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1. HORTICULTURE

Commercialization of Watercress Cultivation for Phytoceuticals and Nutraceuticals Value

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Abstract

Watercress (*Nasturtium officinale*) is free floating hollow stemmed small plant. It can be considered as storehouse of many phytonutrients. It is often recommended for medicinal value. Watercress to be considered an easy crop to cultivate. Watercress production is possible utilizing brook trout flow-through aquaculture effluent. Integrated watercress and troutproduction system becomes a sustainable agriculture versus a phytoremediationapproach that takes benefit of available resources. Watercress serves as secondary marketable crop for farmers to potentially increase farm income.

Introduction

Watercress (*Nasturtium officinale*) the aquatic perennial herb found in abundance along running water ways and nearby natural springsbeside the natural water current (Jafari and Hassandokht, 2012). Thisleafy vegetable belongs to the family Brassicaceae, and closely related to mustard greens, garden cress, cabbage, salad rocket. It has been in cultivation since ancient times in East-Asia, Central Asia, Europe, and Americas for food and medicinaluses. It is free floating hollow stemmed plant-small, oval, deep green succulent leaves carry high moisture content. Its leaves feature sharp, peppery and slightly tangy taste, somewhat like tender mustard greens and garden cress (*Lepidium sativum*). Racemes of tiny white flowers appear in summer, which turns into small pods containing two rows of seeds. Its mature seeds are also edible.

Health Benefits of Watercress

Peppery and tangy flavored crop is storehouse of many natural phytonutrients like isothiocyanates having health promotional and disease prevention properties. Cress contains negligible amounts of fats, an antioxidant rich, low-calorific, low-fat vegetable and often recommended in cholesterol controlling and weight reduction programs. Accordingto Centers for disease control and prevention (CDC) journal, researchers at William Paterson reported that watercress is labeled as the most nutrient dense food, and is considered as "powerhouse of fruits and vegetables". Cress leaves and stem contains gluconasturtiin, a glucosinolate compound that has help in cancer prevention by inhibition of phase-I enzymes (mono-oxygenases and cytochrome P450s). It has higher concentration of ascorbic acid (vitamin C) than most of the vegetables. 100 g of leaves provide 47 mg or 72% RDA of vitamin C. The anti-oxidant (vitamin C) helps to trap free-oxygen radicals and reactive oxygen species (ROS) through its reduction potential properties. It suggest that regular consumption of foods rich in vitamin C helps tomaintain normal connective tissue, prevent iron deficiency, and has resistance against infectious agents by enhancing immunity. Vitamin K has potential role in bone health through promoting osteotrophic (bone formation and strengthening) activity. It helps to limit neuronal damage in the brain and play important role intreatment of patients suffering from Alzheimer's disease. It is also an excellent source of vitamin-A, and flavonoid anti-oxidants like ß carotene, lutein and zea-xanthin. It is also rich in B-complex group of vitamins such as riboflavin, niacin, vitamin B-6 (pyridoxine), thiamin and pantothenic acid that are essential for optimum cellular metabolic functions. It is also rich source of minerals like copper, calcium, potassium, magnesium, manganese and phosphorus. Potassium is an important component of cell and body fluids that helps to control heart rate and blood pressure by countering effects of sodium. Manganese is used by the body as a co-factor for the antioxidant enzyme, superoxide dismutase. Calcium is required as bone/teeth mineral and in the regulation of heart and skeletal muscle activity.

Nutritional value (per 100 g)		Vitamins		Minerals	
Energy:	46 kJ	Vitamin A equiv:	160 µg	Calcium:	120 mg
Carbohydrates:	1.29 g	betacarotene:	1914 µg	Iron:	0.2 mg
Sugars:	0.2 g	lutein, zeaxanthin:	5767 µg	Magnesium:	21 mg
Dietary fiber:	0.5 g	Thiamine (B):	0.09 mg	Manganese:	0.244 mg
Fat:	0.1 g	Riboflavin (B)	0.12 mg	Phosphorus:	60 mg
Protein:	2.3 g	Pantothenic acid (B)	0.31 mg	Potassium:	330 mg
		Vitamin B:	0.129 mg	Sodium:	41 mg
		Folate (B):	9 µg		
		Vitamin C:	43 mg		

Source: Peters, Rick (30 March, 2010) Botany

Watercress is sources as belonging to the genus Rorippa, although molecular evidence shows the aquatic species with hollow stems are more closely related to Cardamine than Rorippa., watercress is not particularly closely related to the flowers popularly known as nasturtiums (*Tropaeolum majus*); *T. majus* belongs to the family Tropaeolaceae, a sister taxon to the Brassicaceae within the order Brassicales.

Scientific classification

Kingdom:	Plantae
(Unranked):	Angiosperms
(Unranked):	Eudicots
(Unranked):	Rosids
Order:	Brassicales
Family:	Brassicaceae
Genus:	Nasturtium
Species:	*N. officinale*

Source: Van Der Kooi, C. J.;Pen, I.; Staal, M.;Stavenga, D. G.;Elzenga, J. T. M. (2015).

Flower petal coloris white. The leaves are compound (made up of two or more discrete leafletsthe leaves are simple (i.e., lobed or unlobed but not separated into leaflets). Leaf arrangementis alternate (there is one leaf per node along the stem). Leaf blade edgeshas teeth and edge of the leaf blade is entire (has no teeth or lobes). Flower symmetryare two or more ways to evenly divide the flower (the flower is radially symmetrical). There are four petals, sepals, or tepals in the flower. Fusion of sepals and petalsboth the petals and sepals are separate and not fusedStamen number. The fruit is dry and splits open when ripe fruit lengthis 6–25 mm.

Production Technique

Watercress is considered to be an easy crop to cultivate; seed should be sown into cubes containing rock wool or another inert media. Seed germination typically takes about 7-10 days under ideal conditions. Sprinkle the watercress seed on rock wool cubes and then cover the cubes lightly with clear plastic to aid in moisture retention. It can be considered a relatively light feeder and many growers try to maintain EC of 1.5-2.0 m/S with a pH between 5.0 and 7.0. It can be cultivated as an annual or biennial in slowly flowing water stream on both a large scale and garden scale, hydroponics. Planting materialconsists of 10-20 cm stem cuttings and seeds. Transplanting can be done on moist sand. Irrigation can be done through continuousrunning water and frequent irrigation when the water source dries up.

Crop management: floating in clean, flowing water; Watercress is first harvested about 20-40 daysafter sowing when new growth is about ‘’6-8” long. Some growers harvest watercress on a weekly schedule for 3-4 weeks before replacing it with new stock. Repeated harvesting can be done by cutting of tender shoots every 3 weeks for a year. Growers wishing to produce watercress hydroponically should research their market carefully and consider locating potential buyers before investing in property, plant, or equipment. Approx yieldis about: 10-20 t/ha.

Conclusion

Watercress considered as sustainable, secondary crop to supplement fish farm income and possible nutrient recovery option. *Nasturtium officinale* exist in the context of invasivespecies ecology, as new cropand research is geared towardthe horticulture industry to enhance betterproduce of plant. There is need for research to examine the influence of environmentalconditions on watercress, as well as the impactsof fungi and viruses. Due to anti-carcinogenic, property it could create huge market in the future in terms of both medicinal, nutraceuticals and farmer’s point to potentially increase farm income.

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2. EXTENSION EDUCATION

Climate Change: A Global Issue

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Climate change is an important ecological issue in recent times and is being seriously viewed at international level by different leaders of developed, developing and underdeveloped countries as well as ecologists. Lot of debate is going on to address the effect of climate change on environments. The major impact of climate change is observed in to either delay in monsoon or heavy rain or flood. With the adoption new technology in farming, the farmers are also facing the new problems like soil and water management, selection of crops, technical know-how, pests and diseases, natural hazards, marketing, finance, surplus production and price fluctuations. The climate change is one of the biggest problems faced by the Indian agriculturists. Climatic condition and agriculture are interrelated both of which are posing threat to the scientists on a global scale. Climate change shows significant impacts on conditions affecting agriculture, including temperature, carbon dioxide, glacial run-of, precipitation and the interaction of these elements. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. The climate change also effects human beings by causing lot of health problems like Air pollution-related health effects, Water and food-borne disease, Vector-borne and Rodent borne diseases, Mental, nutritional, infectious-disease and other effects.

Climate Change: It is simply defined as the increase of the average temperature on earth. The earth is getting hotter, disasters like hurricanes, droughts and floods are getting more frequent. It is caused by green house gases, which trap in the sun's infrared rays in the earth's atmosphere, which in turn heats up the earth's atmosphere.

Greenhouse effect: The greenhouse effect is a process by which earth surface revive high energy short wave radiations from sun. Part of these low energy long wave radiations were emitted by the earth surface. Since part of this radiations re-radiation is back towards the surface, energy is transferred to the surface and the lower atmosphere. As a result, the temperature there is higher than it would be if direct heating by solar radiation. You can think of greenhouse gases as sort of a "blanket" for infrared radiation. It keeps the lower layers of the atmosphere warmer and the upper layers colder.

Impact of climate changes: As a result of climate change, sea level is raised due to melting of glacier and expansion of warmer sea water, arctic sea is melted, sea-surface temperatures is increased, frequent flooding problem is accrued due to heavier rainfall in many regions. In addition to this, due to climate change extreme drought is increased, ecosystems is changed, frequency and strength of hurricanes is increased, heat waves problem is increased in more areas of the world, human health is affected due to warmer temperatures and seawater is becoming more acidic due to more dissolving carbon dioxide into the oceans. Various degrees of uncertainty exist about several technical aspects of climate change. Most of the scientists believe that anthropogenic emissions of carbon dioxide (CO_2), methane (NH_4), nitrous oxide (N_2O), chlorofluorocarbons and other substances are warming the globe.

Effects of Climate change on agriculture: The changes in temperature and precipitation are important perspectives for agriculture; other factors influencing yields include a reduction in soil moisture and increases in plant transpiration. In addition, higher level of atmospheric CO_2 increases photosynthesis rates, thereby increasing yields in favorable conditions. Average temperatures are expected to increase by a greater amount nearer the poles than the equator. In the temperate zones, each degree of warming is expected to shift the climatic zone by 200 to 300 km. Regional climatic changes imply that the production of crops for which temperature is a limiting factor could increase in the higher latitudes. Wheat production could therefore possibly extend into Canada, Scandinavia, the Russian Federation and Argentina, reflecting the longer growing season. For many crops, particularly in tropical agriculture, the limiting factor is precipitation. While the area affected by monsoonal rains is likely to extend, climate models are unable to predict with any certainty the regional distribution of rainfall. If rainfall increases in marginal areas that have fragile soils or mountains or over the sea, increases in production may not offset decreases resulting elsewhere from reduced rainfall or soil moisture.

Related Studies

Sinha and Swaminathan (1991) Showed that an increase temperature by 2˚C could decrease the rice yield by about 0.75 ton/ha in the high yield areas; and a 0.5˚C increase in winter temperature would reduce wheat yield by 0.45 ton/ha.

Aggarwal and Sinha (1993) Using WTGROWS model showed that a 2˚C temperature rise would decrease wheat yields in most places.

Rao and Sinha (1994) Showed that wheat yields could decrease between 28 to 68% without considering the CO_2 fertilization effects; and would range between +4 to -34% after considering CO_2 fertilization effects.

Rath and Mohanty (1994) observed that 59 % of the school going adolescents had medium level of awareness, while 19 % and 22 % of them had high and low level of awareness on environmental pollution respectively. Among the non-school adolescents, 68 % of them had medium level awareness, while 17 % and 15 % of them had high and low level of awareness on environmental pollution, respectively.

Saseendran et al. (2000) showed that for every one degree rise in temperature the decline in rice yield would be about 6%.

Nicholas and Nnaji (2011) They have studied around 20 characters related to agriculture production to know the impact of climate change. Results show that the most significant effect of climate change in the area was intense weed growth (mean score = 4.52).

Nicholas and Nnaji (2011) They have studied around 20 characters related to agriculture production to know the impact of climate change. Results show that the most significant effect of climate change in the area was Re-training of extension staff to acquire the new knowledge and skills (capacity) in climate risk management (Mean score=3.93).

Suggestion for reducing Climate change effect: Efforts should be made by the government functionary, privet sector, NGO and local public to create awareness about the horrible effect of global warming at a glass root level and strategy should be designed to develop green technology having minimum adverse effect on ecological balance. Developed country should take lead to cut emission of green house gases considering their per capita emission of green house gases and should provide green technology to undeveloped and developing countries at cheaper rate. Same time undeveloped and developing countries should also try to develop and adopt technology to minimize global warming problem.

Conclusion: There is high correlation between increase in global temperature and increase in carbon dioxide and other GHG concentrations during the era, due to rapid industrialization and population growth. The frequent severe weather conditions which occur due to dangerous climate change are interlinked with the various types of storms, tornadoes, typhoons, tsunamis, floods, rising sea levels, reversal of the flow of Gulf stream, destruction of native habitats, species of flora and fauna. The way of life of communities, indigenous people and vulnerable tribes and groups, the melting of polar ice caps and a return of severe winter as portrayed by films such as an inconvenient truth and the Day After Tomorrow are very dramatic as well realistic depicting the state of planet.

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3. SOIL SCIENCE

Human Activities Retarding Soil Quality and Health

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Soil is the natural system bearing ultramicroscopic to macro organisms and supporting the life of different kingdoms on the earth. Living and Non-living entities with in the soil, functions to maintain its ability to sustain and support life on earth. Different process, starting from the formation of soil to the degradation of organic matter, has been performed to maintain the balance with in these entities which functions in different cycles of processes.

Any disturbance or harm to these entities leads to discontinuity of these natural cycles that ultimately degrade the soil quality and health. Mostly, Human activities start with interfering with the natural systems but when this interference increases and becomes question mark to the sustainability of human, itself then it becomes a serious problem to be cured or managed. Agricultural activities on one hand are essential for our existence and on the other hand it is a practice that disturbs the natural setups. So, we have to be very much careful while we are dealing with our existence. Concept of sustainability in agriculture is based on the same platform which includes the acceptance of conservational techniques and denial of ill conventional practices. For increasing production we need improved plant varieties, agronomic practices, plant protection measures, farm mechanisation and good soil quality and health. Soil quality and health deteriorates with cultivation, eternally but improper management and adopting ill practices leads to accelerate this deterioration.

Excessive ploughing is one of those practices that affect the soil quality and health. Besides the importance of ploughing before sowing, excessive ploughing has its bad effect on soil quality and health as it is not only uneconomical but also it leads to the oxidation of organic matter present in the soil to the atmospheric carbon dioxide. Furthermore, excessive ploughing results in low biotic population and loss of soil moisture.

To fulfil the current food demand intensive cropping is the essential requirement but continuous practice of intensive cropping leads to the deficiency of macro as well as micro nutrient and low organic matter content in soil if integrated nutrient management or balanced fertilization is not practiced. Organic matter is utilized as food source for most of the microbes in soil thus the reduction in organic matter leads to low biotic population in soil. Biota in soil helps in organic matter decomposition and also in maintenance of physical properties of soil. Thus practicing intensive cropping with improper and unbalanced application of fertilizers also leads to deteriorate the soil quality and health. Similarly, extensive use of pesticides and herbicides has their bad impact on the soil biota and thus, the soil quality.

Human activities like use of fertile soil for filling purposes and brick factories and ignorance of conservational approach makes fertile soil useless for agricultural production. So we have to be very conscious about this natural resource as it is one of the major components, we need for agricultural production and for our sustainability.

4. PLANT PATHOLOGY

Applications of Chitosan in Plant Disease Management

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Introduction

Sustainable agriculture has only a slim margin to make profits while guaranteeing food supply to a growing population in the age of high demand for blemish-free food and high cost inputs. The attention to naturally-occurring products with interesting antimicrobial and eliciting properties such as chitin, chitosan and their derivatives has been getting more attention in recent years. Chitosan as a commercial product has found its place in sectors like cosmetics, medicines and agriculture with a wide range of applications, since last three decades. Chitin, the parent material of chitosan is present in waste exoskeleton material of crab and shrimp harvests. Both chitin and chitosan have been reported to possess antiviral, antibacterial, antifungal properties and have found a promising place in plant protection. This article deals with potential applications of chitosan in plant protection.

Chitosan

Chitosan, the most abundant naturally occurring amino-polysaccharide, possesses many unique physiochemical characteristics and biological activities. Chitosan, a family of linear binary copolymers of (1→4)-linked A units and 2-amino-2-deoxy-β-D-glucopyranose (GlcN) D unit, is obtained from alkaline deacetylation of chitin extracted from the exoskeleton of crustaceans such as shrimps and crabs, as well from the cell walls of some fungi. When the degree of deacetylation reaches about 50%, it becomes soluble in aqueous acidic media and is referred to as chitosan. Owing to its high biodegradability, nontoxicity, and antimicrobial properties, chitosan is widely-used as an antimicrobial agent either alone or blended with other natural polymers.

- **Chitosan in plant disease management:** Chitosan have potential in agriculture with regard to controlling plant diseases. These molecules were shown to display toxicity and inhibit fungal growth and development. Chitosan is also reported to be active against viruses, bacteria and other pests. Some of the mechanisms which have been attributed in reduction of plant diseases by the application of chitosan are discussed in the subsequent sections.
- **Direct antipathogenic activity:** Chitosan has been found to posess direct antimicrobial activity against various pathogens like fungi, bacteria, viruses etc., however, the mechanism of action varies from pathogen to pathogen. In fungi and oomycetes chitosan exerts its effect through inhibition of hyphal growth as well as inhibition of spore germination due to polycationic properties of chitosan, allowing for changes in terms of membrane permeability and cytoplasmic aggregation, thus leading to disorganized hyphae as reported against pathogens such as Fusarium oxysporum, Botrytis cinerea, Monilina laxa, Alternaria alternate, Rhizoctonia solani and Pythium aphanidermatum. Viruses and viriods have altered/inactivated replication after chitosan treatment which leads to stoppage of multiplication and spread of these pathogens. Against the same pathogens chitosan act indirectly by enhancing the host resistance.
- **Blocking of pathogen penetration sites:** Chitosan when applied to plant

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tissues forms a sort of physical barrier and thus prevents the pathogens from gaining entry inside the plant cells. Chitosan application also results in fast wound healing as it can bind to various metals. This wound healing property of chitosan may protect the damaged plant tissues from attack of secondary invaders.

- **Nutrient and mineral chelation:** Chitosan is widely used in fresh and salt water purification processes as chelators of minerals and metals. This property of chitosan has been effectively utilized for the control of plant pathogens as chitosan can chelate minerals (Fe, Cu etc.), and thus helps in preventing plant pathogens from accessing them and thus making an environment of deficient nutrient conditions in which the pathogens are not able to survive.
- **Modulation of plant responses, signaling and role in plant growth promotion:** Plants possess transmembrane pattern recognition receptors (PRRs) which interact with Pathogen/microbe associated molecular patterns (PAMPs/MAMPs). Chitosan behaves as a PAMPs/MAMPs or a general elicitor as the chitosan oligomers are recognized by the chitin elicitor binding proteins" (CEBiP) receptors of plants. The signals gets transported around the plant by jasmonates, several downstream responses of the plants are activated and thus, inducing non-host resistance and priming systemic immunity. These early signaling events include the increase in H+ and Ca2+ influx into the cytosol, the activation of MAP-kinases oxidative burst, hypersensitive responses, the synthesis of abscisic acid, jasmonates as well as the accumulation of defense-related metabolites and proteins such as phytoalexins and PR-proteins. This biopolymer was shown to triggers callose formation and lignification responses. These physical barriers allow for quick wound formation and sealing in order to compartmentalise an infection. This compartmentalisation of wounds and infection sites is an especially important defense response in woody perennials to prevent pathogens travelling systemically around trees. All these properties make chitosan an effective elicitor capable of modulating the plant defense responses and thus curtailing the pathogens at the site of attack only. Application of chitosan leads to improvement in plant growth in many crops like radish, soybean sprouts, sweet basil, grapevine as well as in ornamental crops like Gerbera and Dendrobium orchids. The mechanism of plant growth promotion by chitosan is hypothesized to be due to mechanisms other than simply improving nitrogen nutrition or as a carbohydrate energy source as chitosan was found to improve plant growth even at a very low concentration.
- **Role in abiotic stress resistance:** Chitosan possesses antioxidant activity. The hydroxylated amino groups present on chitosan oligomers make them extremely effective scavengers of hydroxyl radicals, hydrogen peroxide and anion superoxide, which ultimately help the plant in overcoming the stress conditions.
- **Stimulation of antagonistic biocontrol agents:** Antagonistic microbes employ a number of methods to attack plant pests and pathogens. This includes, but is not limited to, the production of lytic enzymes such as chitinases, the production of toxins, direct parasitism, competition for nutriment, and the induction of defense responses in the plant. Therefore, adding chitin-based products such as chitosan to the growing environment may aid beneficial antagonists by stimulating the production and activation of chitinases that can then be used to attack pests and pathogens, or be used as a stable nitrogen-rich polysaccharide food source that boosts the population to the level where other mechanisms control the plant pathogens.

Conclusion and Future prospects: In the present time, in which there is more emphasis on organically grown food stuff, environmental conservation etc. attention is being paid towards naturally-occurring products with interesting antimicrobial and eliciting properties such as chitin and chitosan. A number of modes of action have been identified for the beneficial effects of chitosan-based treatment on crops, including direct antibiosis and the induction of plant defenses. However, they also stimulate beneficial microbes in controlling pathogens, promoting plant growth and remediating soil pollutants, which further enhances their candidature for more efficient use in plant protection. In recent years much progress has been made on the possible mechanisms by which chitosan interact with both plant and pathogen system. These will lead to design specific chitin/chitosan applications/formulations suitable for various stages of plant growth and development in order to achieve a better control of a specific disease. However, there is still need to examine better ways by which these natural products can be incorporated into Integrated Pest Management strategies in many major crops. The attributes in the form of low cost, low concentration required, ample supply (recycled waste) and health/environmental safety which chitosan based products suggest that a range of chitosan based products will become a more common feature in agriculture in the near future.

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5. CROP PHYSIOLOGY

Physiological Functions and Disorders of Micro Nutrients

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In order to complete the life cycle normally, the living organism requires a supply of large number of substances from outside. This is called as nutrition. All green plants synthesizing their own organic requirements are autotrophic.

Thus, the plant growth and development can proceed only when the plants are applied with the chemical elements referred as ***Essential Elements***. These nutrients are absorbed by plant root from the soil. Chemical analysis of the plant ash has shown that plants contain about 40 different elements. *Some of elements which are indispensable or necessary for the normal growth and development of the plants and they are called as Essential Elements***.** Rest of the elements are called as Non-essential elements. It is now known that the following 17 elements are essential for majority of the plants: C, H, O, N, P, K, Ca, S, Mg, Fe, Zn, B, CU, Mo, Cl, Ni and Mo. Besides these, Al, Si, Na, Co and Ga may be essential for some plants. The objective of this paper was to discuss the physiological functions and disorders of micro nutrients.

Iron (Fe)

In well-irrigated soils, Fe is present predominantly as ferric form and in waterlogged soils, ferrous compounds are formed. The availability of Fe to plants increases with acidity and is decreased by phosphates. It is *absorbed in ferric state*; but, *ferrous form is only metabolically active form for the plants.*

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Physiological Role

- It is an important constituent of iron-porphyrin proteins like cytochromes, peroxidases, catalases and essential for the synthesis of chlorophyll.
- It acts as a catalyst and electron carrier during respiration.
- It also acts as an activator of nitrate reductase and aconitase enzymes.
- It is a very important constituent of ferredoxin, which plays an important role in biological nitrogen fixation and primary photochemical reaction in photosynthesis.
- It is immobile in the plant tissues. Its mobility is affected by several factors like presence of magnesium, potassium deficiency, high phosphorus and high light intensity.

Iron Deficiency Symptoms

Iron deficiency causes chlorosis of young leaves which is usually interveinal.

Manganese (Mn)

Like iron, the oxide forms of Mn are common in soil but the more highly oxidised forms (manganous dioxide) are of very low availability to plants. Its solubility increases with increased acidity and in strongly acid soils. Absence of organic matter and poor drainage condition of soil cause unavailability of Mn in the soil. Sometimes, Oxidising bacteria in the soils may also cause Mn unavailable over the pH range of 6.5 to 7.8.

Physiological Role

- It acts as an activator of some respiratory enzymes like oxidases, peroxidases, dehydrogenases, kinases, decarboxylases etc.
- It decreases the solubility of iron by oxidation; in certain cases, *abundance of Mn leads to Fe deficiency* and its essential in the formation of chlorophyll.
- It is necessary for the evolution of O_2 during photosynthesis through photolysis of water.
- It is immobile in the plant tissues. when its deficiency occurs, it is not transferred to the younger leaves but accumulated in the older leaves only. As a result, deficiency symptoms develop first on younger leaves.

Manganese Deficiency Symptoms

- The young leaves are affected by mottled chlorosis and veins remain green.
- Small necrotic spots developed on the leaves with yellow strips.

Copper (Cu)

Copper is found in smaller quantity in soils due to the additions of growing plants and its added residue. Organic matter, soil organism and pH are the important factors affecting the availability of copper. Soils neighbouring the copper deposits are normally toxic to plants.

Physiological Roles

1. It acts as a catalyst and regulator.
2. It is a constituent of several oxidizing enzymes like ascorbic oxidase, lactase, tyrosinase, phenoloxidase, plastocyanin etc.
3. It is essential for photosynthesis, respiration and to maintain carbon/ nitrogen balance.
4. Its higher concentration is toxic to plants.
5. It is immobile in the plant tissues.

Copper Deficiency Symptoms

- Copper deficiency causes necrosis of the tip of the young leaves.
- It also causes die-back of citrus ie., ***exanthema in Citrus*** and fruit trees.
- Also causes ***reclamation disease*** or white tip disease of cereals and leguminous plants.

Zinc (Zn)

Like copper, it is also found in soils in very small quantities and largely it results from the concentration and addition from growing plants and added residue. Its uptake is reduced by large or prolonged supply of phosphate fertilizers. It is generally found to be toxic in the neighbourhood of zinc deposits.

Physiological Role

1. It is a component of enzymes like *carbonic anhydrase*, alcohol dehydrogenase, glutamic dehydrogenase, lactic dehydrogenase, alkaline phosphatase and carboxy pepsidase.
2. It is essential for the evolution and utilization of *CO_2, carbohydrate and phosphorus metabolism.*
3. It is also essential for the biosynthesis of the

growth hormone, lndole-3-acetic acid. (IAA) and also for the *synthesis of RNA*.

4. It is readily mobile within the plant tissues.
5. It is closely involved in the *chlorophyll formation*.

Zinc Deficiency Symptoms

1. Zinc deficiency causes chlorosis of the young leaves which starts from tips and the margins.
2. The size of the young leaves is very much reduced. This disorder is called as ***'little leaf disease'***
3. Stalks will be very short.
4. In rice deficiency leads to ***"Khaira disease"***

Molybdenum (Mo)

It is found widely distributed in small amounts in soils and plants and relatively higher concentration occurs in mineral oils and coal ashes.

Physiological Roles

1. It is associated with the prosthetic group of enzyme, ***nitrate reductase***, and thus involved in ***nitrate metabolism***.
2. It acts as an activator of some dehydrogenases and phosphatases and as *cofactors* in *synthesis of ascorbic acid*.
3. It is necessary in the ***formation of nodules*** in legumes for the fixation of atmospheric nitrogen.

Molybdenum Deficiency Symptoms

1. Molybdenum deficiency causes interveinal chlorosis of older leaves.
2. Flower formation is inhibited.
3. Causes whiptail disease in cauliflower plant.

Boron

Boron occurs in rocks and marine sediments. It is absorbed in the form of borate ions and it has some sort of antagonistic effect with other cations like, calcium, potassium and others.

Physiological Roles

1. It is necessary for the ***translocation of sugars*** within the plant system.
2. It is involved in reproduction and germination of pollens. (tube)
3. It is concerned with water reactions in cells and regulates intake of water into the cell.
4. It keeps Ca in soluble form within the plant and may act as a regulator of K ratios (K/Ca)
5. It is also concerned with the nitrogen metabolism and with oxidation and reduction equilibrium in cells. It is immobile in the plant tissues.

Boron Deficiency Symptoms

1. Boron deficiency causes death of shoot tip
2. Flower formation is suppressed
3. Root growth is stunted
4. The other diseases caused by B deficiency is
5. Heart rot of beet
6. Stem crack of celery
7. Brown heart of cabbage
8. Water core of turnip
9. Internal cork formation in apple
10. Hen and chicken in grapes

Chlorine

Chlorine occurs in soils as chlorides and moves freely in soil solution and form which it is available to the plant. Chlorine increases the water content of tobacco cells; it affects carbohydrate metabolism and speeds up photosynthesis.

Cobalt is needed by the leguminous crop in the absence of nitrogen because; it is required by the symbiotic bacteria for fixation of atmospheric nitrogen. Elements like, aluminium (Al), silica (Si) and selenium (Se) possess stimulating effects of certain non- essential elements by counteracting the toxicity of certain elements present in soil.

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6. AGRICULTURE ENTOMOLOGY

Joint Action of Insecticides in Insect-Pest Management

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Introduction

Joint action or mixture of insecticides is when two or more insecticides are combined into a single spray solution (Cloyd, 2001). An insecticide mixture entails exposing individuals in an insect pest population to each insecticide simultaneously. Insecticide mixtures may be more effective against certain life stages including eggs, larvae, nymphs, and adults of arthropod pests than individual applications although this may vary depending on the rates used and formulation of the insecticides mixed together (Blumel and Gross, 2001). There is already wide-spread use of insecticide mixtures associated with greenhouse and nursery operations world-wide, partly because combinations of selective insecticides may be required in order to deal with the arthropod pest population complex present in the crop (Helyer, 2002; Ahmad, 2004; Khajehali *et al.*, 2009).

Benefits Associated with Joint Action of Insecticides

- Mixtures of two or more insecticides are used in agriculture for various reasons. A mixture may give best control of a complex of pests with varying susceptibilities to the different components of the mixture.
- Insects that are resistant to one or more insecticides may be susceptible to a combination of toxicants or synergism may be exhibited by the combinants.
- Mixtures of insecticides also are used because of cost efficiency. A highly effective, expensive insecticide might be used at a diluted rate with a less expensive chemical to give satisfactory control of a target insect.
- The mixing of insecticides together is a reduction in the number of applications required, which decreases labour costs.
- Furthermore, pesticide mixtures may result in higher mortality of arthropod pest populations than if either pesticide were applied separately.

Analysis of Joint Action of Insecticides

To analyze the joint action of two or more insecticides, the actual toxicity indexes of components and their mixtures are determined by dosage mortality curves. The theoretical toxicity of the same mixture is equal to sum of toxicity indexes calculated from the percentage of each component times its respective toxicity index. Therefore, the joint toxicity or co-toxicity coefficient of a mixture

$$= \frac{\text{Actual toxicity index of a mixture}}{\text{Theoretical toxicity index of a mixture}} \times 100$$

When the co-toxicity coefficient of mixture is 100, the effect of this mixture indicates probability of similar action. If the mixture gives a coefficient significantly greater than 100, it indicates a synergistic action. An independent action give a coefficient less than 100, but the toxicity of mixture should be higher than that of either component.

The Fundamental Types of Interactions between Compounds in a Mixture are:

Additive: no interaction, overall toxicity is equal to the sum of toxicities of the individual components **Antagonistic**: toxicity of the mixture is less than additive

Synergistic: toxicity of the mixture is greater than additive

Concerns Associated with Insecticides Mixtures

- **Physical incompatibility:** Insecticides do not mix properly and form suspension and solution. Instead flakes, crystal, oil clumps forms or there is a noticeable separation. It may be due to physical and chemical properties and impurities of water or types of formulation of insecticides being mixed together.

- **Phytotoxic incompatibility:** Chemicals by themselves are not injurious and do not show any chemical reaction when mixed, mixture causes injury. It may occur due to plant growth stage, temperature, plant condition and method of application.
- **Chemical incompatibility:** One or more of the chemicals undergoing a chemical change when placed in combination and deactivation of active ingredient.

Some Studies of Joint Action of Insecticides are Summarized as Under:

Studies have demonstrated that insecticide mixtures increase efficacy against insect pests such as the western flower thrips, *Frankliniella occidentalis* Pergande (Cloyd, 2003) and whiteflies (Brownbridge *et al.*, 2000) compared to separate applications of each insecticide. For example, when permethrin (pyrethroid) is mixed with chlorpyrifos or methyl parathion (organophosphates), toxicity increases against certain insect pests.

Analysis of Joint Action of Insecticides against House Fly

Analysis of joint action of insecticides against house fly was reported by Sun and Johnson in 1960. To analyze the joint action of two (or more) insecticides, the actual toxicity indexes of the components and their mixture are determined by dosage-mortality curves. The theoretical toxicity of the same mixture is equal to the sum of toxicity indexes calculated from the percentage of each component times its respective toxicity index. Therefore, the joint toxicity or Co-toxicity coefficient of a mixture is,

$$= \frac{\text{Actual toxicity index of a mixture}}{\text{Theoretical toxicity index of a mixture}} \times 100$$

A coefficient of a mixture near 100 indicates probability of similar action; independent action usually should give a coefficient *less* than 100, while a coefficient significantly above 100 strongly indicates synergism. Toxicity significantly less than that of the strongest toxicant alone shows antagonism. Thirty-nine mixtures each containing two to four insecticides were tested against the house fly *(Musca domestica* L.) and their results were calculated by this method. Generally, chemically related compounds gave similar action, while unrelated compounds gave independent action. 3-(Dimethoxyphosphinyloxy)-N, N-dimethyl-erotonamide (SD 35612) and sesamex showed high synergistic action. However, a mixture of methyl parathion and sesamex indicated significant antagonism.

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7. GENETICS AND PLANT BREEDING

Operon System: Regime for Gene Articulation in Prokaryotes

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Introduction

Genetic or gene articulation/ expression is the process where genotypes coded in the genes are exhibited by the phenotypes of the individuals. Regulation of gene expression is essential for prokaryotes as well as eukaryotes as it increases the versatility and adaptability of an organism by allowing the cell to express protein when needed. Most of the genes of an organism express themselves by producing proteins. The products of many genes are needed only occasionally by the cell. Therefore, those proteins are synthesized only when the substrate on which they act is present or when they are needed by the cell. Various mechanisms exist in the cell, which control and regulate the expression of genes. The regulatory system turns the genes "on" when needed and turns "off' when not needed. This proves that gene activity can be regulated. The first discovery of a gene regulation system is considered to be the identification in 1961 of the lac operon, discovered by Jacob and Monod, in which some enzymes involved in lactose metabolism are expressed by E. coli only in the presence of lactose and absence of glucose.

Gene Regulation/Gene Expression in Prokaryotes

In bacteria the expression of genes is controlled by extracellular signals often present in the medium in which bacteria are grown. These signals are carried to the genes by regulatory proteins (activators and repressors-DNA Binding protiens). Regulatory proteins are of two types. Positive Regulators (activators) and Negative Regulators (Repressors).

What is Operon: Bacterial genes that encode for proteins with closely related functions are clustered with cis-acting regulatory elements that determine the transcription of these genes, thus these genes are regulated in a coordinated way. These clusters of genes are unit of expression and regulation and are called operons. An operon comprises of repressor, operator, promoter and structural gene. These segments overlap, and their interaction determines or regulates the gene expression. Opreons are of two types: Inducible (*Lac* Operon) and repressible (*Trp* operon)

1. Lactose Operon or Lac Operon

This is a negative control mechanism. In 1961 Francois Jacob and Jacques Monod proposed operon model for the regulation of gene expression in E. coli. The synthesis of enzyme (3-galactosidase has been studied in detail. This enzyme causes the breakdown of lactose into glucose and galactose. In the absence of lactose, β-galactosidase is present in negligible amounts. As soon as lactose is added from outside, the production of β- galactosidase increases thousand times. As soon as the lactose in consumed, the production of the enzyme again drops. The enzymes whose production can be increased by the presence of the substrate on which it acts are called inducible enzymes.

Addition of lactose to the culture medium of E. coli induces the formation of three enzymes (5-galactosidase, permease and transacetylase, which degrade lactose into glucose and galactose. The genes, which code for these enzymes lie in a cluster and are called cistrons or structural genes. They are transcribed simultaneously into a single mRNA chain, which has codons for all the three enzymes. The mRNA transcribed from many genes is called polycistronic. The functioning of structural genes to produce mRNA is controlled by regulatory genes. There are three structural genes Z, Y and A, which code for enzymes p-galactosidase, lac permease and transacetylase respectively. Regulatory genes consist of Regulator I, Promoter P and a control gene called operator gene O. Regulator I gene produces a protein called repressor or inhibitor.

The repressor is active and binds to the operator gene O and switches it "off" and the transcription is stopped.

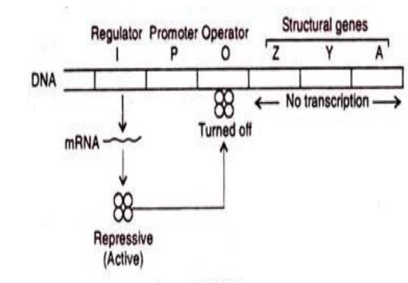

Fig: 2 inducer absent: The repressor produced by regulator gene is in active form and binds to the operator DNA preventing transcription initiation

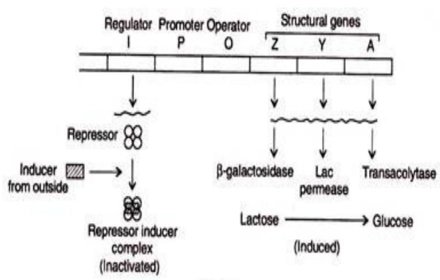

Fig: 3 Inducer present: In the presence of inducer the repressor molecules are inactivated by the inducer molecule so that they can no longer bind to the operator DNA. As a result, structural gene is transcribed.

This happens because RNA polymerase enzyme which binds to the promoter is unable to do so because binding site of RNA polymerase and the binding site of repressor on operator overlap each other. Hence in negative control mechanism, the active genes are turned "off" by the repressor protein. When the inducer (lactose) in supplied from outside, the inducers binds to the repressor. The lactose on entering the bacteria changes into allolactase. Allolactose changes the shape of the repressor (conformational changes) which renders it inactive and unable to bind to the operator. The operator becomes free and is "turned on" and thus transcription starts. In this way, the presence of the inducer permits the transcription of Lac operon, which is no longer blocked by the repressor protein. The synthesis of enzymes in response to the presence of specific substrate (lactose) is called induction. It is also called de-repression. The inducible system operates in a catabolic pathway. In the absence of lactose, E. coli cells have an average of only three molecules of P-galactosidase enzyme per cell. Within 2-3 minutes of induction of lactose, 3000 molecules of P-galactosidase are produced in each cell.

2. Tryptophan Operon or Trp Operon

It is also a negative control system but forms a biosynthetic pathway. It is known as repressible system. It works on the principle that when the amino acid tryptophan is present, there is no need to activate the tryptophan operon. Repressor protein is activated by the co-repressor (tryptophan-the end product) and it binds the operator to switch it "off". Tryptophan is synthesized in five steps, each step requiring a particular enzyme.

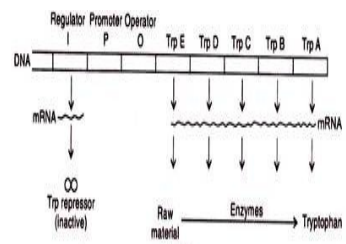

Fig: 4 the regulator gene produces an inactive repressor, which is unable to bind to the operator; hence transcription of structural gene continues.

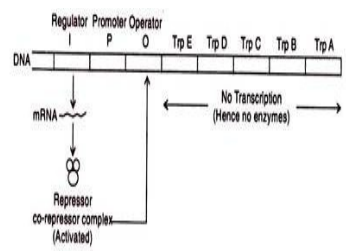

Fig: 5 when the co-repressor (tryptophan) is present it interacts with and activates the repressor, which now binds to the operator which in turn stops the transcription.

The genes for encoding these enzymes lie adjacent to one another, called trp E, trp D, trp C, trp B and trp A. Tryptophan operon codes for five enzymes that are required for the synthesis of amino acid tryptophan. In repressible system, the regulatory gene produces a repressor protein, which is normally inactive and unable to bind to operator on DNA. The repressor upon joining the co- repressor (which is the end product tryptophan in this case) undergoes conformational changes that activate it and enable it to bind to the operator.

This prevents the binding of RNA polymerase enzyme to the promoter. This is opposite to the situation of lac operon in which the repressor is active on its own and loses the affinity for the operator when bound to the inducer. Here the availability of tryptophan which is the end product regulates the expression of this operon and represses the synthesis of tryptophan.

In this way the synthesis of enzymes of a metabolic pathway is stopped by the end product of the metabolic chain. This mechanism enables the bacteria to synthesize enzymes only when they are required. This is known as feedback repression. In feedback inhibition the end product of a metabolic pathway acts as an allosteric inhibitor of the first enzyme of the metabolic chain. Induction and repression save valuable energy by preventing the synthesis of unnecessary enzymes.

8. PLANT BREEDING AND GENETICS

Plant Breeding in Relation To Climate Change

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Climate changes are not new and had dramatic impacts, they involves increased temperatures, reduced rainfall, changing rainfall patterns, increasing CO_2 concentration, widespread melting of snow and ice and rising global average sea level, while the increase in the frequency of drought.

The climate change having an adverse effect on food production, food quality and food security. The adverse effect is a consequence of the expected or likely increased frequency of some abiotic stresses such as heat and drought, and of the increased frequency of biotic stresses (pests and diseases). In addition, climate change is also expected to cause losses of biodiversity, mainly in more marginal environments.

Agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce crop yields while encouraging weed, disease and pest proliferation. Changes in precipitation patterns increase the likelihood of short term crop failures and long-term production declines. The overall impacts of climate change on agriculture are expected to be negative, threatening global food security. Therefore, the most likely scenario for plant breeding is the following:

1. Higher temperatures, which will reduce crop productivity, are certain;
2. Increased CO_2 concentration is certain, with both direct and indirect effects;
3. Increased frequency of drought is highly probable
4. Increases in the areas affected by salinity is highly probable; and
5. Increased frequency of biotic stress is also highly probable.

The major consequence is that our main sources of food are more genetically vulnerable than ever before due to greater genetic uniformity, which does not allow the crops to evolve and adapt to changing environmental conditions.

Breeding Strategies

The most important climate change adaptation tools for crop production are thus breeding and cultivar delivery systems that rapidly and continuously develop new varieties and replace old ones. Rapid breeding cycles drive climate change adaptation by changing allele frequencies in breeding populations. Other strategies include increase in access to a suite of varieties with different duration to escape or avoid predictable occurrences of stress at critical periods.

One most important tool is Participatory-Evolutionary plant breeding. One of the salient features of the traditional farming systems is their high degree of biodiversity by combining the indigenous agricultural knowledge systems with scientific knowledge, and by making use of that, we may be able to provide better adapted varieties that, together with appropriate agronomic techniques, could help millions of rural people to reduce their vulnerability to the impact of climate change.

An understanding of gene networks and the identification of the sequence or epigenetic variation that underlies agricultural traits conferring environmental resilience would also revolutionize our ability to truly breed for new ideotypes. Genomics, in association with phenotypic information, can provide breeders with the knowledge they need to make more rapid selections and apply advanced breeding strategies to produce climate-resilient crops.

Thus plant breeding may integrate conventional activities towards advancing the productivity frontier and transforming production systems along with genomic tools provide an infrastructure to lay bare the secrets of the genetic potential of plants to respond to a range of environments.

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9. AGRONOMY

Castor Cultivation: An Emerging Trend in South Gujarat

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Introduction

In India, castor (*Ricinus Communis* L) is mainly grown in Gujarat, Rajasthan, Andhra Pradesh, Tamil Nadu, Karnataka and Orissa states. Among these, Gujarat is the leading castor growing state having maximum area (7.14 lakh ha), production (14.13 lakh tonnes) and productivity (1979 kg/ha). Gujarat state alone produces 73% of the total castor of our country from about 50% of the area with the highest productivity. In Gujarat, northern and middle region are well-known *kharif* castor growing belts and recently some pockets of south Gujarat is gaining popularity due to its yield potentiality, low cost of cultivation and more economic returns. The crop is cultivated during late *khairf* or *rabi* season in south Gujarat, due to heavy rainfall and heavy black soil having poor drainage capacity of south Gujarat, castor cultivation in *kharif* season is not suitable. Therefore, farmers prefer late *kharif* or *rabi* season for castor cultivation. Rice-rice and rice-sugarcane are the most dominant cropping system of south Gujarat and under this cropping system both the crops are nutrients and water exhaust, because of that soil health is badly affected and soil productivity is now starts to decline. Therefore diversification in cropping system is necessary to sustain the productivity of soil. Castor is one of the important oilseed crops and found more suitable and economical under south Gujarat. Local variety of castor grown in rice fallows on residual moisture is a common practice in south Gujarat. The crop survives without any additional inputs like nutrients, water and adoption of other cultural practices is almost negligible. Consequently, the average yield realized by the farmers is as low as 4 to 5 q/ha. With development of numbers of high yielding and diseases resistant varieties like GCH 7, GNCH 1 etc., there is a vast potential to realize high yields under scientific package of practices.

Soil and its Preparation

In south Gujarat, soil is mainly heavy black clay to medium black type which favours the crops like paddy, sugarcane pulses and some vegetables. Castor can be grown well followed by paddy crop with proper land preparation as it respond under a wide range of soils type *viz.*,

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slightly alkaline to acidic. Heavy clays with poor drainage and marhsy soils are unsuitable. The highly suitable soils for castor are deep, moderately fertile, with slightly acidic conditions (pH 5.5 to 6.5), well drained, sandy loams. Excessively fertile soils are not desirable, as they favour excessive vegetative growth at the expense of seed yield. Deep ploughing followed by cross cultivation is require for good soil preparation, harrowing and planking is done for prepare fine seed bed for good seed germination and crop establishment.

Sowing Time

Time of sowing has a significant bearing on the ultimate yield and returns from castor. The crop is essentially taken up during *kharif* in castor growing states of India. But in case of heavy rainfall zone of south Gujarat, sowing should be carried out in late *kharif* to *rabi* season i.e. between second fortnight of September (depending up on the rainfall and vapsa condition) to first fortnight of November or after harvesting of paddy crop. The availability of early maturing hybrids/varieties and improved agronomic practices has now made *rabi* cropping possible under irrigated condition.

Selection of Varieties / Hybrids

For cultivation in *rabi* season, castor hybrid GNCH-1 is suitable for south Gujarat region. Farmers are advised to procure good quality viable seeds of hybrid from authorized/registered seed agencies like state seed corporation and state agricultural universities etc.

Seed Rate, Plant Population and Spacing

Good plant stands of castor require optimum seed rates i.e. 5 to 6 kg/ha. Plant population of 9259 per ha was found to be optimum with spacing of 120 x 90 cm for irrigated areas of south Gujarat. Also such plant geometry helps to carry out inter-culturing operation mechanically. Seed treatment with thiram or carbendazim @ 3 g/kg seed will help to minimize initial loss of plant due to wilt and root rot disease. Sowing should be carried out on raise bed manually by dibbling.

Fertilizers

The most important factor in fertility level is the supply of nitrogen in the soil. Insufficient nitrogen results in reduced castor yields as it affect sex ratio, whereas excessive nitrogen produces heavy vegetative growth with little or no increase in seed yield. For irrigated *rabi* castor in south Gujarat condition are recommended to apply pressmud 6.0 t/ha or FYM 10.0 t/ha as organic fertilizer at the time of soil preparation. In case of chemical fertilizer, 120 kg N/ha in three equal splits for achieving higher seed yield and economic returns. One-third nitrogen should be applied as basal and remaining at 35-40 and 75-80 DAS. In case of drip irrigation, nitrogen should be applied in six equal splits. Phosphorous and potassium application should be made on soil test basis. In case of deficiency of phosphorous, apply 40 kg P_2O_5/ha as basal dose. It is also advisable to apply biofertilizer like *Azotobactor* & PSB.

Irrigation Management

Castor gives good response to irrigation due to its perennial nature. Under intensive management, *rabi* castor require 6-8 irrigations for higher yield. First four irrigation should at 20 to 25 days interval and then remain four irrigation at 12-15 day interval are applied. Drip irrigation at 0.8 EPF in hybrid castor saves water and offers higher yield. Application of irrigation at 0.8 IW/CPE provides more yield and net returns. Since, castor is a deep rooted crop, sufficient water to wet at least 30-40 cm soil profile should be applied.

Weeding and Interculturing

Castor is very sensitive to weed competition. Initial 90 days of crop period is kept weed free for better crop growth. In south Gujarat, weed has been identified as the most important production constraint for castor. Weeds are more serious problem in irrigated castor. Hence, the crop may need 2 or 3 hands weeding at intervals of 20-25 days followed by interculturing in order to keep weeds under check.

Diseases and Pest

The details on important pest and diseases of castor found in south Gujarat with nature of damage and management practices is given in

Table 1.

Harvesting and Threshing

Castor, by nature is a multiple branching type. On an average, it produces 4 to 5 sequential order spikes over a span of 180 to 240 days, one each at an interval of about 30 days. The main spike is ready for harvest within 90-120 days after planting. The subsequent pickings can be taken up at intervals of 30 days. Physiological maturity in castor is attained when some of the capsules in a spike turn brown in colour. The matured spikes are cut and dried in sun for few days for easy threshing. For good seed filling and oil content harvest the capsules when turn yellow and start drying. Threshing is usually done by either beating the capsules with sticks or alternatively by trampling with bullocks or tractor wherever possible. Power operated mechanical threshers are also available for threshing and cleaning.

Yield Potential

With the adoption of improved technology, an average yield of 3000-3500 kg/ha can be obtained under irrigated conditions.

10. NANOTECHNOLOGY

Application of Nanotechnology in Agriculture

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Introduction

Now, after years of green revolution and decline in the ratio of agricultural products to world population growth, it is obvious that there is necessity of employing new technologies in the agriculture industry more than ever. Modern technologies such as bio and nanotechnologies can play an important role in increasing production and improving the quality of food produced by farmers. Many believe that modern technologies will secure growing world food needs as well as deliver a huge range of environmental, health and economic advantages (Wheeler, 2005). Nanotechnology is one of the most important tools in modern agriculture, and agri-food nanotechnology is anticipated to become a driving economic force in the near future. Nano agriculture focuses currently on target farming that involves the use of nano sized particles with unique properties to boost crop and livestock productivity. The development of nano materials could open up the novel applications in plant biotechnology and soil science. It is anticipated that very soon the industrial production of manufactured nano particles will be increased by manifold and released into the market. However with significant potential benefits, there are considerable uncertainties with regards to potential risks to the environment and human health that needs to be clarified. Application of nanotechnology in the various fields of agriculture is mentioned below:

Nanotechnology in Seed Science

Seed is the most important input determining productivity of any crop. Conventionally, seeds are tested for germination and distributed to farmers for sowing. In spite of the fact that seed testing is done in well equipped laboratories, it is hardly reproduced in the field due to the inadequate moisture under rainfed conditions. In India, more than 60 per cent of the net area sown is rainfed: hence, it is quite appropriate to develop technologies for rainfed agriculture. A group of research workers is currently working on metal oxide nano-particles and carbon nanotube to improve the germination of rainfed crops Khodakovskaya *et al.*, 2009 have reported the use of carbon nanotube for improving the germination of tomato seeds through better permeation of moisture. Their data show that carbon nanotubes (CNTs) serve as new pores for water permeation by penetration of seed coat and act as a passage to channelize the water from the substrate into the seeds. These processes facilitate germination which can be exploited in rainfed agricultural system.

It is shown that the physiological effects are related to the nanometer-size particle, effects of

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nano-TiO_2 (rutile) and non-nano-TiO_2 on the germination and growth of naturally aged spinach seeds were studied by group of research workers; Measuring the germination rate and the germination and vigour indexes of aged spinach seeds observed increase in those factors was at 0.25–4 per cent nanoTiO_2 treatment. During the growth stage, the plant dry weight increased, as was the chlorophyll formation, the ribulosebisphosphate carboxylase/oxygenase activity, and the photosynthetic rate. The best results were found at 2.5 per cent nano-TiO_2 (Lei *et al*., 2004).

Nano-Fertilizers for Balanced Crop Nutrition

In India, fertilizers along with quality seed and irrigation, are mainly responsible for enhanced food grain production from 1960s (55 mt) to 2011 (254 mt) coinciding with the spectacular increase in fertilizer consumptions from 0.5 mt to 23 mt respectively.

It has been conclusively demonstrated that fertilizer contributes to the tune of 35-40 per cent of the productivity of any crop. Considering its importance, the Government of India is heavily subsidizing the cost of fertilizers particularly urea. This has resulted in imbalanced fertilization and nutrient deficiency occurrence in some areas, nitrate pollution of ground waters due to excessive nitrogen application. In the past few decades, use efficiencies of N, P and K fertilizers have remained constant as 30-35 per cent, 18-20 per cent and 35-40 per cent, respectively, leaving a major portion of added fertilizers to accumulate in the soil or enter into aquatic system causing eutrophication. In order to address issues of low fertilizer use efficiency, imbalanced fertilization, multi-nutrient deficiencies and decline of soil organic matter it is important to evolve a nano-based fertilizer formulation with multiple functions.

Nano-fertilizer technology is very innovative but scantily reported in the literature. However, some of the reports and patents strongly suggest that there is a vast scope for the formulation of nano-fertilizers. Significant increase in yields has been observed due to foliar application of nano particles as fertilizer (Tarafdar *et al*., 2012a). It was shown that 640 mg/ ha foliar application (40 ppm concentration) of nanophophorous gave 80 kg/ ha P equivalent yield of clusterbean and pearl millet under arid environment. Currently, research is underway to develop nano-composites to supply all the required essential nutrients in suitable proportion through smart delivery system. Preliminary results suggest that balanced fertilization may be achieved through nanotechnology (Tarafdar *et al*., 2012b). Indeed the metabolic assimilation within the plant biomass of the metals, e.g. micronutrients, applied as nano-formulations through soil-borne and foliar application or otherwise needs to be ascertained. Further, the nano-composites being contemplated to supply all the nutrients in right proportions through the "smart" delivery systems also need to be examined closely. Currently, the nitrogen use efficiency is low due to the loss of 50-70 per cent of the nitrogen supplied in conventional fertilizers. New nutrient delivery systems that exploit the porous nano scale parts of plants could reduce nitrogen loss by increasing plant uptake. Fertilizers encapsulated in nanoparticles will increase the uptake of nutrients (Tarafdar *et al*., 2012c). In the next generation of nano fertilizers, the release of the nutrients can be triggered by an environmental condition or simply released at desired specific time.

Nano-Herbicide for Effective Weed Control

Weeds are menace in agriculture. Since two-third of Indian agriculture is under rainfed farming where usage of herbicide is very limited, weeds have the potential to jeopardize the total harvest in the delicate agro-ecosystems. Herbicides available in the market are designed to control or kill the above ground part of the weed plants. None of the herbicides inhibits activity of viable belowground plant parts like rhizomes or tubers, which act as a source for new weeds in the ensuing season. Fields infested with weeds and weed seeds are likely to produce lower yields than soils where weeds are controlled. Improvements in the efficacy of herbicides through the use of nanotechnology could result in greater production of crops. The encapsulated nano-herbicides are relevant, keeping in view the need to design and produce a nano-herbicide that is protected under natural environment and acts only when there is a spell of rainfall, which truly mimics the rainfed system.

Developing a target specific herbicide molecule encapsulated with nanoparticle is aimed for specific receptor in the roots of target weeds, which enter into roots system and translocate to parts that inhibit glycolysis of food reserve in the root system. This will make a specific weed plant to starve for food and gets killed (Chinnamuthu and Kokiladevi, 2007). Adjuvants for herbicide application are currently available that claim to include nanomaterials. One nano surfactant based on soybean micelles has been reported to make glyphosate-resistant crops susceptible to glyphosate when it is applied with the 'nanotechnology-derived surfactant'.

Nano-Pesticide

Persistence of pesticides in the initial stage of crop growth helps in bringing down the pest population below the economic threshold level and to have an effective control for a longer period. Hence, the use of active ingredients in the applied surface remains one of the most cost-effective and versatile means of controlling insect pests. In order to protect the active ingredient from the adverse environmental conditions and to promote persistence, a nanotechnology approach, namely "nano-encapsulation" can be used to improve the insecticidal value. Nano-encapsulation comprises nano-sized particles of the active ingredients being sealed by a thin-walled sac or shell (protective coating). Recently, several research papers have been published on the encapsulation of insecticides. Nano-encapsulation of insecticides, fungicides or nematicides will help in producing a formulation which offers effective control of pests while preventing accumulation of residues in soil. In order to protect the active ingredient from degradation and to increase persistence, a nanotechnology approach of "controlled release of the active ingredient may be used to improve effectiveness of the formulation that may greatly decrease amount of pesticide input and associated environmental hazards. Nano-pesticides will reduce the rate of application because the quantity of product actually being effective is at least 10-15 times smaller than that applied with classical formulations, hence a much smaller than the normal amount could be required to have much better and prolonged management.

Several pesticides manufactures are developing pesticides encapsulated in nanoparticles (OECD and Allianz, 2008). These pesticides may be time released or released upon the occurrence of an environmental trigger (for example, temperature, humidity and light). It is unclear whether these pesticides products will be commercially available in the short-term.

Nano-based viral diagnostics, including multiplexed diagnostics kits development, have taken momentum in order to detect the exact strain of virus and the stage of application of some therapeutic to stop the viral disease occurrence and its dispersal. Detection and utilization of biomarkers, that accurately indicate disease stages, is also an emerging area of research in bio-nanotechnology. Measuring differential protein production in both healthy and diseased states leads to the identification of the development of several proteins during the infection cycle.

Clay nanotubes (halloysite) have been developed as carriers of pesticides at low cost, for extended release and better contact with plants and they will reduce the amount of pesticides by 70-80 per cent, thereby reducing the cost of pesticide with minimum impact on water systems.

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11. FORESTRY

Urban Forestry: A Simpleway to Healthy Life

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The world is facing worst effect of global warming and the temperature is touching new peaks. Recent decades have been characterized by increased migration from rural to urban areas. As a result, since 2008 and for the first time in history, more than half the world's population lives in towns and cities, and this percentage is expected to swell to 70 percent by 2050. Cities reshape and alter natural landscapes as they expand, creating microclimates in which temperatures, rainfall and winds differ from those of the surrounding countryside. Urban development – as often practised – results in the depletion and degradation of natural ecosystems in and around urban areas, the drastic loss of vital ecosystem services1 and, potentially, little resilience to disturbances, such as those caused by climate change.2 As the world continues to urbanize, sustainable development challenges will increasingly concentrate in urban areas, particularly in lower- and middle-income countries, where urbanization has often taken place rapidly, spontaneously and with insufficient strategic planning, resulting in unsustainable patterns of land use. Increased emission of greenhouse gases resulted in global warming and related many environmental crisis on earth and human health. The effect of global warming is experienced more worst in urban areas comparing to all other places. Many activities are focusing on global warming mitigation. In this view urban forestry is gaining momentum in all over world. Usually urban areas are lack of green cover and contains concrete forest wherever we look, hence to change this phenomena urban forestry concept is included.

Urban forestry is the management of vegetation, particularly trees, in urban and suburban areas (e.g., cities, towns, villages, etc.). Urban forests include all trees within these areas and are often found among high concentrations of people and within an intricate fabric of natural and human-made structures and processes. Urban foresters work to sustain a healthy tree population to meet the increasingly diverse needs of an urban society. Good resource management and design of urban forests can lead to improved environmental quality, enhanced individual and community well-being, a wide range of services to individuals and communities, and a more healthy and comfortable environment for the vast majority of the nation's population.

Good resource management can enhance numerous benefits received from urban forests, including improved air and water quality; reduced air temperatures, noise, ultraviolet radiation at ground level, and building energy use; improved wildlife habitat; increased psychological, physiological, and community well-being; enhanced aesthetics; improved outdoor recreation; and increased worker productivity and property values. These benefits can have direct economic implications in urban areas and can lead to improved environmental quality and human health and well-being.

Urban forest managers are for the most part public employees that directly manage and care for the public tree resource, but they can also influence and help sustain forest health and benefits throughout the urban and urbanizing area. As most urban trees are on private property, ordinances and education are critical tools in helping to guide the management of private tree resources.

Delhi is facing worst effect of pollution due to increased vehicle population resulted by human population and reduced green cover. Delhi government banned vehicle purchase but it will be solution to maintain the pollution in current level but to reduce the pollution level and clean air the government and people should joint hands to plant more trees in open spaces, road side avenues, apartments and all open places. Pollution removal (O_3, PM_{10}, NO_2, SO_2, CO) varied among cities with total annual air pollution removal by US urban trees estimated at 711,000 metric tons ($3.8 billion value) (Nowak et al. 2006). Delhi is indicator city of nation so now all the metropolitan cities should wake up and plant trees and plan the cities construction with more green spaces not only for body health but also but mental wellness of people.

The software technicians and all other computer based workers are facing heavy mental illness and work stress due to their work and this can be sort out by planting more flowering trees in and around the work place. Trees will reduce the work stress by good oxygen supply and their blossoms, avian and butterfly attraction will distract the work stress of people. Urban open green spaces play an important role in offering town-dwellers a more stress free environment, irrespective of sex, age or socio-economic background. The more time people spend outdoors in urban open green spaces, the less they are affected by stress and related complaints (Grahn and Stigsdotter 2003). Tree planting and management activities also cause strengthening of community bonds and keeping crime rates low (Kuo 2003). Many research and ancient literatures prove that trees beauty and aroma of blossoms cure body and mental illness.

Rules must be framed for regulation of green spaces in new Construction in urban areas. Nowadays more awareness and passion created for planting of greens. Comparing to herbs and shrubs trees will provide more pleasure in all way.

Urban foresters often use tree inventories to gather information about the forest resource and how it is changing; and devote much of their time to tree care and maintenance activities (e.g., planting, pruning, tree removal). Urban foresters also develop management plans that help guide forest management and designs in the future. Since urban forestry is a relatively new area of scientific management and study, improvements in urban forest knowledge and how that knowledge is shared can significantly enhance future urban forest management and resource health, sustainability, and benefits. Emphasis areas to improve future management focus on developing management strategies that are collaborative and adaptive, and that incorporate improvements in inventory, dialogue, and collaboration, information, and information dissemination.

Engineers, Municipal corporations have to plan accordingly to mitigate the issues and people have to give more importance to trees than buildings. Policies have to be enumerated to increase the green cover particularly to urban areas. 40 % of urban areas should be green and government have to motivate people by giving tax relaxations and other incentives for having trees in their home. Malls, hospitals and corporate companies must have 30 % area as a green space. There is rule to keep fire distinguisher in every work place, such a way green spaces with flowering and fruiting trees must be set aside in every malls, corporate companies and hospitals. The licence of malls, companies and hospitals have to be banned where there is no green spaces.

Urban forestry will be the only solution to overcome global warming and stress related problems. Filling our place with greens will create pleasure environment and reduce the heat. Space is the biggest constraint in urban areas hence, terrace gardens can be planned and plant. There is no other substitute for nature and Nature’s services.

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12. PLANT PATHOLOGY

Etiology of Die Back Disease of Mango and their Management

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Mango (*Mangiferaindica* L.) belonging to Family Anacardiaceae is one of the important commercially grown fruit crops of the country. It is considered as the King of fruits. A native of southeastern Asia, and cultivated in India for the last 4000years, its cultivation has gradually been extended to other tropical and subtropical countries of the world (Popenoe, 1927). But, Mango is affected by a number of diseases at all stages of its development i.e. from nursery to harvest. The first report on die back of mango caused by *B. theobromae* in India was given by Gupta and Zachariah (1945). In orchards, both young and old trees are affected by die back disease particularly under conditions of neglect. So it is posing a serious threat to successful cultivation of mango. This disease has been recognized as a major bottleneck in raising the mango nursery due to mass mortality of seedlings. Young grafted plants also suffer from rapid necrosis and drying up of leaves. It is considered as one of the major constraints in mango nurseries.

Pathogens

Die back diseases of mango caused by *Colletotrichumgloeosporioides* (Penz.) Sacc and *Botryodiplodiatheobromae* Pat at all stages of its growth reported bySavant and Raut (2000)

Symptoms

In die back disease caused by *Colletotrichumgloeosporioides*, small necrotic spot on the tip of shoot and at the base of leaf petiole were observed initially. Later, they coalesced and developed large brownish black necrotic area. This infection spread gradually down wards and reached up to a length of 2-3cm from the shoot tip. The leaves attached to the infected shoot also dried up, shrivelled and became brownish black in colour and fell down from the infected twigs.

Whereas, in case of die back caused by *Botryodiplodiatheobromae*, black discolouration and darkening of bark of young green twigs were observed at first. These dark lesions increased in size and spread down wards and resulted in typical die back symptom. The leaves present on infected twigs turned black, brittle and rolled up wards. Leaf shedding was also observed in severe infection. Occasionally infection by this pathogen was seen on leaf margin which later spread to petiole and young twigs and resulted in die back symptom. The pathogen produced dark colouredpycnidium on the infected area which appeared as small dark dots.

Mode of Spread

1. Already disease infected material used as a scion for planting
2. Infected twigs are the main source for perpetuation and spread to next season
3. By using contaminated garden tools

Integrated Disease Management

Cultural Practices

1. The selection of mother plants should be free from dieback diseases where we collecting the scion material for grafting.
2. Dieback infected portion along with some healthy portion (3 inch below the infected branch or twigs) should remove while pruning
3. After pruning of infected branches should be collected and burnt

Chemical Method

- Carbendazim (0.1 per cent) is very effective fungicide against *C. gloeosporioides*and *B. theobromae* (Sharma andVerma, 2007: Patil*et al.*, 2007).
- After pruning infected twigs spray with any copper fungicide like copper oxy chloride (0.3 per cent) / copper hydroxide (0.15per cent).

Biological Method

1. Foliar spray with *Pseudomonas fluorescence* at 0.5 per cent concentration with 15 days interval after pruning of infected twigs.

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13. GENETICS AND PLANT BREEDING

Molecular Basis of Apomixis

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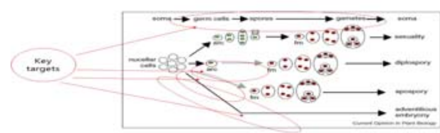
Introduction

Apomixis research has gained wide importance in last two decades due to its potential to revolutionize global agriculture. The prospect of inducing apomixis in crop plants may even dwarf the Green revolution and therefore apomixis was termed as 'Asexual revolution'. Apomixis is a method of asexual reproduction in seeds and because it can fix hybrid vigor, it has aroused wide attention among plant breeders. With apomictic breeding, genetic traits could be propagated indefinitely and seeds from the one harvest could be used to produce the next. But till date, scientists have been largely unsuccessful in their attempts to cross apomictic wild varieties with sexual crop varieties and to overcome that concerted efforts are needed to understand the molecular mechanisms underlying the apomixis so that we can easily produce 'clonal seeds' that retain all the genetic traits of the maternal parent without any of the shuffling of the genetic information.

Apomixis: Apomixis is an asexual mode of reproduction in which an ovule develops in seed without involving meiosis and fertilization.

Developmental Transitions during Sexual and Apomictic Developments (Grimanelli, 2012)



Changes at the developmental transitions are the key targets to identify the basis of apomixis

At least four transitions take place during reproductive development: first, the transition from soma-togerm cells, initiating megasporogenesis; second, the transition between the meiotic products and the functional megaspores (FMs), at the onset of megagametogenesis; third, the transition from the megaspore to the gamete; and fourth, the transition from the egg cell to the zygote following fertilization. Apomixis exists in different flavors depending on the species. In sporophytic apomixis, a somatic cell in the ovule differentiates directly into an embryo, entirely shortcircuiting the gametophytic generation. In gametophytic apomixis, by contrast, a gametophytic generation is formed, albeit containing unreduced female gametes. Two types of gametophytic apomixis have further been defined. In the diplosporous type, which occurs, for example, in Tripsacum, a wild relative of maize, or Boechera species, related to Arabidopsis, the soma-to-germ cell transition is unaffected; a single germ cell (the archespore) differentiates, but fails meiosis and produces an unreduced FM, which follows normal gametogenesis to form the embryosac (ES). In the aposporous type, several germ cells can differentiate. One of them undergoes sexual development, but usually aborts before forming functional ESs. One or several supernumerary germ cells, called aposporous initials and positioned adjacent to the sexual archespore develop directly into functional spores from somatic nucellar cells. These cells totally bypass the soma-to-germ transition and megasporogenesis. Thus, these different apomictic developments involve distinct shortcuts, but not necessarily alterations to the programs themselves. The embryo develops parthenogenetically in all three types of development, meaning that an unfertilized egg gives rise to the embryo without any paternal contribution.

Applications of Apomixis

Fixation of Heterosis

1. Maintenance of Homozygous lines
2. Production of vybrids

Limitations in finding out Genetic Basis of Apomixes

1. Estimation is tedious and time consuming
2. Affected by environmental factors
3. Maintenance of apomictic stocks is difficult
4. The genetic basis of apomixis is not clear

How to Overcome??

1. Answer lies in understanding the molecular mechanisms underlying the apomixis
2. What do concepts of molecular basis can offer???
3. Knowing the molecular basis:-
    a. Might allow the development of new molecular tools for the evaluation of germplasm
    b. Unreveal genetic basis of apomixis
    c. Identify genes or genomic regions that contribute apomixis, that may be used in MAS to increase selection efficiency

Molecular Basis of Apomixes

1. **The acquisition and restriction of reproductive fate:** Differentially expressed genes or mutations at gene level affect the reproductive fate and may affect the number of MMC, MiMC or Archespore per ovule and may result in differential phenotype that mimic the apomixis.
2. That involve-
    a. Differential genes associated with the restriction of additional sporogeneous cells i.e. MSP1,
    b. Mutations in meiotic genes

Control of Female Gamete Formation in ARABIDOPSIS

- Olmedo-Monfil *et al.* (2010) performed the **mutant** analyses and showed that the transition from somatic fate to reproductive fate in *Arabidopsis* ovules is controlled by the **ARGONAUTE 9 (AGO9)** protein.
- While single ovules normally differentiate a unique archespore, ***ago9*** alleles result in ovules with **multiple archespores.** Cell identity markers show that the supernumerary archespores in mutant ovules do not undergo meiosis, but directly differentiate into FMs, thus short-circuiting sporogenesis.
- *Ago9* mutants trigger gametogenesis (without sporogenesis) in somatic nucellar cell and thus mimic early stages of apospory.

Epigenetic Regulation

- Epigenetics" refers to heritable (through mitosis or meiosis) alterations in gene expression that are independent of DNA sequence; different epigenetically regulated forms of a genes are known as epialleles.
- Epigenetics can also generate epigenetic variation/epialleles which can potentially affect gene expression in hybrids.
- Comparison of transcript profile

Hypomethylation Promotes Autonomous Endosperm Development by FIS Mutants

1. Vinkenoog *et al.* (2000) through his studies on mutants displaying elements of autonomous apomixis in *Arabidopsis* led to identification of mutants such as *fertilization independent seed* (*fis*) class of mutants such as
    a. medea (mea),
    b. fertilization independent endosperm (fie) and
    c. fis2
2. Three genes of the *FIS* (*Fertilization*

independent seed) class repress endosperm formation in the absence of fertilization.

3. The disruption of *FIS* class genes leads to formation of endosperm in absence of fertilization due to disruption of a protein complex formed by these genes.
4. Autonomous endosperm development has been reported to progress further if *fis* is combined with genome wide hypomethylation, indicating that mechanisms operating in apomicts rely on deregulation of a larger number of genes.
5. To date, the bulk of research has been conducted in the model crop *Arabidopsis*, expanding research into other crops that display apomixis effects will contribute to advancing of understanding regarding the molecular basis of apomixis.
6. The functional studies to test whether epigenetic regulation is causally central to apomixis or not are currently lacking.
7. In the future, the integration of data from genome-wide association studies (GWASs), transcriptomics, epigenomics, proteomics and metabolomics studies should be used to build genetic models that explain apomixis at different stages of development.

"Yuan Long Ping father of hybrid rice, put forwarded a strategic suggestion for developing hybrid rice breeding. He suggested that there were several possible ways to fix heterosis, and among them the breeding of the apomixis line was the best."

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14. AGRICULTURAL ENTOMOLOGY

Current Status of Cotton Jassid, *Amrasca biguttula biguttula* (Ishida) and its Management

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Introduction

Cotton, *Gossypium hirsutum* is a natural fibre of great economic importance as a raw material in textile industry; and is predominantly cultivated in most of the cotton producing countries of the world including India. India has largest area of cotton in the world but the productivity is still at the lower side. The major cause for the lower productivity in cotton is damage by insect pests. More than 90 per cent of cotton area is under Bt cotton. Adoption of Bt cotton has not only changed the cultivation profile, but also the pest scenario. While there is a decline in the pest status of bollworms; the sap sucking insects, *viz.,* aphids, jassids, mirids and mealy bugs are emerging as serious pests as Bt cotton is susceptible to the sucking insect pests. Among these sucking pests, the jassid, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae) is important causing serious damage to cotton to the tune of 20 % every year (Dhawan *et al.,* 1988).

Damage

Both adults and nymphs cause damage to cotton leaves by sucking plant sap mainly from under surface of leaf and injecting toxic saliva into plant tissues. Leafhoppers occur at all the stages of the crop growth. Since, these pests suck the sap from the leaves; it leads to reduction in growth and vigour of the plants. In severe case of infestation, the plants get dried up and eventually die. However, *A. biguttula biguttula* is a polyphagus pest of economically important agricultural crops and non agricultural plants. This pest is active throughout the season but its higher incidence is observed mainly in September and October (Soni and Dhakad, 2016).

The infested leaves curl downward; turn yellowish, then brownish before drying and shedding. Severe incidence leads to stunting of plants and results in a symptom called "hopper burn". The boll forming capacity of the affected plants is significantly reduced and heavy infestation on young plants may lead to death of plants.

Life Cycle

The average developmental periods of egg, first, second, third, fourth and fifth nymphal instars were found to be approximately 6.65, 2.25, 3.0, 2.90, 2.60 and 1.55 days, respectively and the total nymphal period was 12.30 days. The fecundity was 17 eggs on an average. The life cycle varies from 27 to 35 days (Shreevani *et al.,* 2013).

Identification of the pest: Egg- elongated, yellowish-white in colour and deeply laid in the midribs of veins on the under surface of leaf. Nymph- Light green, translucent, wingless found between the veins of leaves on the under surface. Adult- Green, wedge shaped leafhopper.

Management

Conventional insecticides are widely used in the control of jassids but this has led to serious problems *viz.,* pest resistance, resurgence, secondary pest outbreak, pollution and health hazards. So, it is better to adopt integrated pest management practices and need based use of synthetic insecticides at Economic threshold Level (ETL) of 50 nymphs or adults/50 leaves. The following management practices can be undertaken:

1. Varietal resistance: Hairy cultivars (*e.g.,* PKV 081, NHH 44, PKV Hy2 *etc.*) are successfully used to resist jassids. The intra-*hirsutum* hybrid AHH 468 and *hirsutum* varieties G. Cot 12, G.Cot 10, Khandwa 2, DHY 286, B 1007 are tolerant to jassids.
2. Cultural practice:
   a. Timely sowing (*e.g.* Whole April month in Punjab)
   b. Judicious use of irrigation and fertilizers
   c. Removal of weeds acting as alternate hosts of insect pests
3. Use of botanicals: Neem seed kernel extract @ 5%, neem formulations @ 2 l/ha and neem or karanj oil @ 1%, having antifeedant / deterrent properties are useful against the pest. Neem oil and datura @ 2% concentration were found effective and non-significantly different in minimizing jassid infestation 24, 72, 168 and 240 hours after application (Khan *et al.,* 2013). Therefore, these botanicals can prove to be a good alternative to the use of synthetic insecticides at lower pest densities.
4. Chemical:
   a. Prevention is better than cure. So, approach of pre-sowing seed treatment with systemic insecticides such as, Imidacloprid @ 5 g / kg seed can be practiced. This will protect the plants at young stage.
   b. Economic threshold level based application of one of the following insecticides:
      i. Imidacloprid 17.8 SL @ 100-125 ml/ha, Acetamiprid 20%SP @ 50 g/ha, Azadirachtin 0.03%WSP @ 2500-5000 g/ha, Buprofezin 25% SC @ 1000 ml/ha, Clothianidin 50%WDG @ 30-40 g/ha (foliar spray), Clothianidin 50%WDG @ 200-250 g/ha (soil drench), Diafenthiuron 50%WP @ 600 g/ha, Dinotefuran 20% @ 125-150 g/ha, Fipronil 5%SC @ 1500-2000 ml/ha, Flonicamid 50% WG @ 150 g/ha, Thiacloprid 21.7% SC @ 100-125 ml/ha, Thiamethoxam 25%WG@ 100 g/ha.
5. Transgenic cotton lines expressing *Allium sativum* Agglutinin (ASAL) for enhanced resistance against cotton jassid have been developed recently (Vajhala *et al.,* 2013).

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15. SEED SCIENCE AND TECHNOLGOY

Seed Storage

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Introduction

The ability of seed to tolerate moisture loss allows the seed to maintain the viability in dry state. Storage starts in the mother plant itself when it attains physiological maturity. After harvesting the seeds are either stored in ware houses or in transit or in retail shops. During the old age days, the farmers were used farm saved seeds, in little quantity, but introduction of high yielding varieties and hybrids and modernization of agriculture necessitated the development of storage techniques to preserve the seeds. The practice of storing the seeds starts from the ancient days itself, following simple and cheap techniques e.g. Placing the seeds in salt, red earth treatment to red gram etc. But the same practices are not hold good for the present day agriculture. Preparing for successful seed storage should begin with seed handling during harvesting and post harvest handling prior to storage. The key points in proper seed handling before storage are:

- Minimize insect infestation in the field by timely harvest and removal of seed from the field. This is particularly true with legumes that are prone to weevil attack in the field.
- Dry the seed sufficiently to prevent micro-organism growth, insect growth, and reduce the respiration rate of the seed
- Eliminate insect-infested seed before storage which in effect will remove sources of future infestation or contamination.
- Select a storage method and storage environment appropriate for the seed type and size as well as seed storage duration.
- Treat the seed with a suitable traditional or chemical insecticide to control insect infestation. In a warehouse situation fumigation with gas is done on a periodic basis.

Storage insects are a major threat to seed storage in most countries. Generally two classes of storage insects: primary feeders that can attack the whole seed, and secondary feeders that can only attack damaged seed. Most storage insects are small and require close observation for detection. The essential factors in control of storage insects are:

- Proper drying of seed to low moisture content has a negative effect on biological activities of many insects.
- Sanitation of the storage containers, such as bags or barrels, and of the storage structure is important so insects or larvae are removed prior to storage of newly harvested seed.
- Several insects attack the seed while it is drying in the field and then the insects or insect larvae remain with the seed when it is stored and continue to feed and multiply; prompt removal of the seed from the field is crucial to minimize initial infestation.
- Treating seed with non-chemical or chemical means after harvest to reduce

losses during storage.

Rodents are avoided from storage area that is well organized and clean. Rodent-proof storage denies rodents a place to live and hide or denies them access to the seed. Micro-organisms also can attack if the moisture content of the seed is high due to poor drying or high relative humidity, particularly fungi. So Sufficiently dry seed are less affected by fungi.

Stored seed must be inspected on a regular basis to detect problems and correct them. Periodic inspections should include the following points:

- Inspect the inside of the building for moisture such as leaks in the roof, dampness on the floor, or water stains on the walls. Note signs of rodent activity: places of entry, faeces, damage, and places to hide. Observe insect activity in the floor, walls, bags, or air, and cracks where insects can hide. Any musty odours that suggest a mould problem.
- Keep bags with seed off the floor, moisture can migrate from the floor into the bag and can affect seed moisture content, seed deterioration rates, and seed germination. Bags should be placed on pallets or tree branches placed in a lattice form on the floor.
- Inspect the outside of the building for drainage or erosion problems, signs of rodent paths and holes, and the presence of trash or weeds which should be removed from around the building in order to deny rodent and insects a place to hide.
- Inspect the seed inside the bags or storage container for insects or moisture.

Seed purchased for emergency operations should be received and distributed without delay. Storing seed for prolonged periods of time (more than a few months) should be avoided. If seed stored for long periods, there is a need to ensure proper relative humidity and temperature of the storage facility and monitoring of the condition of the seed through periodic storage inspections.

Hermetically Sealed Storage

Hermetically sealed storage is mostly used for high value seeds like vegetable seed. In this method, the seeds are dried to low moisture content (8%) and sealed in moisture proof packets or tins that do not allow migration of moisture and air. However if the seed is not sufficiently dry and the temperature is high the seed will reach the equilibrium moisture content with the available air in the container, seed respiration will increase, moisture will form inside the sealed container and this will be an ideal environment for the development of fungi and the further deterioration of the seed. For this reason in emergency operations cereal seed of high moisture content in five kilogram sealed plastic bags can be a concern when they must be stored for extended period at high temperatures.

Summary

Temperature and relative humidity of the storage environment are two critical factors for seed storage. The moisture content of particular crop also important. The lower the temperature and relative humidity the longer the safe stored. Therefore in emergency operation seeds should not be stored for extended periods in tropical conditions to avoid problems of seed deterioration due to high temperature and relative humidity.

16. SEED SCIENCE AND TECHNOLOGY

Seed Quality: A Base to Food Security

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Introduction

Seed is a basic input in agriculture. Seed is an embryo, a living organism embedded in the supporting or the food storage tissue. Quality seed is defined as varietal pure with a high germination percentage free from disease & disease organisms, and with a proper moisture content and weight. Quality seeds ensure good germination, rapid emergence and vigorous growth.

Importance of Quality Seed

6. Ensures genetic and physical purity of the crops
7. Gives desired plant population
8. Capacity to withstand the adverse conditions
9. Seedlings produced will be more vigourous, fast growing and can resist pest and disease incidence to certain extent
10. Ensures uniform growth and maturity
11. Development of root system will be more efficient that aids absorption of nutrients efficiently and result in higher yield.
12. It will respond well to added fertilizer and other inputs.
13. Good quality seeds of improved varieties ensures higher yield atleast 10 – 12 %

Major Seed Quality Characters

Seed quality is the possession of seed with required genetic and physical purity that is accompanied with physiological soundness and health status. The major seed quality characters are summarized as below.

1. Physical Quality: It is the cleanliness of seed from other seeds, debris, inert matter, diseased seed and insect damaged seed. The seed with physical quality should have uniform size, weight, and colour and should be free from stones, debris, and dust, leafs, twigs, stems, flowers, fruit well without other crop seeds and inert material. It also should be devoid of shriveled, diseased mottled, moulded, discoloured, damaged and empty seeds. The seed should be easily identifiable as a species of specific category of specific species. Lack of this quality character will indirectly influence the field establishment and planting value of seed. This quality character could be obtained with seed lots by proper cleaning and grading of seed (processing) after collection and before sowing / storage.
2. **Genetic purity:** It is the true to type nature of the seed. i.e., the seedling / plant / tree from the seed should resemble its mother in all aspects. This quality character is important for achieving the desired goal of raising the crop either yield or for resistance or for desired quality factors.
3. **Physiological Quality:** It is the actual expression of seed in further generation / multiplication. Physiological quality characters of seed comprises of seed germination and seed vigour. The liveliness of a seed is known as viability. The extent of liveliness for production of good seedling or the ability of seed for production of seedling with normal root and shoot under favorable condition is known as germinability. Seed vigour is the energy or stamina of the seed in producing elite seedling. It is the sum total of all seed attributes that enables its regeneration of under any given conditions. Seed vigour determines the level of performance of seed or seed lot during germination and seedling emergence. Seed which perform well at sowing are termed as quality seed and based on the degree of performance in production of elite seedling it is classified as high, medium and low vigour seed. The difference in seed vigour is the differential manifestation of the deteriorative process occurring in the seed before the ultimate loss of ability to germinate. Difference in seed vigour will be expressed in rate of emergence, uniformity of emergence and loss of seed germination. Hence it is understood that all viable seeds need not be germinable but all germinable seed will be viable. Similarly all vigourous seeds will be germinable but all germinable seed need not be vigourous. Physiological quality of seed could be achieved through proper selection of seed (matured seed) used for sowing and by caring for quality characters during extraction, drying and storage. Seed with good vigour is preferable for raising a good plantation as the fruits, the economic come out are to be realized after several years. Hence selection of seed based on seed vigour is important for raising perfect finalize plantation.
4. **Seed Health**: Health status of seed is the absence of insect infestation and fungal infection, in or on the seed. Seed should not be infected with fungi or infested with insect pests as these will reduce the physiological quality of the seed and also the physical quality of the seed in long term storage. The health status also includes the

deterioration of seed which also expressed through low vigour of seed. The health of seed influences the seed quality characters directly and warrants their soundness in seed for the production of elite seedlings at nursery / field.

Summary

Hence the quality seed should have high germinability, high vigour, high genetic purity, higher field establishment, free from pest and disease, optimum moisture content for storage. A quality seed gives rise to a better production, increases national income, improves food security and a hunger free food safety nation.

17. AGRONOMY

Canola: An Emerging Oilseed Crop

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Oilseed crops have an important place in agriculture and industrial economy of India. These crops occupied second major group of agricultural crops with 25.7 million hectares and production of 26.7 million tonnes during 2014-15 (Anonymous 2015). The country is facing acute shortage of edible oils since last two decades and current annual production of edible oilseeds in the country fulfils only about 50 per cent of the domestic requirements. The demand for edible oils is further increasing at the rate of 4-6 per cent per annum (Anonymous 2014). This indicates that the country needs to more than double the oilseeds production, which will indeed be a big challenge, requiring efforts much beyond being pursued until now. So, in order to meet the needs of growing demand, reorientation of existing techniques is required to boost the production of oilseed crops.

Among various oilseed crops grown in India, rapeseed-mustard group of crops are next to soybean in terms of area and production. In India, rapeseed and mustard were sown on 5.8 million hectares with a production of 6.3 million tonnes during 2014-15 (Anonymous 2015). Rapeseed-mustard group of crops occupies 22.5 per cent of total cultivated area under oilseeds (25.7 mha) and contributes 23.5 per cent to total production of oilseeds (26.7 MT) in the country (Anonymous 2015).

The Indian cultivars, due to high content of erucic acid and glucosinolates, have limited preference in international market. Canola is an internationally accepted nomenclature for Brassica varieties having less than 2% erucic acid in the oil and less than 30 micro moles glucosinolates per gram defatted meal. Oil rich in erucic acid is not desirable for edible purposes as it causes thickening of arteries and leads to heart problems. Similarly, the defatted meal of non canola varieties when used as animal feed reduces appetite, reproductivity and affects thyroid activity leading to thyroid associated health problems. Elimination of long chain erucic acid in the canola varieties is accompanied by increase in the proportion of desirable MUFA (oleic acid) from 10-20% to about 60-65%. The oil from canola varieties is healthy oil for human consumption.

Climatic Requirements: The rapeseed and mustard crops grow well in areas having 25 to 40 cm of rainfall. Taramira is preferred in low-rainfall areas, whereas raya, gobhi sarson, African sarson and toria are grown in medium to high rainfall areas.

Soil Type: The rapeseed and mustard grow best on well-drained, light-to-medium textured soils. Raya, gobhi sarson and African sarson may be grown on all soil types, toria should be grown preferably on loamy soils. Taramira does well on sandy and loamy-sand soils.

Canola Varieties

RLC 3 (2015): This is the first canola quality variety of raya in the country. It is a yellow seeded, medium tall variety which is recommended for general cultivation in the state under timely sown irrigated conditions. It is resistant to white rust. Its average seed yield is 7.3 quintals per acre with 41.5 per cent oil content. It matures in 145 days.

Gobhi Sarson

GSC 7 (2014): This variety is recommended for cultivation under timely sown irrigated conditions. It is a medium tall variety which is free from white rust and is tolerant to Alternaria blight. It has lusterous brownishblack seeds. Its average yield is 8.9 quintals per acre with 40.5 per cent oil content. It matures in 154 days.

GSC 6 (2007): This variety is recommended for cultivation in the state for timely sowing under irrigated conditions. It has lustrous bold seeds. Its average yield is 6.1 quintals per acre, with oil content of 39.1 per cent. It matures in 145 days.

Hyola PAC 401 (2004): This hybrid is recommended for general cultivation in Punjab under timely sown irrigated conditions. Its seeds are brownish black and lustrous. It contains 42 per cent oil. The average seed yield is 6.7 quintals per acre. It is medium statured and matures in 150 days.

Preparatory Tillage: A fine seedbed is required to ensure good germination. In irrigated areas, two to four ploughings are required. Planking is done after every ploughing. In rainfed areas, one or two ploughings each followed by planking are sufficient.

Time of Sowing: October10-30 is theoptimum time of sowing for rapeseed and mustard.

Seed Rate and Spacing: 1.5 kg seed per acre is used for rapeseed-mustard. Gobhi sarson should be sown in rows, 45 cm apart with plant to plant distance of 10 cm. For sowing of canola gobhi sarson GSC 6 and PAC 401 during November, reduce row to row spacing to 30 cm and maintain plant to plant spacing of 10 cm.

Methods of Sowing: These crops are sown with a drill or a pora attached to a plough. Thinning is done three weeks after sowing to maintain plant to plant distance as per requirement depending on the crops.

Fertilizer Application

Crop	Nutrients (kg/acre)			Fertilizers (kg/acre)		
	N	P_2O_5	K_2O	Urea	Super-phosphate	Muriate of Potash
Raya and Gobhi sarson	40	12	-	90	75	-

In rayaandgobhi sarson drill 1/2 N and full phosphorus and potassium before sowing and the remaining 1/2 N with first irrigation.

Weed Control: One hoeing to toria after the third week of sowing and one or two hoeings preferably with improved wheel hand hoe to raya and gobhi sarson are adequate.

Irrigation: Raya and gobhi sarson sown after heavy pre-sowing irrigaton (10-12 cm), should be irrigated 3 to 4 weeks after sowing to promote deeper rooting and for better utilization of applied fertilizer.

In raya, if necessary, second irrigation at flowering stage may be given. If the crop is threatened by frost damage, the second irrigation may be given earlier. In gobhi sarson, second irrigation may be given at the end of December or begining of January. The third and the last irrigation be given during second fortnight of February. The crop should not be applied any irrigation, thereafter, as it may lead to lodging.

Harvesting and Threshing: Harvest the crop when pods turn yellow. Timely sown raya is ready for harvesting in in March and gobhi sarson in first fortnight of April. Owing to grain shattering in gobhi sarson care should be taken to harvest it at the proper time. The harvested crop should be stacked for 7-10 days before threshing.

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18. AGRONOMY

Significance of Agronomic Practices in Integrated Weed Management

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Introduction

The topic of IWM was first discussed and introduced by Buchanan in 1976 in a paper on "Crop manipulation in integrated weed management systems". After a symposium in 1981 and another in 1990 discussing IWM and its components, there was an increased awareness of integrating weed management practices. These symposia helped to stimulate additional research, teaching, and participation in the use of IWM. This paper will examine the success and current activity of IWM and offer suggestions for future directions for research and education. It was also described by Buchanan as "the application of many kinds of technology in a mutually supportive manner." It involves the deliberate selection, integration, and implementation of effective weed control measures with due consideration of economics, ecological, and sociological consequences". In the 1990 symposium, IWM was defined as "the integration of effective, environmentally safe, and socially acceptable control tactics that reduce weed interference below the economic injury level."

Aims

Integrated Weed Management aims at:

1. Preventing weeds from spreading by:
    a. Cleaning farm machinery and vehicles before transporting, to avoid risk of spreading weeds;
    b. Cleaning the hair and feet of animals before moving to new areas;
    c. Controlling the weeds in feed and bedding grounds;
    d. Using only well stored and rotted manure (4-5 months), possibly improve decomposition;
    e. Making sure that soil disturbances are immediately reseeded
    f. When possible, practicing weed control on all aspects of the farm, including irrigation canals, drainage ditches, fence lines, stockyards, and farm roads.
2. Improving knowledge of the identification and effects of different types of weeds.
3. Monitoring and map the spread of weed populations and the resulting damage
4. Making control decisions based on full knowledge of potential damage, cost of control methods, and the environmental impact of the control strategy.
5. Using combinations of (preferably biological) weed control strategies to reduce the weed populations, these can include: winter cover crops, mulching, crop rotations, natural competition (*e.g.* ryegrass), livestock grazing, proper seedbed preparation, selecting locally adapted varieties, proper fertilizer application, stimulating bio-control by insects, mowing, hand weeding, and try to avoid, when possible herbicide application, tillage, and burning
6. Evaluate and monitor the effectiveness and (environmental) effects of control strategies.

The Future of IWM

If IWM is to continue to be successful in the coming decades, it must be able to adjust to environmental, economic, and social changes. IWM must be more than a mandated program advocated only by research scientists and government policy analysts. It must be part of a larger systems approach that includes environmental, economic, and social concerns that have not been traditionally part of agricultural research but to which agriculture has relevance. IWM must be explained in terms of agroecosystems, and the benefits and limitations must be addressed explicitly so people from across the sociopolitical spectrum (environmental activists, ranchers, farmers, urbanites) can make informed decisions. There may be unease with the agroecosystem health approach because of its unfamiliarity and early stages of development as a concept. We believe that agroecosystem health is a useful communication tool that can help educate people about why IWM is an important part of agriculture's future. The task of implementing IWM within agroecosystem approaches is daunting. Nonetheless, progress has been made and IWM is beginning to move from the conceptual to the applied phase. Though technological improvements in herbicide chemistry, genetic engineering of crops, and application systems such as global positioning systems will be important components of IWM, technology alone cannot obviate biophysical limits indefinitely. Technological advances need to be considered in our approach to examining and managing agroecosystems.

Component of IWM

1. Physical control
2. Chemical control
3. Biological control
4. Cultural/ Agronomic control

Role of Agronomic Control in IWM

Different agronomic practices are used in IWM along with physical, chemical and biological practices. Some practices are discussed below-

Inter-Row Cultivation

Shallow inter-row cultivation can be used effectively within conservation tillage systems. Inter-row cultivation may be timed to coincide with the time period when weeds are most likely to interfere with the crop. To control weeds within the row, herbicides may be sprayed in a band over the row. Banding of herbicides and inter-row cultivation reduced herbicide use by 60% in a ridge-till system yet maintained crop yields.

Cover Crops

Cover crops may be sown into extant crops or the crop residue left after harvest to reduce the time when weeds grow in absence of competition from crops. A cover crop's biomass and canopy helps it compete with weeds. Autumn-sown cover crops will compete with winter-annual weeds; however, the cover crop dies over the winter and the residue often decomposes before suppression of summer-annual weeds can occur. Winter-hardy cover crops compete with summer-annuals but require a quick-acting herbicide, *e.g.*, glyphosate. At present, the utility of cover crops is limited. While cover crops and their mulches do not inhibit crop growth in soybean (*Glycine max* (L.) Merr.) or corn (*Zea mays* L.), increase soil moisture (except in dry years), and decrease temperature fluctuations, the large amount of temporal and spatial variability in weed populations has negated any effects on weed germination, emergence, density, and biomass. The main advantage of cover crops may be reduced soil erosion and improved soil structure and nutrient cycling.

Planting Patterns

Narrower rows and increased crop density can increase crop canopy and the ability of crops to compete with weeds for light and soil nutrients in soybeans and white beans. Despite concerns about increased intraspecific crop competition and disease incidence, yields of corn, soybeans, and white beans in narrower rows either do not change or increase. Often, planting patterns are used with more competitive cultivars, e.g., taller cultivars that are better suited to higher densities. Using narrower rows and increased crop density to reduce weed interference is effective in conservation and conventional tillage systems.

Crop Rotation

Crop rotations may reduce pathogenicity, decrease chances of resistance to pesticides, and stabilize nutrient cycling. Crop rotations are an important part of IWM and the more diverse the rotation, the easier it is to manage weeds. Nonetheless, one sequence will not necessarily increase or decrease weed interference and alter weed species composition. For example, eliminating fallow in crop rotations but introducing conservation tillage did not change weed species composition. Longer-term cropping system studies are needed to examine if differences in crop rotations will affect weed population dynamics in a predictable manner. Predicting when to implement weed control is complicated by genetic and environmental variation. Thus, effective models of weed morphological development, population dynamics, crop-weed competition, and the

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economics of weed management measures under varying conditions are needed. Modeling attempts to combine many factors to determine if control measures will be needed in the short- and longterm. It addresses an important challenge for weed science: a shift from descriptive to predictive approaches. Before such models become practical, however, there are several aspects that need to be explored in detail.

Weed Seed Germination and Seedling Emergence

The time of weed seed germination and seedling emergence, relative to the crop, influences crop yield loss from weed competition. Practical implementation of critical periods and weed economic thresholds require the ability to predict when weeds will emerge. Predictions of germination and emergence are confounded by genetic, climatic, and management-induced environmental variation, especially in terms of soil moisture and temperature and their interaction. Germination and emergence models are being developed for several weed species in different tillage systems in our laboratory and elsewhere.

Critical Periods of Weed Control

Predicting the timing of weed emergence relative to the crop will help determine the critical period of weed control, *i.e.*, the time interval when it is essential to maintain a weed-free environment to prevent yield loss. The critical period of weed control consists of two subunits: (a) the critical weed-free period-maximum length of time weeds emerging with a crop can be allowed to grow until they begin to cause unacceptable yield losses, and (b) the critical weed removal period-minimum length of time weeds that emerge after a crop must be removed so that unacceptable yield losses do not occur. Critical periods can be used to determine when farmers should apply herbicides. To account for environmental variation, critical periods are defined relative to the crop growth stage. Even with this proviso, the spatial and temporal variation may be so large that critical periods need to be defined for specific crop-weed-site-year locations. Predictive models are not yet feasible and probably will not be until weed germination and emergence can be predicted. In general, critical periods in white beans, corn, and soybeans are relatively short if the acceptable yield loss is defined as 5%. This means that the biological and economic value of applying herbicides is low except within a very narrow time period. Thus, season-long residual herbicides may not be needed and non-residual post-emergence herbicides may be timed effectively to reduce cost and amount of herbicide

19. AGRICULTURE

Resource Conservation Technologies for Enhancing Productivity of Cereals and Legumes based Cropping Systems

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Indian agriculture has been successful in achieving increased food grains production albeit at a low level of nutrition. While the mission of increasing foodgrains production stands somehow achieved without major jump in pulses productivity and production in country, these were accompanied by widespread problems of resource degradation, which now pose a serious challenge to the continued ability to meet the demand of an increasing population. Therefore, primary food security concerns are focused on improving and sustaining their productivity. Resource conservation technologies are such innovations which hold good opportunity in increasing productivity and soil health in legume and cereal based cropping systems.

Resource Conservation Technologies (RCTs)

Resource conservation technology (RCT) refers to the practice that enhances resource or inputuse efficiency such as zero or reduced tillage, new varieties, laser land leveling, bed and furrow configuration for planting crops, etc. Resource Conservation Technologies (RCTs) refersto any technologies that are cost and input use efficient as compare to the existing technologies in use.

Practices of RCT s in Legume and Cereal based Cropping Systems

System of Rice Intensification (SRI)

The system of rice intensification (SRI) is a low water requiring, labor-intensive method that uses younger seedlings widely planted singly and typically hand weeded with special tools. It is an evolving set of principles and practices which aims to enhance the rice productivity by changing the management of plant, soil, water and nutrient.

Principles of SRI: Major SRI principles include:

- Raising seedlings in carefully managed nurseries
- Careful transplanting of single, young (8–15 days old) seedlings
- Wider plant spacing (starting at 25X25 cm, but going up to 50X50 cm)
- Intermittent irrigation to avoid permanent flooding during the vegetative growth phase
- Addition of nutrients to the soil, preferably in organic forms such as compost instead of chemical fertilizers
- Intensive manual or mechanical weed control without herbicide use.

Advantages of SRI

1. Lower seed rate- 5-7.5 kg/ha
2. Water saving by 30-40 %
3. Higher grain yield by 50-100 %
4. Resistance to insect, pest and diseases
5. Less weed problem
6. Profuse crop growth and development (30-50 tillers/plant)
7. Less lodging due to vigorous root growth and strong stem
8. Positive correlation between number of panicles and size of panicles
9. 1-2 weeks reduced crop period
10. 10-15 % higher out-turns of milled rice.

System of Wheat Intensification

System of Wheat Intensification (SWI) which is based on the principles of system of rice intensification (SRI) is a new wheat cultivation technique which demands to maintain plant of 20X20 cm. This kind of sowing with proper plant density allows for sufficient aeration, moisture, sunlight and nutrient availability leading to proper root system development from the early stage of crop growth.

Elements of SWI

1. Improved seed-8-13 kg/acre
2. Seed treatment

   Procedure for Seed Treatment under SWI:

   a. Grade out bold seeds separately from lots of improved seed
   b. Take 10 liter of hot water (60 degree Celsius) in an earthen pot
   c. Dip 5 Kg of improved graded seeds in it
   d. Remove the seeds which float on the top of water
   e. Mix 2 kg well decomposed compost, 3 liter cow urine and 2 kg of jaggery
   f. After mixing it properly, keep the mixed material as such for 6-8 hour
   g. After this, filter it so that solid materials along with seeds and liquids get separated
   h. After that, mix 10 gm of fungicide properly and keep in shade for 10-12 hrs
   i. Then wheat gets germinated. The germinated seed is used for sowing in the tilled field.
3. Wider spacing (20X20) and line sowing by dibbling
4. Gap filling within 10 days of sowing
5. Application of organic manure (5 t/ha) and weeding by conoweeder
6. Irrigation (15, 30, 45, 60, 80 and 100 days after sowing)

Sequential Cropping

Sequential cropping is a kind of multiple cropping systemin which two or more crops are grown in sequence within a year, once crop being sown after the harvest of the other crop to break the monotony of crop rotation. Sequential cropping (rice-wheat-mungbean) provides safeguard against crop failure, enrich soil fertility and improves nitrogen economy.

Intercropping

Intercropping is the practice of growing two or more crops in proximity. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. Apart from increasing profitability and resource use efficiency, pulses as intercrop act as safe guard under unprecedented moisture stress condition

Conservation Tillage

According to the Conservation Technology Information Center USA, conservation tillage is defined as: "any tillage or planting system in which at least 30% of the soil surface is covered by plant residue after planting to reduce erosion by water; or where soil erosion by wind is the primary concern, with at least 1120 kg ha^{-1} flat small grain residue on the surface during the critical wind erosion period. Zero-tillage, mulch tillage, ridge tillage, contour tillage etc are different type of conservation tillage.

Utilization Ofrice-Fallows

The timely sowing of pulses is crucial in view of the moisture deficit during critical periods in the rice fallow conditions. The farmers usually broadcast the seeds to take advantage of residual moisture in rice fallow. The mechanization in such conditions needs development, standardization and adoption of farm machinery for direct seeding under residue retained on the soil surface. These mono-cropped areas can be used for double cropping by relay planting small seeded lentil or lathyrus.

Inclusion of Mungbean in Rice-Wheat System

Inclusion of (dual purpose) mungbean during summer months in rice-wheat system may help in increasing the productivity of the system, soil fertility, pulse availability and additional income. Mungbean can be grown after the harvest of wheat and before transplanting/ sowing of rice during April to June. Matured pods are picked up and the residues left ploughed down into the soil.

Direct Seeded Rice

DSR, an alternative to transplanted rice for saving labor and water. Rice can be sown directly on dry soil or on puddle soil (by broadcasting or drum seeder). It is labor, fuel, time & water-saving technology. DSR can be practiced in different ecologies including upland, lowland, deep water & irrigated condition. DSR save 35-40% of irrigation water.

Turbo Happy Seeder

Turbo happy seeder (THS) is a planter capable of direct drilling in the fields with surface retention of residues and without any soil disturbance which in turn take care of 2 of the 3 basic elements of CA. The direct drilling (zero tillage) operation saved on labour, water, energy, reduce cost of production and improved maintain soil heath while facilitating timely planting with similar or higher crop productivity. The THS has a provision of direct drilling of seed and fertilizers at desired seed and fertilizer rates, depth and spacing in one go.

Legumes under Raised Bed Planting System

Technology of raising row crops on beds and furrows system is gaining popularity amongst the progressive farmers, mainly because the cost of crop production is considerably reduced as a result of minimum tillage, water saving, *etc.* Furrow irrigated raised bed (FIRB) technology of crop production saves about 30-40 percent irrigation water; reduce seed requirement and fertilizers (by 25-30%) as compared with flat system, reduce chances of plant submergence due to excessive rain or over irrigation, less crusting of soil around plants and, therefore, more suitable for saline and sodic soils.

Summary

Attaining food security for a growing population and alleviating poverty while sustaining agricultural systems under the current scenario of depleting natural resources, negative impacts of climatic variability, spiraling cost of inputsare the major challenges before the Indian agriculture.

Under the changing climatic scenario and limited resource availability, resource conservation technologies (RCT) holds ample opportunity to make the agriculture sustainable and profitable through balance utilization and recycling of certain resources with adoption of certain innovative technologies such as zero or reduced tillage, new varieties, laser land leveling, bed and furrow configuration for planting crops, etc.

20. AGRONOMY

Innovative Agro-Techniques for Enhancing Water Productivity of Crops under Water Deficit Areas

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Water is the basis of life, it is an irreplaceable input. Water is a major component for crop production. Annual precipitation in India including snowfall is 4000 BCM. Presently, the groundwater utilization is about 1280 BCM and major portion (92%) is being used for irrigation. Scarcity of water resources and growing competition for water in many sectors reduce its availability for irrigation. Effective management of water for crop production in water scarce areas requires efficient approaches. Promoting water saving agro techniques will not only increase water productivity, but also facilitate the structural adjustment needed for agriculture.

Water Productivity

Productivity is a ratio between a unit of output and a unit of input. The term water productivity is used exclusively to denote the amount or value of product over volume or value of water depleted or diverted. The value of the product might be expressed in different terms (biomass, grain yield). The so-called 'per drop more crop' approach focuses on the amount of product per unit of water.

Key Principles for Improving Water Productivity

- Increase the marketable yield of the crop for each unit of water transpired by it;
- Reduce all outflows (e.g. drainage, seepage and percolation);
- Increase the effective use of rainfall, stored water, and water of marginal quality.

Following agronomic practices can be useful for improving the water productivity in major crops and cropping systems:

1. Moisture management
2. Selecting appropriate crops and cultivars
3. Timely land preparationand sowing of crop
4. Laser land leveling
5. Planting methods
6. Plant population
7. Planting geometry
8. Conservation tillage
9. Supplemental irrigation
10. Nutrient management
11. Irrigation method/low cost irrigation technologies
12. Mulching
13. Fallow management

Moisture Management

Agriculture in rainfed areas is "***gamble with monsoon***." Therefore, judicious use of available precipitation is essential to make rainfed agriculture a viable preposition. Hence, water harvesting and its efficient utilization is vital, can be use as pre- sowing irrigation to facilitate land preparation and also as supplemental/life saving irrigation during critical growth stages when long dry spell occurs. Water can be harvested both in situ and ex situ conditions.

Selecting Appropriate Crops/ Cultivars and Cropping Systems

In rainfed area, the cropping intensity is generally 100%, means that only a single crop is taken in a year. But, it can be increased by both intercropping and sequential cropping. Therefore, efficient utilization of available land and water resources, identification of locationspecific cropping system is necessary. Selection of crops and varieties is also an important aspect. During the selection of crops and varieties following points should also taken into account: Should be matched with rainfall pattern

1. Shorter crop duration
2. Faster growth during initial period

3. Strong and penetrating root system
4. Response to fertilizers

Timely Land Preparation

In rainfed area, timely land preparation is essential as it not only conserve the moisture but also helps in weeds control besides creating a suitable bed for sowing of seeds. Early land preparation after harvesting of previous crop conserves more moisture than un-ploughed soils because of breaking the capillaries and reduces the evaporation losses from deeper layers of the soil. If immediate land preparation after harvesting is not possible than field should be mulched and residues must be removed from the field during final land preparation.

Laser Land Leveling

It is the process of smootheningthe land surface and altering the fields to create a constant slope of 0.2-1 % using laser equipped drag bucket. It provides very accurate, smooth and graded field. It uses GPS and laser guided instrumentation. It saves irrigation water by 30%.

Seed Priming

Poor germination is a main constraint for getting higher yield in rainfed areas. Seed priming can be a viable option for improving germination and to maintaining satisfactory plant population in the field; however its response depends on the type of the seed and moisture content of the soil.

Plant Population and Planting Geometry

Maintaining optimum plant population is always a matter of controversy in rain fed areas, depends on the soil moisture content and crop duration. Under limited moisture condition, optimum plant population for rainfed areas is lower than irrigated areas as this put less pressure on the conserved moisture. In rainfed areas, wider spacing is preferred. Rectangular planting has been found more effective in rainfed areas than square planting for raising crop under conserved soil moisture condition.

Planting Method

Broadcasting of seed is a common practice for sowing in rainfed area though it is quick and less energy demanding but crop suffers due to uneven germination and poor crop growth. Line sowing of seeds in moist zone not only ensures good germination but also facilitate the mechanical intercultural operations.

Alternate wetting and drying- Periodic drying and re-flooding of the rice field. Save water up to 30 % because reduces seepage and percolation losses.

SRI-Synergistic effects of modification in the cultivation practices such as use of young 8-12 days old and single seedlings per hill, limited irrigation, and frequent loosening of the top soil to stimulate aerobic soil conditions and mechanical weeding 10 DAT. It saves 30-40 % water.

Aerobic Rice- Aerobic rice is a renewed way of growing rice in well-drained, non-puddled, and non-saturated soils. Rice is direct seeded on dry bed and irrigation is applied at an interval to maintain optimum soil moisture in the field. It saves 40-50% water.

Direct Seeded Rice (DSR)-Farmers sown rice seeds onto dry soil surface, then incorporates the seed either by plowing or harrowing. It can be adapted in upland, medium and lowland, deep water and irrigated areas. It is labour, fuel, time and water saving (75%) technology.

Wheat on FIRB- The crops are grown on the raised beds alternated by furrow. Beds are usually made at 0.6-1m wide and 2-3 rows of crops are sown on the beds. FIRB system of wheat cultivation has been shown to result in saving of seeds by 25-40%, water by 25-40% and nutrients by 25%.

Zero till wheat- Zero tillage technology soils are not plowed but sowing of crops is done by using a specially designed seed drill, disturbing soil to the least possible extent. At the time of seeding fertilizers are simultaneously placed beneath the seeds.

Conservation Tillage

Conservation tillage can be an effective tool for soil and moisture conservation in rainfed area. It not only saves the water but also reduces the cost of cultivation includingfuel and energy consumption, compaction and labor requirements.

Nutrient Management

Application of organic matter not only improves the soil fertility status but also increases the water holding capacity of soil. Adequate soil fertility is essential for efficient water use by crops and also for improvement in crop tolerance to moisture stress condition. Hence, balanced nutrient supply in an integrated manner is essential for optimum water productivity.

Weed Management

Weeds not only compete for nutrients and light but also transpire more water than crop plants for producing equal amount of dry matter. Therefore timely control of weeds is essential for improving the crop and water productivity. Use of herbicides along with manual weeding in integrated manner can be the best approach for weed control in rainfed areas.

Mulching

Mulching acts as a barrier between soil surface and atmosphere and thus improved soil profile moisture by reducing the evaporation losses. Mulching also moderate the soil temperature besides increasing the infiltration rate and addition of organic matter into the soil.

Contingent Crop Planning

In rainfed areas, where crop production depends on the monsoon rainfall but the trend of rainfall (onset of monsoon, its distribution and with drawl), is unpredictable especially in changing climate scenario. Since these factors are uncontrollable, modifications need to be made in crop management practices to overcome theadverse effect of uncertainty of rainfall, are called “contingent crop planning”.

Water Management

In rainfed areas, most of the water goes waste as runoff and leach down especially in hilly areas due to topographical constraints. There is ample scope to harvest surplus water in tanks or ponds and can be reutilized at most critical stages of the crop as supplemental irrigation, helps in improving the crop and water productivity.

Conclusion

Several agronomic practices are now available which hold the potential to improvethe water productivity in different crops and cropping systems. The impacts of these technologies are location-specific and thus, need to be further fine–tuned to suit the farmers' situations for their wider adoptability. The effects of improved technologies on water savings are poorly understood at the farmer field scale and have hardly been considered at higher spatial scale.

21. ENTOMOLOGY

Mite Pests of Store Product and their Management

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Mites are one of the smallest arthropods found all over the world. They belong to the class Arachnida and are closely related to ticks and spiders. The majority of mites are ectoparasites of other animals; however, some species are known to infest stored food products, while others are plant feeders. They are gaining importance due to their increasing incidence and their association with other insect pests and pathogenic fungi which causes rapid qualitative and quantitative loss of grains. Among different groups astigmata constitutes a dominant group in stored grains ecosystem followed by prostigmata and mesostigmata. Its presence can be detected by occurrence of “moving” grain dust which contains the mites. Heavy infestation of grain mites have a minty odor. It reduces the germination percentage of seed grains. Germination percentage of seeds reduce 20 -38 %, 5 -12 % and 35.8 % in wheat grains, pulses and vegetable seeds respectively after 6 months of infestation. Weight of seed grains also reduces due to mite attack. The percentage reduction of grain weight is 17.3 %, 20 %, and 26 % in groundnut, sugar beet and wheat respectively. Important mite pests of stored products are described below -

1. **Mold mite - *Tyrophagus putrescentiae* (Shrank) (*Astigmata: Acaridae*)**: It is found in stored food products, cereals, nests of birds, bees and is commonly associated with fungus and moulds in the store products thus called as mould mite. It will cause infestations in areas where acaricide or

fumigant use may be restricted, prohibited or highly impractical. It prefers a source of high fat and protein, such as linseed, peanut, cheese, ham, oats, barley and flour, dry dog food (DDF) where it rapidly reproduces. The mite is not only found in stored products but also in house dust. Therefore, *T. putrescentiae* is a domestic mite as well as a stored-product mite (SPM). These mites are closely associated with a number of pathogenic fungi and transmit a number of plant diseases in the stored products. It causes deterioration of stored products along with these microbes. It also acts as a good bio agent for controlling *Lasioderma serricorne* (*Coleoptera: Anobiidae*). However, *T. putrescentiae* can cause enteritis, copra itch, diarrhea and damages to the urinary tract besides allergic reactions when products with this mite are ingested, manipulated or inhaled.

2. **Flour mite - *Acarus siro* Linn. (Sarcoptiformes: *Acaridae*)**: It is cosmopolitan in nature and commonly found in cool and humid regions, rare in tropical and sub-tropical parts of the world. It feeds upon most organic substances, including stored and processed grains, hay, cheese, fungi, dead animals and rotting plant parts. The adult flour mite is pale greyish white in colour with pink legs. The female is about 0.3–0.6 mm long where as males are from 0.33 - 0.43 mm long. Its forelegs are spindle shaped with spiny out growth in males.

   The mite always preferred high humidity (70-80 %) and cool climate (20 -25 ^oC) for its multiplication. Fertilized female lays 120 -200 eggs depending upon the environmental conditions. The total life cycle from egg to adult completes in 10 days at optimum environmental conditions The adult and nymph feed on the germ portion of the grains leaving only the husks. It also causes complete spoilage or rotten of bulk areas resulting in production of hot spots.

3. **Glossy grain mite,** *Tarsonemus granarius* Lindquist (Prostigmata: Tarsonemidae): This is a mycophagous mite commonly found in stored grain, grain dust and spillage. In storage the abundance of *T. granarius* is related to moisture content of the grain, depth of bulk-stored grain, temperature, and storage fungi such as *Chaetomium* and *Aspergillus sp*. This mite plays an important role in disseminating fungi from infested area to non-infested areas. It shows a typical type of reproduction in which the fertilized eggs developed into female offsprings where as unfertilized eggs into males. Its multiplication is high at a temperature of 30^o C and relative humidity 90 %. In long term storage of rice and other cereals the mite is associated with grain quality deterioration and formation of hot spots.

4. **Brown flour mite, *Gohieria fusca* Oudemans**: It is also known as brown flour mite, is frequently breeding in wheat flour, rice, corn, feeds, wheat bran and herbal medicines as well as other stored products which is stored for a longer duration in the bulk container. This species exhibits mild to moderate cross reactivity with allergens of house dust mites, eventually resulting in various allergic disorders including asthma, allergic rhinitis, atopic dermatitis and urticaria. This mite produces large colonies in the stored grains. It is thermophilus in nature. Optimum temperature and moisture for its development is 22 -24 ^oC and 15 -16 %.

5. ***Suidasia nesbitti* astigmata: suidasidae:** It is associated with wheat, wheat flour, rice bran, pearl millet, pulses and other stored grains. The female lays upto 120 -130 eggs. Diet containing wheat germ is preferred by this mite out of various foods tested.

6. ***Carpoglyphus sp*** It is found in all kinds of dried fruits, honey comb and food substances containing sugar. It completes its life cycle within a temperature range of 5 - 35^o C but temperature below 10^o C, its egg laying is hampered.

7. ***Lardoglyphus konoi***: The mite is associated with salted fish and other fish products. The hypopus formation is higher in nutrient deficient diets.

Management of Mites in Storage

Preventive measures should be taken to reduce the attack of mite. The measures are as follows-

- Carefully inspect all high moisture food and grain products. Grains should be stored below 12 % moisture content. Low moisture is critical for mite control than low temperature.

- Avoid prolonged storage. Food grains that are stored in bulk and in bags for long periods of time should be checked routinely to avoid mite infestation.
- Never store foods under damp, poorly ventilated conditions. If necessary, increase air circulation to reduce relative humidity and prevent molds and mildews.
- Periodically cleansing and disinfection of the storage areas. Preventing breaking of packaging seals should be given attention before storage.
- Stored un-infested food products in a container with tight fitting lids and perfectly screwed it.
- When products become infested with mites, locate the source of infestation (bags stored over a long period of time in a undisturbed storage area) and eliminate it.
- Don't mix old food stuffs with new one as sometimes the older unused foods act as source of intial infestation. Rotate food materials to remove the older items first.
- Packaged foods should be stacked on pallets to permit air ventilation and to prevent floor dampness.
- Remove bird or rodent nests near the storage areas.

Fumigants

Few reports are available on the efficacy of fumigants against mites. Some earlier studies, it was established that it is not so effective on eggs than adults. Chlorpyriphos, phoxim mixture, etrimphos and primiphos methyl are reported to be effective against *A. siro, T. putrescentiae, G. destructor*. Nayak (2006) reported that phosphine at 1 mg/L (720 ppm) at 25 °C controlled all life stages of *T. putrescentiae* in six days. Methyl bromide is also used as fumigant for controlling mite and it is more effective than phosphine (Jalil et al., 1970; Barker, 1967; Bowley and Bell, 1981) Acrylonitrile, carbon tetrachloride, ethyl bromide, ethyl formate, ethylene dibromide, ethylene dichloride, ethylene oxide, methallyl chloride, methyl chlorform, methyl formate were also used to control mites like *A. siro, T. longior, G. destructor* at 10 °C temp. (Bowley and Bell, 1981)

Several grain protectants like pyrethrin plus pb, s-methoprene and spinosad controlled the mite population of *T. putrescentiae* after at least 3 weeks of exposure in wheat (Nayak, 2006) Several mite spp., including *T. putrescentiae*, *T. longior*, *A. siro*, and *G. destructor* were also controlled by etrimfos and profenofos (Stables, 1980). Among pyrethroids, phenothrin, fenopropathrin and permethrin at a very high rate of 500 ppm were shown to be effective against *T. putrescentiae* (Chisaka et al., 1985).

Inert Dust

Inert dust is effective against *A. siro* and *G. destructor* @ 3 - 5 g/ kg of grain at 10 ºC temperature and 14.5 % moisture content after 28 days of exposure.

Use of Botanicals

Spice oil like black pepper, mint, turmeric, garlic etc. have inhibitory or repellent activity against store mite. Neem oil, vegetable oils (like sesame, mustard, ground nut), tulsi extracts and mahua extracts are also very effective against store mites.

Behavioural Control

T. putrescentiae contains neryl formate in its body fluid which act as alarm pheromone when released. This behavioural chemical is used to impregnate filter paper and the paper is wrapped and placed adjacent to food stuff. By adopting this method complete protection is achieved at a conc. of 0.5 % of this chemical.

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22. SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Soil Enzymes: Bioindicators of Soil Quality

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Introduction Recently the concerns on agricultural sustainability have increased worldwide due to expansion of agricultural edges near to the maximum. Economical and environmental sustainability can be achieved only with the maintenance of soil health. Soil health is a state of dynamic equilibrium between flora and fauna and their surrounding soil environment in which all the metabolic activities of the former proceed optimally without any hinderance, stress or impedance from the later (Goswami and Rattan, 1992) whereas soil quality is capacity of a specific kind of soil to function within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality and sustain plant, animal and human health (Doran and Parkin, 1994).

Changes in soil quality can be measured through indicators which include physical, chemical and biological processes and characteristics so it is necessary to provide quality indices including different indicators, to determine soil quality. Physical and chemical indicators respond slowly, when compared to the biological ones, such as microbial biomass C and N, biodiversity, soil enzymes, soil respiration, *etc.*, in addition to macro and mesofauna. Among biological indicators, soil enzymes are one of the important ones playing a major role in regulating physiology and metabolism of microorganisms. Enzymes are organic protein catalysts that transform inorganic and organic substances without themselves being changed. They lower the activation energy of chemical reactions and allow the reactions to proceed at temperatures and pressures at which they would not normally occur. Sources of soil enzymes include living and dead microbes, plant roots and residues, and soil animals.

Functions of Enzymes in Soil

Enzymes play key biochemical functions in the overall process of organic matter decomposition in the soil system (Sinsabaugh *et al.*, 1991) and are also important in catalyzing several vital reactions necessary for,

1. Life processes of micro-organisms in soils
2. The stabilization of soil structure
3. Organic matter formation
4. Nutrient cycling

Importance of Soil Enzymes

1. Release of nutrients into the soil by means of organic matter decomposition
2. Identification of microbial activity
3. As sensitive indicators of ecological change

Application of Soil Enzymes

1. Correlation with soil fertility
2. Correlation with microbial activity
3. Correlation with biochemical cycling of various elements in soil (C, N, S)
4. Degree of pollution (heavy metals, SO_4)
5. To assess the succession stages of an ecosystem
6. Rapid degradation of pesticides
7. Disease studies

Biological Indicators of Soil Quality

Properties associated with biological activity on organic matter, such as

1. Microbial biomass carbon
2. Soil respiration.
3. Abundance, diversity, food chains and stability of microbial communities
4. Mesofauna such as earthworms, nematodes and arthropods
5. Biological activities such as enzyme activity
6. Potentially mineralized nitrogen
7. CO_2 production

Why Soil Enzymes are Considered as Useful Indicators of Soil Quality?

Soil enzyme activity is,

1. Closely related to soil organic matter, soil physical properties and microbial activity or biomass.
2. Changes much sooner than other

parameters, thus providing early indications of changes in soil health.
3. Involve simple procedures for determination of activity (Dick *et al.*, 1996).

Potential role of soil enzymes in maintaining soil health

Soil Enzyme	Enzyme reaction	End Product	Indicator of microbial activity
ß glucosidase	Cellobiose hydrolysis	Glucose	C Cycling
FDA hydrolysis	Organic matter decomposition	Different nutrients	C Cycling
Amidase	N-mineralization	Ammonium	N Cycling
Urease	Urea hydrolysis	Ammonium	N Cycling
Phosphatase	Hydrolysis of organic P compounds	Inorganic Phosphate	P Cycling
Arylsulphatase	Hydrolysis of organic S compounds	Inorganic Sulphate	S Cycling
Phenol oxidase	Lignin hydrolysis	Low molecular weight C compounds	C Cycling
Cellulase	Cellulose hydrolysis	Glucose	C Cycling
Dehydrogenase	Electron transport system	Oxidized products	C Cycling

Soil Management Practices Affecting Enzyme Activities

1. Crop rotation
2. Irrigation practices
3. Pesticide application
4. Tillage and cultivation
5. Conservation practices
6. Soil amendments-lime and gypsum application
7. Land use changes
8. Long term fertilizer experiments with integrated nutrient management

Conclusions

Soil enzymes play an important role in organic matter decomposition, nutrient cycling and identification of microbial activity. They provide insight into the living components of soil. Enzymes also respond to soil management changes long before other soil quality indicators and hence provide early indication of changes in soil health.

Future Research Needed

Development of soil enzyme index can be used as a reliable measure of soil fertility and health. The impacts of management practices on soil enzymes in relation to climate change are not well understood.

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23. AGRICULTURE PLANT PATHOLOGY

Management of Soil Borne Diseases in Protected Cultivation

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Protected cultivation is an emerging technology for raising vegetables and ornamental crops. Flower crops (cut rose, carnation, chrysanthemum, gerbera, orchid, gladiolus, anthurium and lilies) and vegetables (tomato, capsicum chilli, lettuce, brinjal, bell pepper, black pepper, leafy vegetables and cucurbits) are mostly grown under protected cultivation. Due to controlled environmental conditions, dense population and relay cropping, incidence of air and soil borne pathogens are more. Among these, soil borne pathogens causes most serious diseases as they are difficult to eradicate once they establish in the soil ecosystem. *Pythium* spp., *Phytopthora* spp., *Fusarium* spp., *Sclerotium* spp., *Ralstonia* spp and *Meloidogyne* spp. are the major soil borne pathogens observed in protected cultivation.

Protected cultivation: Cultivation of the crop in artificially controlled environment is known as protected cultivation.

Soil borne diseases: Diseases which caused by the soil borne pathogen are know as soil borne diseases.

Fungal and bacterial soil borne diseases of vegetables crops

Crops	Diseases	Pathogen
Tomato	Fusarium wilt	*Fusarium oxysporum*
	Bacterial wilt	*Ralstoniasolanacearum*
Cruciferous	Stalk rot	*Sclerotiniasclerotiorum*
	Club rot	*Plasmodiophorabrassicae*
Cucurbits	Fusarium wilt	*F. oxysporum* f. sp. *Cucumerinumowen*
	Bacterial wilt	*Eriwiniatracheiphila*
Chilli and Bell pepper	Phytopthora fruit rot and foot rot	*Phytopthoracapsici*
	Bacterial wilt	*Ralstoniasolanacearum*
Leafy vegetable	Coriander wilt	*Fusarium oxysporum*
	Root rot and damping off	*Pythium aphanidermatum*

Strategies for the Management of Soil Borne Diseases in Protected Cultivation

1. Avoidance:
   a. Proper selection of geographical area (Soil replacement)
   b. Proper selection of the field
   c. Adjusting time of sowing
   d. Disease escaping varieties
   e. Proper selection of seed and planting material
2. Exclusion:
   a. Seed inspection and certification
   b. Plant quarantine regulation
3. Eradication
   a. Rouging
   b. Eradication of alternate and collateral hosts
   c. Suppression of pathogenic microbes from the soil through soil sterilization by
4. physical or chemical method
   a. Crop rotation
   b. Crop sanitation
   c. Sanitation of microenvironment by application of disinfectant through fogger
   d. Manures and fertilizers (Balance application)
   e. Soil amendments (to make the soil suppressive for the pathogen by increasing population of antagonistic microbes)
5. Protection
6. Resistance
7. Therapy

General Management Strategy for Control Soil Born Diseases in Protected Cultivation

1. Good sanitation practices
2. Precaution should be taken by labour
3. Sterilization of soil or potting media

4. Seed treatment
5. Regular monitoring of plant disease occurrence
6. Solarization
7. Biological control
8. Chemical control
9. Resistant variety
10. Use of healthy planting material
11. Use of organic manure and compost manure

Conclusion

Protected cultivation is increasing in India due to its merit to overcome seasonal barrier. Availability of the host and environmental conditions for the disease remain favorable throughout the crop season, therefore, incidence of diseases in protected cultivation is more and is difficult to control. Soil borne diseases viz., damping-off, wilt, root rot, fruit rot, root knot nematode etc. are most common and causing enormous losses in protected cultivation. Cultural, biological and chemical management practices are promising techniques to reduces the disease however, it posses limited scope. Integrated disease management (IDM) strategies proved to be best for the management of these diseases, however, more promising and widely accepted IDM strategies must be developed to manage these diseases effectively and efficiently.

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24. AGRICULTURAL

Polymer Coated Fertilizers: An Advance Technique in Nutrient Management

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Introduction

Control release fertilizers (CRF's) are coated fertilizers that release nutrients over an extended period of time at a rate driven primarily by temperature and moisture of the root zone. It has been estimated that slow-release fertilizers comprise only 8-10% of the total fertilizers used in Europe, 1% in the USA and only 0.25% in the World. In Japan 70% of polymer coated controlled-release fertilizers are used in rice. Controlled-release is one of the modern application that has enhanced nutrient use efficiency. Fertilizer use efficiency can be increased by modification of fertilizer products. e.g. coated encapsulation. Controlled release fertilizers (CRFs) will bring revolution in agricultural industry in near future.

Polymer coated fertilizers (PCF's) were also a type of CRF's, which are solid or other nutrient core, coated with various polymers (plastics). Fertilizer use efficiency can be increased by application of polymer coated fertilizer compared to common fertilizers due to very less nutrient losses. Three most commonly marketed products are Nutricote, Osmocote and Polyon. Coatings are tough, resist to damage and thin. Nutrient release is due to controlled diffusion, which is fairly constant over time. Nutrient release depends on coat thickness, chemistry, temperature and moisture.

Types of Coating Technology of CRFs

1. Polymer (polyethylene, polyesters)
2. Sulphur
3. Sulphur plus polymer

Polymer Coated Fertilizers (PCFs)

Polymer-coated fertilizer technologies vary greatly between producers depending on the choice of the coating material and the coating process. The Pursell Reactive Layers Coating (RLCTM) uses polymer technology, while Polyon uses a polyurethane as does Haifa

(Multicote) and Aglukon (Plantacote). Chissoasahi polymer technology (Meister), Nutricote is a polyethylene; while Scotts polymer technology (Osmocote) is an alkyd-resin.

The quantity of coating material used for polymer coatings of conventional soluble fertilizers depends on the geometric parameters of the basic core material (granule size to surface area, roundness etc.) and the longevity target. In general, the coating material represents 3-4% (RLCTM) to 15% (conventional coating with polymers) of the total weight of the finished product. For example, the capsule or coating film of Meister (encapsulated urea) is 50 to 60 µm in thickness and approximately 10% in weight. The longer the need to supply the nutrients, the smaller is the amount released per unit of time. The producers indicate the period of release, e.g. 70, 140, up to 400 days release at constant 25°C. However, if the polymer-coated fertilizers are not straight nitrogen but NPK fertilizers, particularly when containing secondary and micronutrients, the rate of release of the different nutrients, N, P, K, S, Ca, Mg and micronutrients, are generally Slow- and controlled-release and stabilized fertilizers not stated.

Mechanisms of Nutrient Release

The nutrient release through a polymer membrane is not significantly affected by soil properties, such as pH, salinity, texture, microbial activity, redox-potential, ionic strength of the soil solution, but rather by temperature and moisture permeability of the polymer coating. Thus, it is possible to predict the nutrient release from polymer-coated fertilizers for a given period of time.

In a recent assessment of polymer-coated materials, multiple mechanisms of release, including diffusion, osmotic pumping (apparently caused by changes in hydrostatic pressure and an osmotic gradient), and convective release by coating disruption. Release occurs mainly by diffusion when the water potential is at steady-state and the coating material is permeable to the solutes within. Release by diffusion yields a relatively steady release, subject mainly to changes in coating permeability and temperature. Osmotic pumping (mass flow) and diffusion of solutes is likely when the coating is semi-permeable to at least some solutes and cracks of limited volume are formed in the coating by the build up of hydrostatic pressure. If the coating is completely impermeable to the internal solutes, there is no solute release until cracks are formed. Impermeability to fertilizer salts may be associated with swelling of the prill, although swelling may not be easily detectable. Finally, convective solute transfer by coating disruption would occur when the build up of hydrostatic pressure causes coating rupture. This is the release mechanism for sulfur-coated urea, likely happens in most polymer coated fertilizers only due to coating failure.

Nutrient release from Osmocote (an alkyd-resin-coated fertilizer) follows water entering the microscopic pores in the coating. This increases the osmotic pressure within the pore, which is enlarged and nutrients are released through the enlarged micropore. The alkyd-resin-type coating makes it possible to satisfactorily control the release rate and timing. Polyurethane-like coatings also provide a good control over rate and duration of release.

Why to use PCFs

1. 70 per cent of conventionally applied fertilizer goes unutilized
2. Loss of nutrients due to volatilization and leaching
3. Fertilizer run-off in surface water leads to eutrophication process
4. Negative environmental impacts
5. Fertilizer waste through leaching increases ground water pollution
6. Less fertilizer use efficiency

Advantages

1. Minimize nutrient losses and increase Nutrient Use efficiency (NUE)
2. Extend nutrient release timing and meet plant demand timely and efficiently
3. Reduce labour requirement and reduction of the labour cost.
4. To improve the yield and reduce the cost of production
5. Reduction in ground water pollution and water bodies
6. Root burn can be avoided with the application of controlled release fertilizers even at the increased quantities of fertilizers supplied.

7. Reduced leaf burn from heavy rates of surface application
8. More uniform growth response
9. Flexibility of release periods from 40 to 360 days at 25^{o} C
10. Improved storage and handling properties of fertilizer materials

Disadvantages

1. Very high cost.
2. Prills can be damaged by abrasion.
3. Nutrient deficiencies may occur if nutrients are not released as predicted because of low temperatures, flooded or droughty soil, or poor activity of soil microbes.

25. Plant Biotechnology

Association Mapping: a Potential Tool for QTL Mapping

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To understand the concept of association mapping we should have an idea of genetic mapping. Briefly genetic mapping indicates the relative genetic distances between genes/markers in order, and assigning them to their chromosomes. The distance between two genes/markers can be calculated using the following formula:

Distance = Recombination frequency = No. of recombinants / Total number of progeny x 100

Properties of Ideal Markers used in Genetic Mapping

a. Easily detectable at genotypic level, b. The principles of mapping and linkage analyses remains the same way, c. Genes (marker or loci) segregate via chromosome during meiosis thus allowing their analysis in progeny, d. Should be highly heritable, e. Should be linked to gene of interest, f. Must co-segregate with the gene

Why Mapping Genes?

To find molecular markers linked to target genes and then used in Marker assisted selection (MAS). The markers can be used to transfer the gene of interest from a donor line to the target genotype.

Two Main Approaches for Mapping

1. ***Family-based Linkage mapping:*** Constructing linkage maps and conducting QTL analysis–to identify genomic regions associated with traits–is known as QTL mapping (also genetic,' 'gene' or 'genome' mapping/ gene tagging/ Family based mapping)
2. LD-based Association mapping

Now the question is Why QTL/ Family based mapping is unsuccessful???

It has been observed that more than 11,000 articles published on QTL mapping in different species and more than 360 articles related to reports of over 1000 QTLs associated with various traits in maize. Despite to date only a few QTLs have been commercially exploited (http://www.ncbi.nlm.nih.gov/pubmed 2011). This approach is successful only in case of major genes (Disease resistance genes) because of following reasons:

1. Small fraction of all genetic variation within a species,
2. Only alleles at which the two parents differ can be detected-thus difficult to examine full range of genetic diversity,
3. Low map genetic resolution (10-20 cM)-due to limited recombination,
4. QTL often are not consistent across mapping populations,
5. Linked markers not suitable for unrelated genotypes,
6. Additional steps required to narrow QTL or clone gene,
7. Time consuming and costly

Thus, ASSOCIATION MAPPING could be an answer and alternative to family based mapping to dissect complex traits

- Also, called linkage disequilibrium (LD) mapping. It is a natural population based survey which exploits historical and evolutionary recombination events and natural population to determine marker-trait associations using Linkage Disequilibrium.

- The power depends on the strength of this correlation (i.e., on the degree of LD between the genotyped marker and the functional variant)

How Association Mapping (AM) Works?

Association studies assume that a marker locus is 'sufficiently close' to a trait locus so that some marker allele would be 'travelling' along with the trait allele through many generations during recombination. (Murillo and Greenberg, 2008.)

Major Goal

To identify inter-individual genetic variants, mostly single nucleotide polymorphisms (SNPs), which show the strongest association with the phenotype of interest, either because they are causal or, more likely, statistically correlated or in linkage disequilibrium (LD) with an unobserved causal variant(s).

Advantages of Association mapping over conventional mapping

S. No.	Trait	Conventional	LD mapping
	Mapping population	Biparental, structured	Natural/ breeding pool, not structured
	Meiosis cycle	Few (6-7)	Several
	QTL precision	Less	High –Great resolution
	Trait variation	Explains between parents	Natural
	LD Decay	Less	more
	Perennial crops	Not applicable	Effective
	Markers	Specific	Diverse genotypes
	Cost and ease	More cost and labour	Less cost and reduced time

What is Linkage Disequilibrium?

It is non- random association of alleles at adjacent loci throughout its natural history. The closer two markers are, the stronger the LD

Linkage v/s LD

Linkage: Refers to the correlated inheritance of loci through the physical connection on a chromosome whereas, LD: Refers to the correlation between alleles in a population

Approaches for Association Mapping

- **Candidate gene association mapping (2002):** Relates polymorphism in selected candidate genes
- **Genome wide association mapping (2005):** Relates polymorphism in whole genome to find signals

Limitations

Needs statistical assessment to investigate the relatedness of the lines and the overall population structure

Softwares used in AM

Various software's are available which includes: Haploview 4.2, SVS 7, TASSEL, GenStat, JMP genomics, GenAMap, PLINK, STRUCTURE, SPAGeDi, BAPS 5.0, mStruct, LDheatmap, Arlequin 3.5

Conclusion

The ultimate aim of plant breeding is prediction of phenotype from genotype. Major agricultural economic traits are of complex nature. It is desperate to dissect these complex traits and assign them function. Advanced genomic tools like association mapping will be a valuable option which can be effectively and efficiently utilized to accelerate crop improvement.

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26. GENETICS AND PLANT BREEDING

Transcriptomics and Transcriptome Sequencing

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Introduction

Transcriptomics is the science which deals with study of transcriptome sequence of an organism. Then what is transcriptome? Transcriptome is a complete set of RNA molecule that are form in given organism. It could be m-RNA, r-RNA, t-RNA, or micro-RNA molecules. In response to different type of environmental stimulations constant qualitative and quantitative changes occurs at the transcriptome level. By observing and comparing this changes can provide information on how the living organisms function and deal with the changing environmental conditions. The main aims of transcriptomics are: to catalogue all species of transcript, including mRNAs (codding RNAs), micro-RNAnon-coding RNAs and small RNAs; to determine the transcriptional structure of genes, in terms of their start sites, 5′ and 3′ ends, cleavage pattern and other post-transcriptional modifications; and to quantify the changing expression levels of each transcript during development and under different condition.

Transcriptome Sequencing involve following steps

1. Step 1: Library construction.
2. Step 2: DNA sequencing.
3. Step 3: Data analysis.

Step1: Library construction

Most current next-generation sequencing instruments generate reads significantly shorter than standard Sanger sequencing. In case of Illumina SBS technology, reads are 35-150 nucleotide long. The template length must be therefore adjusted accordingly to permit uniform transcript coverage by the sequence reads. This is typically achieved by chemical fragmentation of RNA prior to cDNA synthesis. Fragmented RNA is then reverse transcribed into cDNA, followed by a second strand synthesis and end-modification steps. The latter permits subsequent ligation of oligonucleotide adapters to both DNA ends. The adapters include annealing sites recognized by primers used for cluster generation and sequencing. They also contain a short region, called index, which can be sequenced independently of the template DNA, using the Index primer. The index identifies the adapter used for library preparation. If different adapters are ligated to different DNA libraries, those libraries can be mixed and subjected to multiplexed sequencing in one lane of a flow cell. Optionally, the DNA library may be PCR-amplified to selectively enrich the DNA fragments that have adapter molecules ligated to both ends. Finally, the DNA quantity and quality is validated by capillary electrophoresis, spectrophotometry and/or qPCR, before proceeding to the next stage. In this step we isolate high quality RNA molecules from an organism& chemical fragmentation of RNA prior to cDNA synthesis. Fragmented RNA is then reverse transcribed into cDNA, followed by a second strand synthesis and end modification steps. The latter permits subsequent ligation of oligonucleotide adapters to both DNA ends. The adapters include annealing sites recognized by ligation of oligonucleotide adapters to both DNA ends. The adapters include annealing sites recognized by primers. They also contain a short region, called index, which can be sequenced independently of the template DNA, using the Index primer. The index identifies the adapter used for library preparation. Optionally, the DNA library may be PCR-amplified to selectively enrich the DNA fragments that have adapter molecules ligated to both ends finally, the DNA quantity and

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quality is validated by capillary electrophoresis, spectrophotometry and/or qPCR, before proceeding to the next stage.

Step 2: DNA Sequencing

There are several sequencing technology available for sequencing but most widely use technology is illumine sequencing. In the Illumina sequencing workflow, all further steps of DNA preparation and sequencing occur on a flow cell – a plate that is physically divided into eight separate channels, called "lanes". The surface of each lane is densely and uniformly covered by covalently attached short oligonucleotide primers that are complementary to binding sites in the adapters, previously ligated to the DNA. The templates are hybridized to these primers, copied and removed. The immobilized DNA copies are further amplified in the process called isothermal bridge amplification. So, the template DNA molecule gives rise to about two thousand identical double-stranded DNA copies, attached to the flow cell surface and tightly clustered in a very small area. In this way, millions of dense clonal clusters are generated on each lane. In the next step, DNA is linearized by denaturation, followed by cleavage and removal of the DNA strand with P5 binding site on its 5^N end. The 3^N ends of the remaining DNA strand and the flow cell-bound oligonucleotides are blocked to prevent unintended extension. After hybridization of thesequencing primer to thecomplementary adapter located at the unbound end of each template, the flow cell is ready for sequencing in the sequencer.

Step 3: Data Analysis

The sequences are analyzedby appropriate software, therefore soon after the run is finished, data analysis can be begins. The dataset should be filtered for high quality sequences. Typically, the reads are mapped to the reference genome or transcriptome. Next, the reads that align to the same locus are assembled into transcripts. Finally, the expression level of each transcript is estimated by counting the number of reads that aligned to this transcript. To enable data comparison, the values are normalized by taking into account the fact that the number of reads per transcript depends on the transcript length and the total number of reads obtained for a particular library. Specific software exists for each of the analysis steps and many methods are available as free or open-source programs.

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27. AGRONOMY

Climate Change: Its Impact on Weed Management

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Introduction: Due to human activities not only combustion of fossil fuel but industrialization and pollution have caused significant increase in CO_2 level in atmosphere. The long term alteration in the average weather conditions prevailing in a area or zone may be known as climate change. The main factor responsible for climate change is increase in CO_2 level and temperature. To estimate impact of climate change on crop -weed competition and interrelations we have to focus on photosynthetic activities, phenology and development of crops and weeds. Most of the weeds belongs to C_4 and even in C_3 have large number of weed plants those who are in C_3 types will become more cumbersome in elevated CO_2

and temperature in such scenario it seems that weed management in near future will become more costly and complex phenomena. When we compare adaptability between crops and weeds we found that weeds have better adaptability to the changing climate due to virtue of greater genetic diversity. Ultimately this will influence cropping system globally.

Climate Change

The earth received heat from short -wave radiation of the sun, which has 6000°C temperature. From last two centuries due to scientific and industrial development human being voraciously extracting natural resources for short term benefits without considering provision for future generations leading to enhancement in greenhouse effect. Emission of gases mainly CO_2 is the most significant contributing about 64 % of the effect followed by CH_4 (19%), CFCs (11%) and N_2O (6%). Human interference not only increasing CO_2 concentration but in term causing a reduction in the ozone (O_3) layer. Also nitrogenous compounds deposition is increasing.

Impact of Elevated CO_2

Increase in CO_2 concentration have direct impact on the growth rate of crop plants including weeds and also cause vegetation communities to change. CO_2 may influence temperature, rainfall distribution may lead to change in the productivity of different ecosystem significantly. Rise in sea level may be there due to global warming CO_2 has risen 33 % as compared to a pre-industrial concentration. Resultant impact of CO_2 elevated level on C_3 and C_4 plants may have noticeable implications for crop-weed interaction (Singh and Kumar, 2013). As CO_2 enrichment it is found that there is increase in growth and productivity of weeds. (Rogers *et al.,* 2008)

Some evidence shows that increased CO_2 would build up plants to tolerate environmental stresses. Further increase in such tolerance may leads to modification in the distribution of weeds across the globe and their competiting ability. (Bunce, 2001)

Effect of Rise in Temperature

In the 21st century doubling of CO_2 concentration may lead to increase air temperature 1.5 - 4.5° C (IPCC, 2001). If we compare tolerance of temperature C_4 species found to be more tolrant to higher temperature change than C_3 plants as stated by Rodenburg *et al.* (2011). This increase in global temperature particularly in tropical and sub-tropical regions will lead to increase in ET rates that would lead to suffer from moisture stress. Increase in temperature may lead to early maturity 82 days instead of 117 days in wild oat. Rajkumara (2007) concluded increase in temperature is totally in favour of weeds in crop-weed competition. Due to rise in temperature coastal area limited Striga in North and South Carolina will encroach complete belt of corn cultivation (Ziska, 2010).

Weed Managements in Accordance with Climate Change

Increase in CO_2 concentration helps in growth of underground parts i.e. root, rhizome specially in perennial weeds which may result in plant propagation due to mechanical weed control methods and reducing the effect of herbicide application. It is observed that glyphosate resistant in C_3 type weeds due to increase in atmospheric CO_2 concentration which may lead to limit the efficacy of some herbicides. Cost of weed control may increase due to increased CO_2 level and air temperature we have to follow adaptative methods according to weed problems.

Different Practices for Control of Weeds

1. Prevention is better than cure. Weed free crop seed is best practice to prevent weed in field. Avoiding contaminated tools and implements use in the field.
2. Stale seed bed is a method in which allowing weeds to germinate by rain or wetting and tilling to kill them before sowing seeds.
3. Spudding means removal of weeds by cutting off below the soil surface.
4. Keeping bunds and irrigation channels free of weeds.
5. Clean farming for several years reduce down weed problems.
6. Crop diversification with inclusion of weed smothering crop in cropping system help to reduce down weed infestation.
7. Inclusion of Bajara crop found to be significant due to its ability to exhibits residual weed suppression in the

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succeeding crop.

8. In conservation agriculture use of pre and post emergence herbicide according to need of field is suggested.
9. Killing of existing weed cover with application of a non-selective herbicide 14 days prior to planting is crucial.
10. In near future use of GM crops like soybean, maize and cotton with herbicide resistant characteristics will control or reduce the dependency on pre-emergence herbicides.
11. Integrated weed management a holistic approach is best way to keep under control all weed problems.

The climate change can't be controlled by blaming one another country with their emission quantity of gases all will face problems of climate change on equal basis either today or tomorrow hence unanimously we all have to work for reduction of CO_2 level. We have to mitigate not only CO_2 level but also our differences among different countries with finding alternatives for energy sources, increasing afforestration with restoration of soil fertility and productivity and also have to conserve river basins with their natural boundaries.

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28. ENVIRONMENTAL SCIENCE

Carbon Sequestration in Urban Trees

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Introduction

Earth is enveloped by layer of gases called the atmosphere. It is composed of different concentration of mixture of gaseous components along with water vapor, dust, suspended particulate matter etc. Among these gases, there are greenhouse gases which includes water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO), and ozone (O_3), along with traces components of certain minor greenhouse gases. Among these, carbon dioxide is considered as a major greenhouse gas (GHG). If the GHG is completely absent, then the average atmospheric temperature would be as low as -18 °C and 15 °C in its presence, thus forming an integral part in maintaining the earth's ambient temperature (Ming *et al.,* 2014). On the other hand, the earth's changing climate is the impact of GHG emission from manmade sources which resulted in increase in average temperature, in turn melting of the polar ice caps and glaciers; and also rise in the sea level (IPCC, 2007). Henceforth, the increase in the concentration of the GHGs and especially CO_2 is the sole reason for the climate change.

Presence of carbon is observed in different forms in various parts on the earth. The CO_2 from the atmosphere is utilized auto photosynthetic organisms for production of different organic compounds. And such metabolized compounds are again added back to the atmosphere as CO_2 as a result of respiration. Ocean absorbs a portion from the atmospheric carbon reserve, which is later on converted to sedimentary rocks and in due course of time, carbon is again added back to the atmosphere. Thus, carbon moves from one place to another and changes from one form to another through a cycle. But there is a substantial increase in the concentration of carbon in the atmosphere over the decades and also there is a projected increase in the future.

An increment in the atmospheric carbon level at times helps in stimulating the plant growth and thus its productivity. On the contrary, it has also resulted in the extremities of climate and irregular rainfall patterns across the globe. Pertinacious increase in the carbon storehouses such as plant, soil and ocean is called as Carbon Sequestration (Pandey *et al.,* 2016). United Nations Framework Convention on Climate Change has defined carbon sequestration as storage of CO_2 in plants and animals in secure manner. When CO_2 is metabolically converted into carbonaceous materials through photosynthesis is termed as bio-sequestration.

Carbon Sequestration in Plants

A collection of processes are involved in the carbon sequestration in soils and plants. In agroforestry systems, it involves both aboveground and belowground systems of carbon sequestration. The plant constituents such as stem and leaves of herbaceous plants and trees compose the aboveground system; whereas the belowground system is constituted by the roots of plants and trees, soil microbes and soil organic carbon available in various soil horizons. As a result of the net positivity of belowground component towards climate change, it is used in place of carbon sequestration. It is also observed that belowground biomass carbon component is much more stabilized as a result of their interactions with the soil particles accompanied by slow decomposition process as compared to the aboveground component.

Scientists have observed that sequestered carbon is stabilized as soil organic carbon in urban and agricultural soils. Also, they are built up from historic times which have helped in the formation of humus in soil. When soil humus stabilizes itself over time, it forms long-term storage of carbon in soil which remains intact for hundreds and thousands of years (Abbas *et al.,* 2017). Scientists have reported that land use systems such as agroforestry has higher net primary carbon assimilation. Also their residues add to the soil organic carbon content.

Trees in urban areas perform carbon sequestration and help in reducing pollution due to automobiles. Carbon emission saved by planting trees in urban locality can be achieved to an extent of 18 kg CO_2/year per tree which corresponds to the benefit obtained from 3-5 forest trees. Apart from this, the trees provide cooling and shade to the nearby localities through transpiration. Due to their proximity to roads, roadside trees help in taking up more carbon from vehicular emissions. Also, they help in capturing particulate matter. All these factors contribute in improving the air quality standards. Apart from these, they add to the aesthetic value along roadside imparting green infrastructure. On the contrary, roadside trees face stresses caused by natural and anthropogenic factors leading to their degradation and reducing their life span as compared to the natural forests or rural localities. The reason behind is they are directly affected by pollution which affects their health by reducing their growth and their extent to concentrate and distribute the pollutants (Kiran and Kinnary, 2011).

Conclusion

It understood that sequestration of CO_2 is attained naturally through plants and soils. In recent trends carbon sequestration and reduced carbon emissions from surmounting deforestation is gaining momentum. Urban forestry requires site specific identification for the strategies utilized by the trees to overcome pollution and other environmental factors.

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29. AGRICULTURE ENTOMOLOGY

Insect Nuclear Receptors

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Nuclear receptors (NRs) are a group of transcription factors that play key roles in the major biological processes including development (King-Jones and Thummel, 2005). NRs constitute a superfamily of metazoan proteins that includes the steroid receptors of vertebrates. NR proteins have modular functional domains designated (from the NH2-terminal end) as A/B, C, D, E, and F. The C domain is also referred to as the DNA Binding Domain (DBD); it is the mostconserved region of NRs and is characterized by invariant cysteine residues that stabilize twozinc fingers essential for DNA binding. The E domain contains the Ligand Binding Domain (LBD), which permits NRs tofunction as ligand-dependent regulators of transcription: it is characterized by a COOH-terminalmotif (AF-2) that drives ligand-dependent transcription upon binding of the receptor (sometimesas a monomer, but typically in the form of either a homodimer or a heterodimer with anothermember of the NR superfamily) to enhancers referred to as hormone response elements (typicallya purine followed by GGTCA, although mutations, extensions, and repeats have generatedreceptor-specific enhancers) in nuclear DNA. The E domain also mediates dimerization and interactionswith other categories of proteins, including heat-shock proteins. It is the second-mostconserved region of superfamily members. The A/B domain is variable and in many NR proteinscontains a motif (AF-1) that can drive ligand-independent transcription. The D domain is alsovariable; it is sometimes referred to as the hinge, as it connects the DBD (C domain) and theLBD (E domain). The D domain, however, is much more than a simple connector, as it providesthe critical function of nuclear localization and modulates transcription through interactions withother nuclear proteins. (Fig.,1)

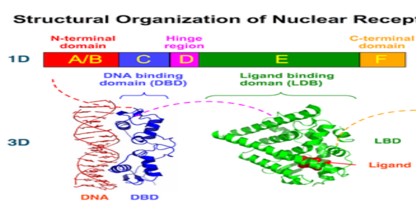

Figure.,1: Structural organization of Nuclear Receptors.

Known ligands ofNRs include steroids, thyroid hormones, retinoids, vitaminD, mammalian bile acids, farnesoids, fatty acids, phospholipids, and even diatomic gases. Despite the length of this list, many NRs, including those of insects, remain orphan receptors insearch of endogenous or xenobiotic ligands. An active area of current research investigatesinteractions of the insect juvenile hormones (JH) with Ultra spiracle protein (USP).

NRs have been identified using polymerase chain reaction (PCR)-based approaches in many metazoans, including taxa as atypical as cnidarians, ctenophores, and sponges. In 1999, phylogenetic analysis of the 65 NR genes then sequenced prompted a proposal for a formal system of nomenclature, which has since been widely adopted, six NR subfamilies (NR1–NR6) were initially identified; added since then is a seventh (NR7) that comprises unusual receptors to date found only in genomes of the cephalochordate amphioxus and the sea urchin, an echinoderm. A small NR0 subfamily includes NR-related proteins with a DBD but no LBD. Representatives of all six major subfamilies are present in humans and other vertebrates, but the chordates are not exceptional in this regard, as numerous comparative studies have revealed that all NR subfamilies were present prior to ancient splits in the metazoan lineage (Susan E Fahrbach *et al., 2012).*

A substantial subset of NRs is expressed in the tissues, including the brain, of adult insects. In *Apis mellifera*, for example, this subset includes EcR and several orphan NRs, including all NR members of the metamorphosis cascade. Disruption of signaling via EcR disrupts sleep and learning in adult *D. melanogaster*. Even after completion of metamorphosis, adult tissues, including the ovaries and possibly the brain, synthesize ecdysteroids. Study of the role of NRs in the regulation of adult insect behavior, especially theNRs other than EcR, will lead to improved understanding of behavioral plasticity. This new knowledge may also lead to novel strategies for insect pest controlVelarde *et al.* (2009).

Applications of Nuclear Receptors in Entomology

Use of EcR in Development of Target-Specific Insecticides

The most dramatic deployment of NRs in applied entomology has focused on *EcR* in its role as the master transcription factor for insect steroid hormone signaling.

EcR (NRs) have been utilized in the development of target specific insecticides to control particular group of insecticides. Diacylhydrazine (DAH): An example of a molt-accelerating compound analogs for agricultural pest control. These strategies exploit subtle differences in the ability of nonsteroidal agonists to bind to the LBD of the EcRs of different groups of insects. Thus, specificity can be obtained despite the high degree of cross-taxa sequence.

Key words: Nuclear receptors, Ecdysteroids, target specific insecticides.

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30. AGRICULTURE

Polymer Coated Fertilizers: An Advance Technique in Nutrient Management

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Introduction

Control release fertilizers (CRF's) are coated fertilizers that release nutrients over an extended period of time at a rate driven primarily by temperature and moisture of the root zone. It has been estimated that slow-release fertilizers comprise only 8-10% of the total fertilizers used in Europe, 1% in the USA and only 0.25% in the World. In Japan 70% of polymer coated controlled-release fertilizers are used in rice. Controlled-release is one of the modern application that has enhanced nutrient use efficiency. Fertilizer use efficiency can be increased by modification of fertilizer products. e.g. coated encapsulation. Controlled release fertilizers (CRFs) will bring revolution in agricultural industry in near future.

Polymer coated fertilizers (PCF's) were also a type of CRF's, which are solid or other nutrient core, coated with various polymers (plastics). Fertilizer use efficiency can be increased by application of polymer coated fertilizer compared to common fertilizers due to very less nutrient losses. Three most commonly marketed products are Nutricote, Osmocote and Polyon. Coatings are tough, resist to damage and thin. Nutrient release is due to controlled diffusion, which is fairly constant over time. Nutrient release depends on coat thickness, chemistry, temperature and moisture.

Types of Coating Technology of CRFs

- Polymer (polyethylene, polyesters)
- Sulphur
- Sulphur plus polymer

Polymer Coated Fertilizers (PCFs)

Polymer-coated fertilizer technologies vary greatly between producers depending on the choice of the coating material and the coating process. The Pursell Reactive Layers Coating (RLCTM) uses polymer technology, while Polyon uses a polyurethane as does Haifa (Multicote) and Aglukon (Plantacote). Chissoasahi polymer technology (Meister), Nutricote is a polyethylene; while Scotts polymer technology (Osmocote) is an alkyd-resin.

The quantity of coating material used for polymer coatings of conventional soluble fertilizers depends on the geometric parameters of the basic core material (granule size to surface area, roundness etc.) and the longevity target. In general, the coating material represents 3-4% (RLCTM) to 15% (conventional coating with polymers) of the total weight of the finished product. For example, the capsule or coating film of Meister (encapsulated urea) is 50 to 60 µm in thickness and approximately 10% in weight. The longer the need to supply the nutrients, the smaller is the amount released per unit of time. The producers indicate the period of release, e.g. 70, 140, up to 400 days release at constant 25°C. However, if the polymer-coated fertilizers are not straight nitrogen but NPK fertilizers, particularly when containing secondary and micronutrients, the rate of release of the different nutrients, N, P, K, S, Ca, Mg and micronutrients, are generally Slow- and controlled-release and stabilized fertilizers not stated.

Mechanisms of Nutrient Release

The nutrient release through a polymer membrane is not significantly affected by soil properties, such as pH, salinity, texture, microbial activity, redox-potential, ionic strength of the soil solution, but rather by temperature and moisture permeability of the polymer coating. Thus, it is possible to predict the nutrient release from polymer-coated fertilizers for a given period of time.

In a recent assessment of polymer-coated materials, multiple mechanisms of release, including diffusion, osmotic pumping (apparently caused by changes in hydrostatic pressure and an osmotic gradient), and convective release by coating disruption. Release occurs mainly by diffusion when the water potential is at steady-state and the coating material is permeable to the solutes within. Release by diffusion yields a relatively steady release, subject mainly to changes in coating permeability and temperature. Osmotic pumping (mass flow) and diffusion of solutes is likely when the coating is semi-permeable to at least some solutes and cracks of limited volume are formed in the coating by the build up of hydrostatic pressure. If the coating is completely impermeable to the internal solutes, there is no solute release until cracks are formed. Impermeability to fertilizer salts may be associated with swelling of the prill, although swelling may not be easily detectable. Finally, convective solute transfer by coating disruption would occur when the build up of hydrostatic pressure causes coating rupture. This is the release mechanism for sulfur-coated urea, likely happens in most polymer coated fertilizers only due to coating failure.

Nutrient release from Osmocote (an alkyd-resin-coated fertilizer) follows water entering the microscopic pores in the coating. This increases the osmotic pressure within the pore, which is enlarged and nutrients are released through the enlarged micropore. The alkyd-resin-type coating makes it possible to satisfactorily control the release rate and timing. Polyurethane-like coatings also provide a good control over rate and duration of release.

Why to use PCFs

1. 70 per cent of conventionally applied fertilizer goes unutilized
2. Loss of nutrients due to volatilization and leaching

3. Fertilizer run-off in surface water leads to eutrophication process
4. Negative environmental impacts
5. Fertilizer waste through leaching increases ground water pollution
6. Less fertilizer use efficiency

Advantages

1. Minimize nutrient losses and increase Nutrient Use efficiency (NUE)
2. Extend nutrient release timing and meet plant demand timely and efficiently
3. Reduce labour requirement and reduction of the labour cost.
4. To improve the yield and reduce the cost of production
5. Reduction in ground water pollution and water bodies
6. Root burn can be avoided with the application of controlled release fertilizers even at the increased quantities of fertilizers supplied.
7. Reduced leaf burn from heavy rates of surface application
8. More uniform growth response
9. Flexibility of release periods from 40 to 360 days at 25^{o} C
10. Improved storage and handling properties of fertilizer materials

Disadvantages

1. Very high cost.
2. Prills can be damaged by abrasion.
3. Nutrient deficiencies may occur if nutrients are not released as predicted because of low temperatures, flooded or droughty soil, or poor activity of soil microbes

31. HORTICULTURE

The New Generation of Phytohormones and their use in Horticulture

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Introduction

Plant hormones are small molecules derived from various essential metabolic pathways, which are present at very low concentrations and act either locally, at or near the site of synthesis, or in distant tissues. Plant hormones include the new generation PGRs like brassinosteroids (BRs), jasmonic acid (JA) and salicylic acid in addition to the classical hormones like auxins, cytokinin (CK), gibberellic acid (GA), abscisic acid (ABA) and ethylene.

Brassinosteroids

These are class of polyhydroxysteroids that have been recognized as a sixth class of plant hormone. Brassinolide was the first isolated brassinosteroid, since over their discovery 70 BR compounds have been isolated from plants

Role of Brassinosteroids in Plants

1. **Vegetative role-** Enhance germination, rhizogenesis, cell and shoot elongation, respiration, photosynthesis.
2. **Reproductive role-** Flower and fruit development, flower sex expression, post harvest role, improved yield.

Applications of Brassinosteroid

Brassinosteroid is very effective on the yield of yellow passion fruit plants and produced the highest number of fruits per plant it is also improve quality of Grapes by increase cluster weight, berry weight, length and breadth and reduced the rate of berry softening, maintained external colour, stabilized anthocyanins, of Grape cultivar.

Jasmonic Acid (JA)

JA is plant immune hormone derived from Linolenic acid which can convert into variety of derivatives including Methyl jasmonate (MeJA), initially MeJA was discovered as a secondary metabolite in essential oils of jasmine and it's role in plant defence was first shown by Farmer & Ryan (1990).

Role of Jasmonic Acid (JA) in Plants: Regulated plant growth and development

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processes include growth inhibition, senescence, flower development and leaf abscission also helps in tuber formation in potatoes, yams, and onions, response to wounding of plants, also helps in transcription of many genes involved in plant defense.

Applications of JA: N-propyl dihydrojasmonate (PDJ) a JA derivative has been used to improve apple fruit quality and colour it is also regulates ethylene biosynthesis and influence aroma volatiles. Jasmonate have a role in plant defense against environmental stress. The application of PDJ decreased low-temperature injuries such as splitting and spotting in apple fruit.

Salicylic Acid

Salicylic acidis ortho-hydroxybenzoic acid and is a secondary metabolite acting as analogues of growth regulating substances. For the first time saliciline was extracted from white willow (*Salix alba*) and hence the name salicylic acid.

Role of Salicylic Acid in Plants: Salicylic acid (SA) and methyl salicylate (MeSA) are endogenous signal molecules, playing pivotal roles in regulating stress responses and plant developmental processes including heat production or thermogenesis, photosynthesis, stomatal conductance, transpiration, ion uptake and transport, disease resistance, seed germination, sex polarization, crop yield and glycolysis (Malamy and Klessig,1992).

Applications of Salicylic Acid: Salicylic acid (SA) and acetyl salicylic acid (ASA) provide multiple stress tolerance in plants and its derivatives regulate the expression of stress tolerance. Chitinase, β-1,3-glucanase, Phenylalanine ammonia-lyase and Polyphenoloxidase enzymes increased total phenolic compounds and lignin in mango fruit. Moreover, SA treatment effectively maintained fruit firmness by suppressing conversion of insoluble protopectin into water soluble pectin.

Polyamines

A **polyamine** is low-molecular weight organic compound having two or more primary amino groups, linear polyamines perform essential functions in all living cells, examples are putrescine, cadaverine, spermidine, and spermine. Signal transduction pathways of PAs and JAs by interfering with ethylene biosynthesis and perception, lead to a less ripe fruit - quality control in the postharvest handling chain.

Role of Polyamines: Cell division, Embryo development, regulate fruit ripening, flower development, reduce physiological weight loss, hypersensitive response to microbial infection, defense mechanism against abiotic stress.

Applications of Salicylic Acid: In pomegranate increasing salinity level increased tissue concentration of Na^+ and Cl^-, while the K/Na ratio decreased. Using polyamine, increased concentrations of potassium and proline content can increase plant resistance to salinity levels.

1-Methyl Cyclo Propane

It is a cyclopropene derivative used as a synthetic plant growth regulator and non toxic gas that delays fruit softening and improves quality of several fruits also affects in ripening and senescence processes, including pigment changes, softening and cell wall metabolism, flavour and aroma, and nutritional properties, but to varying degrees in both non-climacteric and climacteric products.

Role of 1-MCP: 1-MCP interacts with ethylene sensitive sites in the fruit and delays ripening, it also slows fruit softening and senescence, maintains firmness, decreases storage disorders such as scald, core flesh and internal browning from senescence and chilling injury also delays chlorophyll degradation

Prohexadione – Ca: Chemical compound of carboxylic group, Prohexodione calcium is a new generation anti- gibberellin. It is a mimic of 2-oxoglutaric acid and ascorbic acid.

Role of Prohexadione – Ca: Reduces longitudinal shoot growth by blocking dioxygenases involved in biosynthesis of gibberellin also reduces ethylene formation and delays abscission of young fruits and senescence it can also reduces alternate bearing

Conclusion

The application of new generation plant growth regulators and chemicals may improve the physiological efficiency of the crop growth and development mainly on delaying senescence, ethylene regulation, chlorophyll retention, pest and disease resistance, postharvest shelf life and quality in fruit crops. The time of application, crop stage, dosage, age of crop, plays an important role for effective utility of plant growth regulators. The availability, toxic effect and cost were the limiting factors of new generation plant growth regulators.

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32. AGRICULTURE

Induction of Germination in *Tectona grandis*

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The germination rate of Teak is low, usually it less than 50% but in some case it would be maximum 80%. Seed has hard pericarp (dormancy) and fresh seed is more difficult to germinate in natural process due to which the teak seed has been stored for 12 months. Seedling is raises in nursery due to low germination percentage and more average time requirement for seed germination (Luna, 1996). In fact the drupes germinate slowly and irregularly if it is untreated (Jackson, 1994). Germination is start from 10 days after harvested but it makes after 2-3 months. Seedlings should be given a little shade for their first year and can then be planted into their permanent positions. The main problem in teak is poor germination in nurseries, only 3% seeds results in a plantable seedling due to irregular dormancy cycle. The nature of barriers which prevent germination can be physiological (presence of germination inhibitors in faulty mesocarp), physical (thick and hard endocarp) and morphological (hormone imbalance in seeds) which results in low germination (Masilamani, 1996). Natural regeneration is particularly abundant in forests exposed to fires and often occurs in patches. Seeds collected and used to establish plantations. It is recommended that seeds would be collected from trees over 20 years old. Seed is often collected from selected stands. The dormant fruit which lay in the ground for 30 - 40 years has been known to germinate abundantly. Eco-physiological studies thus are important to know most desirable means of determining seed viability and consequently germination (Sen, 1977).

The germination of fresh seed involves pre-treatment to remove dormancy arising from the thick pericarp. Teak is propagated from seeds. Pre-treatment involves alternate wetting and drying of the seed. The seeds are soaked in water for 12 hours and then spread to dry in the sun for 12 hours. This is repeated for 10–14 days and then the seeds are sown in shallow germination beds of coarse peat covered by sand. The seeds then germinate after 15 to 30 days. Clonal propagation of teak has been successfully done through grafting, rooted stem cuttings and micro propagation. Bud grafting on to seedling root stock has been the method used for establishing clonal seed orchards that enables assemblage of clones of the superior trees to encourage crossing. Rooted stem cuttings and micro propagated plants are being increasingly used around the world for raising clonal plantation. Both grafting and budding methods good result than branch cutting methods. The rooting time of cutting is 8 - 15 days, and the survival rate of rooted stock is 90 - 100%. According to Billah *et al.*(2015) the highest germination percentage was observed 86.67% in Pith method, followed by 73.33% in soaking in normal water (72 hours) and 45% in soaking in normal water (24 hours). Vázquez et al., 2014 reported that greater germination percent observed when seeds were exposed to sunlight for three days recorded 78% germination, seeds were soaked in water for 72 hrs get 66% germination, seed were soaked in water for 12 hrs and dried for 12 hrs at a temperature range of between 22 and 45°C recording 79% germination and seeds were soaked in fast-flowing water for 24 hrs and exposed to sunlight for 24 hrs, 80% germination was observed. Mayer *et al.,* 1963 reported that endocarp is the main hindrance in teak seed germination. In treated teak seeds (40°C/ 4°C for 15 minutes) the quick change in temperature resulted in splitting endocarp and facilitated the emergence to solve the germination problem. Alternate heating and chilling (40°C/ 4°C for 24 hours) treated with 90% HCL and 90% H_2SO_4 for 15 minutes followed by KNO_3 treatment for 4 hours to teak seeds showed 4 to 6% germination (Jatt,2007).

Teak's oils is make it useful in exposed locations, and make resistant against timber termite and pest. Oil of the seeds promotes hair growth as well as oil from tender shoots is used against scabies in children and oil from root treats as eczema, ringworms and inflammation. Bark has used as astringent and in the treatment of bronchitis. Flowers are diuretic used for treats biliousness, bronchitis and urinary disorders. Wood has been used as a hair tonic. Wood powdered has poured with hot water to makes wood tar, which is effective in relieving bilious headaches and tooth aches; reduces inflammations or eruptions of the skin. Charred wood are soaked in poppy juice to prepare a paste that has been used to relieve the swelling of the eyelids. Extracts of the leaves are reported to be effective against mycobacterium tuberculosis, to treat bleeding of larynx, trachea, bronchi, or lungs, and sore throat.

Tectona grandis germination was difficult but now it easy for germination. Physical methods as well as chemical method are helping to germinate the seed. Most of the research worked was done above the dormancy of seed.

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