and poor physical development of children and wide range of illinesses. In the developing countries a large portion of the population relies mainly on one or more staple food crops for their nutrition. In this context, it has become imperative to supplement the staple crops with important necessary nutritional factors. Biofortification can be defined as increasing the concentration of plant-derived nutrients in the edible organ during growth and development. Today Biofortification has proven to be a promising and economical approach to increase the concentration of essential micronutrients in edible portions of staple crops. Increasing the nutritional value of vegetables through biofortification, or increasing their nutrient density, is an attractive means of increasing nutrition without necessarily increasing intake. Today, there are several large scale success stories in Asia and Africa that support the research and development of biofortified crops.

Key Words: Bio-fortification, Micronutrient, Conventional plant breeding

Introduction

Our diets affect both our own health and health of the planet or country. Imbalanced diets low in fruits, vegetable, legumes, nuts/seeds and whole grain, and high in red and processed meat are responsible for one of the greatest health burdens globally and in most region. According to Global Nutrition Report, 2018 anemia and stunting are the two forms of malnutrition burdens being experienced by our country. 37.9 per cent of children under-5 are affected by stunting. 20.81 per cent of children under-5 are defined as wasted. 51.4 per cent of women in reproductive age were affected by anemia. in India, 17.8 per cent of adult men and 21.6 per cent of adult women are overweight. Child wasting is the share of children under the age of five who are wasted and child stunting is the share of children under the age of five who are stunted. (Anonymous, 2018). Micronutrient deficiency is also called "hidden hunger" or "silent epidemic" because it can exist even where the food supply is adequate and those affected at first glance seem well fed.

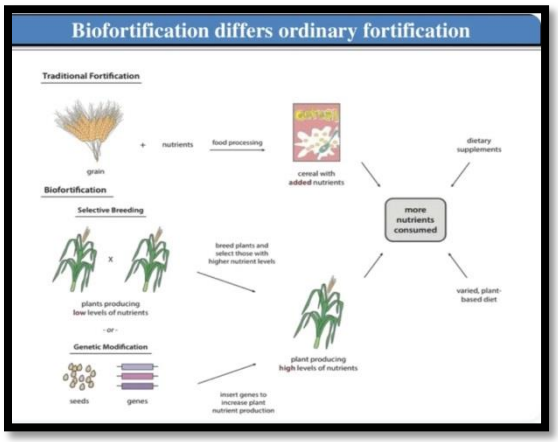
Why micronutrients are so important??

- Micronutrients deficiency affect blindness, birth defects, mental health and child survival
- Vitamin A & Zinc important for immune system- deficiency increase mortality
- Lack of vitamin A can lead to blindness
- Iron needed for physical & cognitive development
- Zinc deficiency causes stunting in children
- Women and young children most affected

Person can get micronutrients into their system by different ways:

- **Supplementation:** Taking a vitamin pill.
- **Dietary Diversity**: Eating a balanced diet.
- **Commercial (Food) Fortification:** Through the addition of micronutrients to staple products.
- **Biofortification:** The process by which the nutritional quality of food and horticultural crops is improved through different methods.

How biofortification differs from ordinary fortification: Bio-fortification is differs from fortification because it focuses on making plant foods more nutrition as the plants are growing rather than additional during processing.



Bio-fortification: Greek word "bios" means "life" and Latin word "fortificare" means "make strong". It refers to the nutrient enrichment of crops to address the negative economic and health consequences of vitamin and mineral deficiencies in humans (Prasad *et al.,* 2015). Developing bio-fortified crops also improves their efficiency of growth in soils with depleted or unavailable mineral composition. It consists of breeding new varieties of staple foods that have higher mineral and vitamin content. It can be described as a complementary, rural-targeted micronutrient program strategy for better reaching remote regions, which often comprise the majority of the malnourished vulnerable populations. Conventional breeding and genetic engineering techniques are the two approaches that is used to bio-fortify the crops with minerals like iron and zinc. This approach not only will lower the number of severely malnourished people who require treatment by complementary interventions, but also will help them maintain improved nutritional status. Moreover, it provides a feasible means of reaching

malnourished rural populations who may have limited access to commercially marketed fortified foods and supplements.

Advantages of boi-fortification:

- **Cost-effective:** The potential to impact a large number of people at a low cost per person
- **Sustainable approach:** Less susceptible to economic and social changes than short term interventions
- **Rural-based:** Complements fortification and supplementation
- **Targets the poor:** Who depend heavily on staple food which eat high levels of food staples

Methods of Biofortification

1. **Agronomic Bio-fortification:** It is the application of micronutrient-containing mineral fertilizer by the soil application and/or foliar application on plant leaves, to increase micronutrient contents of the edible part of crops. Success of agronomic biofortification depends on the presence and bioavailability of soil nutrients for plant uptake (soil to crop). Nutrient allocation within the plant and retranslocation into the edible part (crop to edible part). Bioavailability of nutrients to the human body (food to human). Bioavailability of micronutrients from soil to crop is influenced by many soil factors (i.e. pH, organic matter content, soil aeration and moisture and interactions with other elements). Degrees of success in agronomic biofortification is directly proportional to mobility of mineral element in soil and plant.
2. Gene biofortification:
   a. **Genetic engineering:** Targets for transgenes include, redistributing micronutrients between tissues, increasing the efficiency of biochemical pathways in edible tissues, or even the reconstruction of selected pathways. Some strategies involved in the removal of 'antinutrients'. For Instance, one of the first biofortified crops was golden rice, which was engineered to produce beta-carotene or provitamin A in the edible portion of the grain.
   b. **Conventional plant breeding:** This method is most important. Traditional breeding mainly focused on yield attributes and resistance breeding from last four decades and lack of priority on nutritional aspects leads to decreased amount of nutrient status in the existed varieties. The potential to increase the micronutrient density of staple foods by conventional breeding requires adequate genetic variation in concentrations of β-carotene, other functional carotenoids, iron, zinc, and other minerals exists among cultivars, making selection of nutritionally appropriate breeding materials possible.

Bio-fortified Varieties:

- **Pusa Beta Kesari (Cauliflower): Country**'s first biofortified variety. Which contain high β-carotene (8-10 ppm) in comparison to popular varieties. It is pure line variety.
- **Bhu Krishna (Sweet Potato):** High anthocyanin (90 mg/100g) content in comparison to other popular varieties which have negligible anthocyanin content. It is pure line variety.
- **Bhu Sona (Sweet Potato):** High β-carotene (14 mg/100g) content as compared to 2-3 mg/100g β-carotene in popular varieties. It is pure line variety.
- **Shree Neelam and Da-340 (Yam):** This variety increased level of Iron, Zinc, Anthocyanin and Calcium.
- **Madhuvan Gajar (Carrot):** This variety of Carrot which is developed by a 96 years old organic farmer of Gujarat. Variety having high β-carotene and Iron content.

Conclusion

Bio-fortified crops have the potential to solve many of world's hunger and malnutrition problems, and to help protect and preserve the environment by increasing yield, quality and reducing reliance upon chemical pesticides. Address the challenges ahead for governments, especially in the areas of safety testing,

regulation, industrial policy and food labelling. Biofortification helps in overcoming nutrient deficiency economically, especially in rural areas.

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13. PLANT PATHOLOGY

Fall Armyworm: An Invasive Pest

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Introduction

The fall armyworm (FAW), (*Spodoptera frugiperda*) belongs to the order Lepidoptera and the family Noctuidae originated from tropical and subtropical regions of America. In Latin, the word *frugiperda* means "lost fruit". Thus pest leads to severe loss in major crops like maize of about 6.2 billion, hinders the life of about 200 million people in Africa and overall loss due to pest in all staple crops was about $ 13,383m (Anon., 2017a). Sharanabasappa and Kalleshwaraswamy reported the pest for the first time in India during May 2018 in maize fields in Karnataka (Anon., 2018a). then it was observed in the month of august in Telangana and Tamil Nadu and Telangana. In Gujarat, The pest was first time reported in Ankalv village in Anand from a field of sweet corn on 20th September 2018 (Sisodiya *et al.,* 2019).

FAW is having huge host range of 100 species feeds on the reproductive parts, stems and leaves, (Anon., 2017a) damaging most of the important field and vegetable crops *viz.,* maize, rice, sorghum, sugarcane, pearl millet, cotton, tomato, cabbage, beet, onion, potato and other crops like peanut, soybean, alfalfa, and pasture grasses.

FAW has a complete life cycle of 30 days (summer) and 60 days (spring and autumn). Larva has dome shaped eggs with a diameter of 0.4mm diameter laid in 100-200 batches with 1000eggs/female fecundity. Cannibalism is also observed in the larval stage. The larva goes through six instars are Pale green with a dark head in the early instar and whereas four tubercles on the 8th abdominal segment are present in the late instar larvae in a square manner and dark head with a pale with inverted Y-shape marking on the dark head. Pupa found deep into the soil 2 to 8 cm is shiny reddish brown with cremasters present in pair for a period of 7 to 13 days. Adult moths are nocturnal with a 32 to 40 mm wing span and can fly up to a speed of 100 km per night. Males are smaller than females having brown forewings with triangular white spots at the tip.

Nature of Damage

Feeding of young larva creates a characteristic "windowing" effect or a line of identical "shot" holes on leaves and ragged leaf edges. Frass like moist sawdust was observed near the funnel. Mature caterpillar damages the reproductive parts like tassels, kernels and burrows into cobs in maize. In cotton, the first few instars "skeletonize" leaves and fruiting structures like bracts, squares and bolls are damaged by the older instars in the same manner as bollworms. The incidence of FAW on maize crops was ranged between 9.0 and 62.5% (Shylesha *et al.,* 2018).

Management

Cultural control: Deep ploughing, collection and destruction of egg masses, crop rotation, resistant varieties, early planting and neem cake application @ 250 kg/ha to reduce the adult emergence from pupae (Anon, 2018a). Maize crop powercore containing the *Bt* protein Cry1A105, Cry2Ab2 and Cry1F showed maximum resistance against FAW damage (Burtet *et al.*,

2017).

Monitoring of pest: Traps baited with Scenturion lures, the Trece and Scentry 2 lures ranked second in the number of moths captured and Hercone lure captured the fewest number of moths (Hall *et al*., 2005).

Biological control: Several eggs (*Trichogramma* sp. & *Telenomus* sp.), larval (*Chelonous* sp. & *Cotesia* sp.) and pupal parasitoids are effective for FAW management. The maximum number of FAW larvae parasitized by *Chelonus insularis* under different locations (Cruz *et al*., 2010). FAW larvae parasitized by *Habrobracon hebetor* up to 7 % larvae parasitized (Anon., 2018b). NPV infected larvae were found during the survey, more NPV infected larvae were found and collected at Kanisa village of Anand districts (Raghunandan *et al*., 2019).

Botanicals: The hatching of recently laid eggs of FAW reduced up to 11.30% by using 1% piperine extract. Hydroalcoholic extract obtained from the bark of Mulaterio, *Calycophyllum spruceanum*) has the highest ovicidal activity against eggs of FAW in the Amazon region (Santos *et al*., 2016).

Chemical control: Application of spinosad 45 SC @ 50 ml/ha reduced the infestation of FAW up to 1.2 ± 1.2 % after the 11th day of application followed by methomyl @ 600 ml/ha in maize crop Cruz *et al*. (2010). Hardke *et al*. (2011) evaluated different insecticides and found that chlorantraniliprole 18.5 SC @ 0.10 kg a. i./ha and cyantraniliprole @ 0.09 kg a. i./ha have maximum (100 %) mortality of FAW feed on sorghum grains. Spinoteram @ 12 g a.i. /ha found most effective against FAW in maize crop (Burtet *et al*., 2017). FAW fed on Si-treated rice plants through soil application exhibited lower larval weight, male and female longevity and viability of eggs.

Conclusion

Fall armyworm is rapidly getting status of globally invasive pest in maize growing regions of the world including India. There is a big threat to other crops also. The pest can be effectively managed with host plant resistance (*Bt* varieties), behavioral, mechanical, biological and chemical control. Strict foreign and domestic quarantine measures should be enforced at the country level and state level to prevent further spread. Area wide survey and monitoring of fall armyworm is a must to know the current status of this pest in the region**.** Need to develop resistant variety against the fall armyworm and Innovative and effective approaches for management should be initiated

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14. SOIL SCIENCE

Nutrient Management in Soilless Cultivation Techniques

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Important parameters in soilless farming

Nutrient solution

Soilless culture plants also need other essential elements (nitrogen, potassium, magnesium, calcium, sulphur, phosphorus, iron, copper, manganese, zinc, molybdenum, boron, etc.), which play important roles in plant growth and development. But the quantities of these nutrients required by particular plant species remain the same despite being cultivated on soil or in any soilless system. The soilless culture grower has the benefit of regulating nutrient concentrations in the solution for optimizing plant growth, proliferation and yield. This can also become one of the limitations of soilless farming as managing nutrients concentration in nutrient solution for different plants requires a couple of months of intensive training.

pH level

The availability of essential nutrients for plants is controlled by the pH of a nutrient solution. The pH of the nutrient solution ranges between 5.8 and 6.5 which is suitable for soilless cultures, but it mostly depends on the plant species to be cultured. If the pH of the nutrient solution is not regulated from the recommended range, it can create a barrier against the development of plants.

Electrical conductivity

The electrical conductivity (*Ec*) measured in dS/m represents the strength of nutrient solution. One of the drawbacks of *Ec*is, it indicates the concentration of the solution rather than the concentration of individual nutrient components. For hydroponics systems the ideal *Ec* ranges between 1.5 and 2.5 dS/m. Imbalance in *Ec*of solution can obstruct the uptake of nutrients by plants due to osmotic pressure, affecting plant growth and yield.

Commonly used substrates in Soilless Cultures

Peat moss

Peat moss substrate may be used in various ways for raising crops the most popular are bags, modules and troughs, but also in basins, rings, mattresses and bolsters.

Pumice

Pumice is rich in silica composition and occurs as massive blocks or unconsolidated, fragmenteted material. Pumice has many advantages such as high strength-to-weight ratio, insulation and high surface area, which result from the vesicular nature of this rock.

Pumice

Vermiculite

Vermiculite has excellent exchange and buffering capacities as well as the ability to supply potassium and magnesium. Although vermiculite is less durable than sand and perlite, its chemical and physical properties are very desirable for container media.

Vermiculite

Rockwool

Rockwool is also produced as a loose flock, which is used as a growing medium in pots, in a similar way to peat, or as an additive to other media.

Rockwool

Advantages and Disadvantages of Soilless Cultures

Advantages of soilless cultures

- **Production augmentation:** The application of soilless culture approximately increases the yields as the result of the precise control of the growth elements to the plants such as nutrition, pH, oxygen, carbon dioxide, light and temperatures. However, increasing the yield using soilless cultures will help the offset the initial and any additional costs of the soilless cultures. Soilless culture produced vegetables can be of high quality and need little washing.
- **Water control:** In most kinds of soilless culture the uses of irrigation water are accurately controlled with extremely less amount as compared with normal irrigation in the case of traditional soil cultures. It save much needed labor and time for checking, cleaning irrigation nozzles and frequent examination of trippers which easily can be blocked by calcium carbonate or other compounds that can be eliminated by acidification of nutrient solution or by pretreatment of irrigation water and that need more costs, labor and time.
- **Monitor of plant nutrition:** The nutrition elements are used as solution forms in accurate amounts as the plant needs and not in Hugh amounts as in the normal plantation. In soilless culture, the harmful elements to plants above certain dosages can be kept within safe dosages. However, there is distribution uniformity of nutrition elements only for all the plants in water cultures. PH and E.C. of the nutrient solution can be controlled according to the requirement of the crop and environmental conditions and that is strongly difficult and expensive in the case of normal soil cultures.
- **Purge practices:** Soilless culture is occurred under controlled conditions and that led to avoid spreading of weeds, diseases and insects therefore no need for using the pesticides which finally pollute the environments as used in soil cultures and that mean less labour and less costs.
- **Monitor root surroundings:** In soilless culture, it is easily to control the surrounding environmental and root temperature and supplying roots by oxygen.

- **Crop diversity:** In soilless culture, the interval time between crops is nearly null set because the absence of cultivation operation as in soil cultivation therefore, multiple crops cultivated per year and that mean increasing income.
- **Agriculture of land inappropriate:** Agriculture without soil provides an idealistic process for plant cultivation when there is no appropriate land empty of pathogens and salinity is available.
- **Alleviation of labor requirements:** In soilless culture, all cultural practices of soil cultivation such as soil sterilization, weed control and others can be excluded in soilless culture and that save the labor input and the needed time of work.

Disadvantages of soilless cultures

- **High capital investment:** The initial cost of building the system of soilless culture is high, but the fast and big yield production offset such costs rapidly in the firstly 3-4 years from the beginning of the system if all things running ok.
- **The shortage of technicians and skilled labor:** Agriculture without soil suffers from a shortage of workers and trained professionals.
- **The risk of Pathological Injuries:** Morbidity in open systems of soilless culture is few whereas in closed systems be great and that need a big care and strong sanitation.

Conclusion

Soilless culture is more popular and accepted in some countries, especially in commercial production of vegetables and is quickly catching on in other parts of the world. Soilless culture could well dominate food production in the future. In developing countries, this technique could not get popularity among gardeners till the date. The main bottleneck behind this is lack of its standard knowledge and poor dissemination of its available technologies. Although, more literature on soilless culture is available but standard, precise and authentic information's are still lacking. Continuing research and development may lead to more cost-efficient structures and materials; to reduced requirements of purchased energy; to new cultivars more appropriate to controlled environments and mechanized systems; to better control (including improved plant resistance) of diseases and pests.

15. AGRONOMY-WEED SCIENCE

Geospatial Technology in Assessing Climate Change

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Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle. Scientifically, it has been proven that the average increase of global temperature is largely due to the anthropogenic (man-made) emission of greenhouse gases (GHGs) that include carbon dioxide, methane and oxides of nitrogen. Climate change for India is not just about rising temperatures due to global warming, but also about changes in rainfall, melting of glaciers that feed our river systems and rise in sea level. Natural and anthropogenic activities, greenhouse gases and aerosols have increased. As a result, there is rise in temperature of land, oceans and atmosphere, melting of glaciers in mountains, changes in pattern and distribution of precipitation, variations in crop pattern and in seasons. These may be a direct and indirect response to changes in climate. It is feared that the prediction of the Intergovernmental Panel on Climate Change (IPCC), a rise in temperature to 1.5°C and 6.4°C by the year 2100 may happen much sooner. Geospatial technology has proved to be an

important tool to examine these changes and to suggest adaptation and mitigation, locally, regionally and globally. The software tools in geo-informatics help scientists to access vast data sets in cloud computing platforms.

Geospatial Technology is an emerging field of study that includes Geographic Information System (**GIS**), Remote Sensing (**RS**) and Global Positioning System (**GPS**). Geospatial technology enables us to acquire data that is referenced to the earth and use it for analysis, modeling, simulations and visualization. Geospatial technology allows us to make informed decisions based on the importance and priority of resources most of which are limited in nature, used to create intelligent maps and model. It has become an essential part of everyday life used to track everything from personal fitness, transportation to changes on the surface of the earth. "It's one of the hottest technologies out there". With the help of the remote sensing sensors large amounts of data can be mined and such that the earth system can be made more accessible than past.

Geospatial technology provides general public the ability to react to climate change. One can monitor, map, and share the effects of: El Niño Ocean warming and La Nina ocean cooling; tropical forest depletion; the melt down of sea glaciers in Antarctica or at the poles; vegetation monitoring through detailed knowledge of soils, erosions rates, nutrient cycles, and local agricultural practices; and water resources management through weather monitoring. With GIS, the global temperature pattern is mapped and shared among users. Data from NASA's GRACE and GRACE Follow-On satellites show that the land ice sheets in both Antarctica and Greenland have been losing mass since 2002. GIS has the ability to represent data in the forms of charts and graphs such the user can explore the data based on different applications. Any geospatial project for carbon storage consists of three components namely 1). Capture of carbon dioxide from the point sources 2). Transportation to the storage site and 3). Injection and the storage of carbon dioxide in the geological reservoir. GIS to combine worldwide CO_2 point sources of oil and coal fields to indentify worldwide early opportunities for CO_2 sequestration. Geospatial technology helps in understanding, mapping of the vulnerabilities about climate change and come up with the adaptation strategies. Vulnerability analysis includes three types of information about society and environment interactions, including: patterns of exposure to hazards, sensitivity, and resilience. Researchers use the spatial information technology to prepare society to withstand the challenges. Hotspot identification and analysis is a prime tool of geographic information sciences. Through geospatial technology use, governments can identify factors and hotspots responsible for global warming and climate change and locate areas affected by them. Governments can then act accordingly to save vulnerable populations. Thus, the use of geospatial technology can help in mitigating global warming problems and after effects. There are many institutions working on climate change studies using geospatial technology like National Geospatial-Intelligence Agency studies the effect of climate change throughout the world.

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