About the Book

The aim of the book "Integrated Farming System: The Future of Agriculture" to the today's basic needs such as Food, clothing, shelter, health, education, security, roads, electricity and drinking water. Farmers produce food. About 70% of Indian population is engaged in farming. The farming system approach, assumes great importance for sound management of farm resources to enhance farm productivity, reduce the degradation of environmental quality and improve the quality of life of farmers and above all to maintain sustainability in farm production and productivity. Human race depends more on farm products for their existence than anything else since food and clothing – the prime necessaries are products of farming. The world population was increased day by day and the per capita availability of land was decreased day by day and food production also decreased rate. In the fourth coming years and decades will see and exciting time of realisation, discovery and change. Scientists and the technologists will have to explore the benefits that humanity can derive from the mother earth by taking advantage out of this frontier technology. Multidisciplinary efforts are needed for successful utilization of the modern technology to rewarding future of great social relevance. Husiung must be banished from the surface of earth, as a first responsibility of any civilised society to provide sufficient food for the people who are below the poverty line. The development of crop and site specific customized fertilizers and appropriate application of these fertilizers may prove to be very effective to enhance nutrient use efficiency and hence crop productivity. In long run, such practice can arrest the decline in soil fertility and boost the crop yields. Agroforestry has emerged as a robust land use which advocates crop diversification, soil and soil-water conservation, cycling of organic matter and sequestration of CO₂ in plant and soil. This tree-crop combination provides shade to the field crop with making land productive and increasing revenue. Increased productivity, improved soil fertility, nutrient cycling and soil conservation are the major positive effects of interactions, and competition is the main negative effect of interaction, which substantially reduces the crop yield. There are many research reports indicating significantly higher yield of crops in different agroforestry systems compared to sole crop yields. I am highly thankful all authors whose contribute your research/ideas to enhance the utility of the book.

Integrated Farming System: The Future of Agriculture

Joginder Singh
Wajid Hasan
Rashmi Nigam
Prabhat Tiwari
Shish Ram Jakhar

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Integrated Farming System: The Future of Agriculture
Editors

Dr. Joginder Singh
Assistant Professor Horticulture
Janta Vedic College, Baraut, Baghpat, UP

Dr. Wajid Hasan
Scientist Entomology
Krishi Vigyan Kendra, Jehanabad (BAU Sabour) Bihar

Dr. Rashmi Nigam
Assistant Professor Plant Pathology
Janta Vedic College, Baraut, Baghpat, UP

Dr. Prabhat Tiwari
Teaching Associate, Agroforestry
Rani Lakshmi Bai Central Agricultural University, Jhansi, UP

Mr. Shish Ram Jakhar
Ph.D. Scholar, Soil Science & Agriculture Chemistry
JNKVV, Jabalpur, Madhya Pradesh

Weser Books
Zittau, Germany
Indian agriculture is facing a number of constraints such as burgeoning population. Shrinking farm sizes, limit in water availability, imbalanced fertilization low soil organic carbon, besides the fatigue of green revolution and vagaries of climate change. Farming system is a resource management strategy to achieve economic and sustain agricultural production to meet diverse requirement of the farm household while preserving the resource base and maintaining high environmental quality. The farming system in its real sense will help in subsequent ways to lift the economy of Indian agriculture and standard of living of the farmers. The income from cropping alone from small and marginal farm is insufficient now to sustain the farmers’ family. A judicious mix of any one or more of these enterprises with agronomic crops. Should complement the farm income and help in recycling the farm residues / wastes. The selection of enterprises must be based on the cardinal principles of minimizing the competition and maximizing the complementary between the enterprises. Of late, the researchers on multi disciplinary approach greatly realized and started developing the various farming systems models in accordance with the agro-eco systems zones. IFS system integrate different production systems like dairy, poultry, livestock, fishery, horticulture, sericulture, apiculture, etc. with agricultural crops production as the base. Increase farm resource use efficiency (land, labor and production/by- products) so as to increase farm income and gainful employment opportunity. IFS promote multi-cropping, for multi-layered crops of economic value so as to sustain land productivity and maintain environmental quality and ecological stability. The role and factors associated with integrated farming system have been studied as a potential option to improve farmers’ income and ensure their sustainable livelihood in India. The contribution of different combinations of enterprises such as poultry, fishery, sheep and goat and horticulture; with crop and dairy as base enterprises have been analysed for their impact on farmers’ total income.

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Rashmi Nigam
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EFFICIENT WATER MANAGEMENT STRATEGY THROUGH APPLICATION OF SUPER ABSORBENT POLYMER (HYDROGEL) IN RAINFED AGRICULTURE

Shashank Tyagi\textsuperscript{1}, Vinod Kumar\textsuperscript{2}, Sunil Kumar\textsuperscript{1}, Pramod Kumar\textsuperscript{3} and G.R. Sharma\textsuperscript{4}

\textsuperscript{1}Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, India
\textsuperscript{2}K.V.K. Banka, \textsuperscript{3}K.V.K. Jamui and \textsuperscript{4}K.V.K. Munger B.A.U. Sabour, Bhagalpur

Corresponding author Email: drshashank_tyagi@rediffmail.com

ABSTRACT

Water availability is a key limiting factor for securing superior yield in rainfed as well as irrigated agro-ecological systems. The rapid increasing population demand for irrigation water resources and food cereals crop, coupled with the impact assessment of predictable climate change scenario makes them essential to build up the various technological strategies for the judicious and efficient utilization of water, plant nutrient sources and pesticides. Under rainfed and supplemental irrigation conditions, the crops can better withstand drought stress conditions or may have the without moisture stress and improvement in seed germination capacity, crop seedling establishment and growth pattern will be the consequence of application use of various super absorbent polymers in agriculture. These will certainly help to ensure uniformly and healthy/ suitable crop vigor stands as well as achieving higher crop economic yields. Under irrigation facility conditions, the irrigation intervals can be easily and suitably extended and thus water applying cost is saved. Due to the considerable volume reduction of the water absorbent hydrogels as water is released to the crop plants, it creates within the soil profile, free soil pore volume offering additional pore space for air and water infiltration rate, storage within soil and root growth of the crops. The remarkable improvement of the several soil physical properties like soil porosity, soil permeability and water infiltration rate will significantly reduce water surface runoff and soil erosion, especially when soils form semi hydrophobic crusts under compacted soil conditions. Hydrogels are safe for human beings and the healthy environment, are not more persistent and will not pollute the soil surface or ground water surface. After a certain particular period of time duration, it becomes susceptible to natural degradation process in the soil matrix by physical means and microbial activities.

With Indian Meteorological Department, Pune forecasting above normal heat wave conditions starting from the months of March to May and ABM declared the possible below-normal monsoon scenario, potassium poly acrylate based water containing gel might be the key factor to unhindered kharif crops in India in 2017. Our country is expected to have experience an above-normal summer months in 2017 with mean temperature to rise up by 1.0°C. Heat waves may last throughout summer month planting season that can greatly hamper the seedlings and harvest of the kharif crops. To make matters up to be worsen, Australian Bureau of Meteorology forecasted approximately 75% likelihood of El-Nino on the Pacific oceans that can directly reduce the monsoon intensity on Indian Sub-continents.

Since kharif season is the major crop season and monsoon season is pivotal for various farming situations which is greatly dependent on rainfed farmings, anomalies in weather conditions may lead to delayed planting of various crops i.e. rice, soybean, cotton, pulses, and groundnut. In this respect, it have been tried best to implement the various weather forecast schedules through Department of Agriculture & Cooperation Centre on moisture controlled saving release methods during water scarce situations.
One such method is use of water absorbing material to retain soil moisture along with root zone for prolonged periods to combat drought stress and reduce irrigation frequency without compromising plant growth. Such materials are called Super Absorbent polymers. SAP for agriculture can greatly reduce costs in terms of irrigation expenses as well as reduce crop mortality and need for pesticides and fertilizers.

**Major drawbacks/ constraints with modern irrigation practices**

The pre-dominant irrigation practices are the surface draining i.e., direct application of irrigation water to agricultural crops from the soil surface. This has a problematic and flawed system as the agricultural crops can efficiently utilize only 50% of the provided irrigation water while remaining water is lost in conveyance, runoff and by evaporation processes. Modern advanced methods like drip irrigation system and use of sprinklers can effectively reduce the wastage of irrigation water but because of their higher initial cost, inadequate governmental subsidies and operating co-operation, lack of technological inputs and after sale’s services, faulty agricultural equipments, damages caused due to pests attack and being higher investment cost. Spatial diversifications in soil profile characteristics, ample shortage of extensive land holdings and under privileged/ discouraged nature farmers from adopting advantageous and economical water conserving irrigation techniques, even in arid zones with distinct scarcity of surface water. Stress on sustainable agricultural development processes even in agricultural farm sector have laid down the emphasis on further precious, economical and optimal utilization of land, irrigation water and plant derived farm resources with major attainable goals to maximize the optimal soil and water productivity without deteriorating the environmental and natural bio-resources.

**Super Absorbent Polymers (SAPs) uses in other countries**

Extensive and exhaustive researches all over the entire world, particularly, China, Europe, Iran and USA countries have led to the development of particular classes of Super Absorbent Polymers that could enhance the water use efficiency and enhance the crops’ yield. Soil conditioning properties with SAPs is very interesting as well as innovative facets in the area of modern advanced agriculture as well as rainfed/ dryland agriculture. The uptake could be as much as 100,000% and even then higher. SAPs are generally, in less sugar resembles hygroscopic crystals that can also directly be added to the cultivated soils. They are oftenly predominantly utilized for reducing the ample quantity of soluble NPK fertilizers per particular crop cycle, thus greatly contributed to the water bodies and environmental conservation practices.

**Super Absorbent Hydrogel Technology available in India**

National Research Development Corporation, an enterprise under Department of Scientific and Industrial Research, Ministry of Science and Technology, Govt. of India occasionally agreed to commercialize a “Novel Super Absorbent Hydrogel Technology”. The prime features as stated under the agreement are: Its high absorbance at very high temperatures is appropriate for various semi arid and arid regions. Low application rate of hydrogels also improves the soil physical properties viz., aggregate stability, porosity, and hydraulic conductivity of soil medium. SAPs had multi-dimensional applying aspect aimed in mitigating various problems remarkable associated with the farming systems and environment safety. Hydrogels act as major water reservoirs at plant root proliferations which provided the water supply for crop growth.

**Hydrogels: Super Absorbant Polymers for Precision Irrigated/ Rainfed Agriculture**

Hydrogels are generally known as the cross-linked three-dimensional water absorbent polymers. Three chief kinds of hydrogels have also been found appropriate for several agricultural uses: Starch-grafted co-polymers, Cross-linked Poly acrylates, Cross-linked Poly acrylamides and Acrylamide acrylate co-polymers. Because of their tremendous water absorbing nature and gel making capability, they are therefore referred as super absorbent polymers or hydrogels. They are often three main groups of
hydrogels (i) Starch-grafted co-polymers (ii) Polyacrylate based polymers (iii) Acrylamide-acrylated co-polymers.

Three kinds of super absorbent polymers are often used and are commonly classified as natural, semi-synthetic and synthetic based polymers (Mikkelsen, 1994). Synthetically poly acrylamides with potassium salt bases manufactured by Beijing Hanlisorb Poly water Hi-tech Co. Ltd. used is of cross-linked polymer which is developed to retain and store rain/irrigation water and fertilizers in the agricultural allied and horticultural sectors. Therefore, the polymers can often retain the residual soil moisture available and fertilizers up to approximately 3 to 5 years after their application.

Potassium poly acrylate is the principle matter which is often used in SAPs industries and marketed as super absorbent hydrogels for basic agricultural uses because of their longer and persistent water retention and superior efficiency into soil with negligible toxicity levels.

![Fig. 1. Interaction impact of super absorbent polymers and varieties on harvest index](image)

These are generally made from acrylic acids with cross-linking agents like potassium by solution and/or suspension’s polymerization process. These polymers so formed is so called as poly acrylates where swelling capacities and gels modulus greatly depend on the quantities and types of cross-linkers utilised. Poly-acrylates are very non-toxic, non irritating and non-corrosive in properties and be tested for biodegradability with the degradation rate of 10-15 per cent per annum. It is very effective at decreasing the irrigation frequencies, maintaining the soil textures and permeability of the soil while giving assurance for suitable and healthy growth of crop plants itself. Uses of hydrogels lead to enhanced the water use efficiency by protecting the leaching losses and enhancing the frequencies of irrigation. During summer months especially in semi-arid region, inadequate soil moisture regime can cause the plant stresses. Moisture being released by the hydrogels near the root zone area of the crop reduces the water stress and increases the plant growth. Hydrogels can often reduce the fertilizers leaching and reduce the application techniques of the pesticides.

Under the inappropriate soil situations, this has been long unstable working life style without the adverse effect on the agro-ecological systems. It is very easy to utilize the farmers’ friendly products when compatible with the larger arrays of the soil types and orders. It was found a large scale applications in the open fields and protected cultivations, terrace’s farmings and vertical farmings. Nazari (2010) reported that the application of polymers tend to enhance test (100-seeds) weight of the sunflower crop as compared to control (without polymers). Similar findings were also reported by Allahdadi et al. (2005).

Super absorbent polymers are the water retaining polymer, cross-linked hydrophilic nature, bio-degradable as well as amorphous form polymers which can also absorb and retain amount of water which is at least 400 times of its own original weight and makes them at least 95 % of it is stored and be water available for absorption for the crop (Johnson and Veltkamp, 1985). When the polymers are often mixed with the soil solution matrix, it often forms an amorphous form gelatinous mass form on hydration process and is being capable of the absorption and desorption over the long time period, hence is acted as slow released sources of water in the soil. The SAPs particles might be considered as ‘miniature of water reservoirs’ in the soil and the water will also be removed from the water reservoirs upon the demand of the roots through the osmotic pressure’s differences. Assuming the efficiencies of hydrogels into the soil conditioning and the moisture retention capacities, an optimum rate of mixing ratios is often needed to achieve the maximum efficiency of the standard methods. Since the moisture
holding capacities is the function of the soil characteristics, doses of the hydrogels varied on the basis of the soil types.

Super absorbent polymers were also introduced to the open markets in 1960s by the American Companies, Union Carbide’s (Dexter and Miyamoto, 1995). The materials having their capacities to absorb the soil water 20 times greater than their own weight is also considered to be as the super absorbent polymers (Abedi-Koupal and Sohrab, 2004). But, owing to rapid development of the cross-linked polymers with their high level of water holding capacities (about 400 times and even up to level of 2000 times) and relatively lower cost effectiveness have been rejuvenated the prime interests on the uses of these polymers in modern agriculture.

### Doses of application of super absorbent polymers in agriculture

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<th>Type of soils</th>
<th>Dosage of hydrogels</th>
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<td>Arid &amp; Semi-arid Regions</td>
<td>4-6 g/kg soil</td>
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<tr>
<td>For all level of water stress and improved irrigation period</td>
<td>2.25-3 g/kg soil</td>
</tr>
<tr>
<td>To delay permanent wilting point in sandy soils</td>
<td>0.2-0.4 g/kg or 0.8% of soil</td>
</tr>
<tr>
<td>To reduce irrigation water by 50% in loamy soil</td>
<td>2-4 g/plant pit</td>
</tr>
<tr>
<td>To improve relative water content &amp; leaf water use efficiency</td>
<td>0.5-2.0 g/pot</td>
</tr>
<tr>
<td>To reduce drought stress</td>
<td>0.2-0.4% of soil</td>
</tr>
<tr>
<td>To prohibit drought stress totally</td>
<td>225-300 kg ha(^{-1}) of cultivated area</td>
</tr>
<tr>
<td>To decrease water stress</td>
<td>3% by weight</td>
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Both water soluble as well as insoluble polymers have been made for the purpose of agricultural use. Water soluble polymer does not form the gels as they become soil conditioners. Water soluble polymers were being developed primarily to aggregation and stabilization of the soils, combats the erosion of the soil and improves the percolation losses and improves the crop yield on droughty and structured less soils.

Polyethylene oxide hydrogels, poly acrylamide hydrogels and cross-linked poly-ethylene oxide co-poly urethane hydrogels were also alleviated plant damages that have been resulted from the salts induced and water-deficient stresses (Shi et al., 2010). Poly acrylamide hydrogel doses applied to the soils may often need to be maintained on the basis of soil properties, slopes and types of the soil erosions targeted (Wallace and Wallace, 1986).

### Salient peculiar features of hydrogels

They are available as dryness, white color granules and powdery form, long shelf life, be compatible with the all soils’ and plants’ types, being less affected by presence of soluble salts in their immediate co-environment, amends the crop root growth and density, decreases the establishment period of the nursery, decrease in the fertilizers and herbicides’ leaching, increase in water holding capacity, reduction in soil compaction tendency, prevention in pre-mature defoliation, increase in fruiting or flowering density and increase in whole growth and biomass of crop plant. Hydrogels are the chief economical and eco-environmental steps for better and efficient water management practices for modern agriculture, especially in the areas of arid and semi-arid without compromisation of the crop yield.

### Water absorption process with application of hydrogels

Hydrogels worked as water absorbing reservoirs around the root proliferation mass of the crop plant. There is a sufficient possibility to trap the irrigation/ rainwater that may be collected into soil, being stored and then gradually released to meet the crop requirements over long time durations. Hydrogels often mixed with the soil increased the soil permeabilities’ and improves the germination capacities of...
Integrated Farming System: The Future of Agriculture

the seed and the seedling’s growth. The rain water retention, erosion of the soil by stormy water runoff specially in the sloppy terrains and leaching on the surface can be greatly affected. This is the soil conditioners that may be used simply in all soil types and with all crop types and reduces the losses in soil moisture content by the leaching and / or evaporation process.

Agricultural applications of hydrogel materials

Hydrogels application in modern/advanced agriculture in respect of the proposed agricultural practices and their benefits are being summarized.

Conservation theme for Agricultural Arable Lands

Application of hydrogel’s polymers can enhance the water retention/absorption capacities of the soils by 50-70% with the proper soil amendments with different doses of the soils to doses of hydrogels ratio. Bulk density of the soils can decrease by approximately 8-10 per cent. There is almost upward trend’s in a volumetric saturated water content of the soil with increasing doses of hydrogels have shown the clear cut signs of increment in water use efficiencies particularly in arid and semi-arid zones of India. These have the positive effect on the net yield of the crop plant. Hydrogels directly affects the soil permeability, structure, density, texture, infiltration and evaporation of soil water. Irrigation frequencies, compaction tendencies and soil water runoff are also decreased whereas the aeration and soil microbial activities are being promoted.

Enhancement in Irrigation Efficiency of the Crop System

Water stress owing to scarce moisture around the crop root zone is oftenly associated with the premature shedding of leaves, decrease in chlorophyll, reduction in seed yield, lower fruit and/ or flower yield/ plant. Uses of hydrogels may assist the moderation of these impacts caused by deficient irrigation practices. Being water retaining and releasing agents greatly increased the irrigation intervals of crop cultivation, enhancement in irrigation efficiencies specially in the arid and semi-arid regions.

Reduction in Drought Stress of the Region

Drought stress can occasionally led to the formation and production of oxygen bearing radicals that can be resulted in enhanced lipid per-oxidation and oxidative stresses in crop plants. Visible impacts include the stunted plant height, reduction in leaf area and damage in foliar matrix. Hydrogels can also reduce the drought effect on the crop plant led to the reduced water stress and oxygen bearing radical formations which provides the scope for proper growth and productivity of the crops even in adverse climatic conditions.

Enhancement in Nutrient Use Efficiency

Irrigations have the major drawbacks/constraints in huge application of fertilizers and/or the herbicides. Application of synthetic made fertilizers can also be reduced when hydrogels are practiced in farm agriculture without deteriorating the crop yield and plant quality nutrition. This is much appropriate method for achieving the sustainable farming particularly in arid and semi-arid zones.

Bio-degradation of Super Absorbent Polymers

Hydrogels, sensitive to action of UV rays had been degraded into the oligomers. Poly acrylates have become more sensitive to the aerobic and anaerobic microbiologic degradation which degrades at 10-15% per annum into soil water, CO₂ and nitrogen compound. Hydrogel’s molecule is bulky be absorbed into tissues and has zero bio-level of accumulation potential. In northern China, particularly arid and semi-arid region, there are interests in saving water super absorbent polymers for maize. In recent, increase in water deficits associated with heavy utilization of surface water, reduction in ground water, water pollution and soil salinization are threatening the agricultural sustainable production (Hu et al., 2005). Hydrogels are innovatives having superior qualities and high performed super absorbent polymers based on cross-linked K-poly acrylate polymers. Water absorbing and
releasing materials available in *Alsta* hydrogel were found widespread applicability in soil situation as substrate enhancement in farming, horticulture, agriculture, arboriculture, hydroponics, hydro-seeding etc.

![Graph](image)

Fig. 2. Effects of polymer applied (0.5% and 0.25% (w/w) in sandy clay loam soils on soil moisture retention (%) as function of time at saturation in distill water

**Importance and Benefits of hydrogels’ applicability**

Three very common conditions of the soils that restrict the plant growth and crop yield are the lower water retention capacity, higher ET rate and leaching losses of soil moisture. Apart from them, the factors *viz*., drought, degradation and salinization, over doses of synthetic based fertilizers and/ or pesticides and in-appropriate irrigation operations that can severely have on soil and crop plants, often render the permanent damage to the soil micro-flora and fauna as well.

Hydrogels in agriculture technology can also improve the soil qualities, preserves the water and resists the drought stress in soil. It may also increase the sprouting of seed and seedling development leads to better success of the farm. In agriculture and agro-forestry practices, SAPs actes as mini water reservoirs at roots of the plant. SAPs form consistent and cyclic processes of absorption and released the water which can provide optimum soil moisture for early germination and seedling maturity. It reduces the mortality of the seedlings by several times in the nursery. Application of 0.75% (w/w) water soluble super polymers with 50% soil moisture depletion to tomato crop produced the highest crop yield than other polymer’s levels (0, 0.25, 1.25 and 1.75%, w/w) (Lakshmi, 2011). Khadem *et al.* (2010) also noted that water is the limiting factor considered for yield improvement of the agricultural crop. In order to conserve soil moisture, some moisture conserving materials *viz*., crop residues, mulches, wastages, leaf/crop litters, crop straws and crop stubbles and other synthetic based materials i.e. hydro-plus, super absorbent polymer materials can also be used. A super absorbent polymer are of highly hydrophilic in nature owing to lower cross-linked structure and retains much more water into soil. In cold desert zones, crop plant deaths during germination time and maturity stages are mainly common owing to soil moisture freeze in and around root tissues of the crop plant. Absorbed soil moisture by the hydrogels do not freeze and make them easier accessibilities to the crop plant. This regulates temperature of the seedlings growth, prevention in crop plant death by the freezing process. SAPs may help in saving of moisture and manpower by overcoming the drought stress conditions and acted as soil conditioners, prevented them from leaching losses in case of sandy soil, soil surface runoff in mountain and sloppy lands, improves the virescence and restoration of soil biota.
SAPs may reduce the over dose of the fertilizers and/or pesticides in the crop fields. Chemicals then so absorbed within water are gradually released into root system, thus extends the shelf life and nutrient uptake efficiency by the roots. SAPs acted as soil matrix flocculation’s. They bind the loosen soil. Thus it forms them into loams that may help in suitable root latching. Repeated mechanism of absorption and release of soil moisture prevents the over compaction of soil and provide the more space for aeration and progress of soil edaphon. It has very wide range of application ranged from agriculture, agro-forestry, industries’ planting, gardening, drought escape, soil and water conservation. This helps in reducing soil erosion by sub surface runoff, fertilizers and pesticides leach out to the ground water, reduction in cost of applied water and irrigation sources and success per cent at growth parameters and higher yields of the crops. Application of super absorption polymer (Bhagiratha) at 28 kg ha$^{-1}$ with recommended dose of fertilizer in arhar crop maintained their higher seed yield by 12% than that of control (fertilizers alone) (Mondal, 2011). Polymers applied at 300 kg ha$^{-1}$ produced the highest economic yield and escaped the effect of drought stress in the agriculture (Nazarli and Zardashti, 2010).

**Operations and uses of super absorbent polymer in rainfed agriculture**

Hydrogels for crops is consisted of non-toxic potassium based polyacrylate polymers. With water, polymers’ chain absorbs soil moisture by osmosis process and swelled out into the soil. Absorbed soil water makes the gel matrix and may be stored intact for long time period. Irrespective of types of the soil, hydrogels ensure proper biomass of the crop. This protects them from the transplanting shocks, subsoil binders and soil aeration, reduction of need for mulching, reduction in germination capacity, greatly reduction in mortality, application of fertilizers and pesticides etc. Super absorbent hydrogels are synthetically water absorbing polymers which have their potential of water uptake as much high as 100,000 per cent of their own body weight in short span by osmosis process and form the granules in the soil to improve the soil properties. Polymers are introduced in our country with an objective to motivate them in rainfed agriculture for saving of water and nutrients. A dose of co-polymers varied from 2.50 to 60.0 kg ha$^{-1}$ depends upon the types of polymers, methods of their application and types of the crop.

Application of 20 kg PAM ha$^{-1}$ prior to sprinkler’s irrigation enhanced the infiltration rate and decreased the runoff erosion (Stern et al., 1992). In some situations, overdoses of hydrogels caused reverse findings because it decreases the soil air followed by filling the vacant spaces and swelling of the gels. There are no effects or low effects of the gels in overdoses hydrogels’ application into soil on growth indices. The main logistic is due to vacant spaces occupied in soil resulted in greater ventilation of the soil (Abedi-Koupai and Mesforoush, 2009). Spraying of the hydrogels as granules or mixing with entire root zone is not much effective (Flannery and Busscher, 1982). Better results are obtained when hydrogel is layered few inches below the soil.

Determination of quantity of gels for the best performances was influenced by several factors having climatic, soil types, crop specific etc. Field under arid/semi-arid condition is needed to give appropriate dose of hydrogels, and their method of co-polymers used and assessment of economics. Treatment of the seeds, soil application (broadcasting, row application, dibbling), root dipping tested on establishment of the crop and growth in the dryland is critical for farmer’s livelihood security. Maize needs the water and minerals to develop their plant organs (Orosz et al., 2009). Water supplied for agricultural food production will be decreased with increasing demand from the domestic as well as industrial user of water. Simultaneously, water productivity is yet very low owing to poor or low irrigation and underdeveloped infrastructure facilities (Wang et al., 2007). Polymers are decomposed
to CO₂, ammonia, water and potassium ions (Mikkelsen, 1994). Although manufacturer made the recommended doses of SAPs for maize crop production varying from 15 to 30 kg ha⁻¹. Zeolite, highly cross-linked polyacrylamides with 40% amide groups be hydrolysed into the carboxylic groups were usually able to make it prolong the survival mechanism of the crop plants under drought situations. Zeolite can improve the soil structures by coupled it with high CEC with selectively affinities for NH₄+ and K+ ions. Quantity of the total soil water needed for irrigations is reduced by 15 to 50 per cent when soil conditions by SAPs are often adopted. SAPs are more safe, bio-degradable, non-toxic and with inert matter with increasing their shelf life and lasted for several years in the soils actively. However, the better soil aeration in the root zone of the crop enhances the germination, root growth and microbial biomass activities.

This may be concluded that this is a hydrogel which absorbs water and fertilizer at the roots and releases these for the plants again in dry conditions. The gel particles store rainwater and water from irrigation systems, thus creating a constant water store exactly where the plant requires it at the roots. The water quantity available to the plants is thus significantly increased, resulting in an optimum water supply and ensuring quicker and better root growth. This gives the plants lasting protection against drought.

References


NANO TECHNOLOGY FOR SUSTAINABLE AGRICULTURE

Suresh Kumar and S. F. A. Zaidi

Department of Soil Science and Agricultural Chemistry, Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U. P.)

Corresponding author Email: skumarnduat@gmail.com

Abstract

Indian agriculture is facing a number of constraints such as burgeoning population. Shrinking farm sizes, limit in water availability, imbalanced fertilization low soil organic carbon, besides the fatigue of green revolution and vagaries of climate change. To discuss all the challenges ahead, we have to think of an alternate technology such as nano-technology to detect and deliver the correct quantity of nutrients or other inputs required by crop which provide the productivity for ensuring the environmental quality. The strong scientific foundation of nanoscience was establishment by Nobel Laureate (1965) and physicist Richard Feynman who first emphasized and realized the importance of nano scale range and how properties of nanomaterials and devices could present future and scope in materials science research. (Rao, 2016). Nanotechnology applied as a tool, it can be address some of world’s most critical sustainable development problem in the areas of agriculture and biodiversity, water, energy, health and environment and ecosystem management. In India depletion of natural resources, deterioration of soil health, declining productivity, incidence of new pests and diseases, global warming and climate change are the major challenges for sustainable agriculture. Nanotechnology can play in soil science as the most potential area in the field of agriculture. Nanotechnology found potential applications in controlling nutrient release and availability, soil properties, weathering of minerals and development, nature of soil Rhizosphere, nutrient ion transport in soil plant system, soil and water conservation, water treatment and efficient management and remediation of soil and ground water pollution. (Mukhopadhyay et al., 2009).The word nanotechnology originated from a Greek word which means dwarf and nanometer is one billionth of a water (1 nm= 10^-9 m) nanotechnology is defined as the understanding and control of matter at dimensions of roughly 1-100nm, where unique physical properties make novel applications possible (EPA 2007).

Use of nano technology in agriculture

The use of nano technology in agriculture is still their juvenile stage and no many studied have been carried out in this field. In spite of the scientific and technical knowledge achieve so far, in many conditions, productivity potential has not been fully realized. Nano technology offers a new scientific approach to break this yield barrier and may improve our understanding the biology of different crops. This has the potential to enhance yield and nutritional value and improve systems for monitoring environmental conditions and delivering nutrients and pesticides as appropriate. In addition, it can offer solution to meet the challenges of food security and environmental remediation. Separation and isolation of Nano particles are difficult to perform from the bulk soil, because of their timing, size and tendency to aggregate and form coatings over mineral surfaces. So yields are generally low. Enhancement in yield could be realized by repeated by wetting, drying and freezing-thawing, prolonged shaking, ultrasonification and chemical treatment eg. Hydrogen peroxide. But the, minerals like Allophane and Imogolite can be separated from volcanic soil in large amount. Characterization of nano particles could be achieved by analytical methods such as total organic carbon analysis, x ray diffractometry, fourier transform infrared and nuclear magnetic resonance spectroscopies combined with atomic force, scanning electron and transmission electron microscopy. A number of advanced instrumental technique have also been use to characterized to soil nanao particles. These include X-ray photo electron and x ray absorption fine absorption spectroscopies. The size distribution of the nano
colloids can be assessed by laser diffraction granulometry, while there elemental composition can be determined by Inductively coupled plasma atomic emission spectrometry (Das, 2011). New area of pedology is nanopedology which deals with the study of soil as a natural body, it covers soil mineralogy with imaging technique and artificial intelligence and establishing realationship between biomolecule and polymers, and microscopic atoms and molecule and between macroscopic property and microscopic property (Mukhopadhyay, 2009).

Nanoparticles related to soil physical properties

Nanoparticles can play an important role in characterization and modification and improvement of soil physical properties. Characterization of soil properties such as physical infrastructure of soil microaggregates of 10-50µm scale can be done by using nanoscale secondary ion mass spectroscopy and microscopy (Lal, 2007). Nanotech based soil binder called ‘Soil set’ developed by Sequoia Pacific research, Utah (USA) is a quick setting mulch which release on chemical reaction on the nano scale to bind the soil together (Das, 2005). Natural organic matter in soil or pore water can sorb, coat or stabilize the nano particles suspension and affect their mobility, bioavailability, reactivity and toxicity (Handy et al., 2008). Synthetic nano composite polymer clays have high water retention capacity (Sarkar, 2011) and can be used to conserve soil moisture in arid soil. These are water saving synthetic nano-membranes of zeolite and hydrogels for water treatment and efficient management.

Nano fertiliser to enhance Nutrient Use Efficiency

Nano fertiliser are the nanoparticles, these can directly supply the essential plant nutrients for plant growth, have higher nutrient use efficiency and can be delivered in a timely manner to a Rhizosphere target or by foliar spray. Nano particles can adsorb on to the clay lattice thereby preventing fixation while releasing into the soil solution then can be utilized by the plants and improve the soil health and nutrient use efficiency. The nano fertilizer technology is a very innovative . Fertilizer particles can be coated with nano membranes that facilitates in slow and steady release of nutrients thereby reducing loss of nutrients and enhancing its use efficiency of crops. Nano clay composites have been developed in order to supply with range of nutrient in desirable proportions (Datta, 2011)

Slow release nano nitrogenous and phosphatic fertilizer

Zeolite can be impregnated with urea which causes slow and steady release of nitrogen NH$_4^+$ ion occupying the internal channels of zeolite slowly set free N allowing progressive absorption by the crop. Amending sandy soil with NH$_4^+$ loaded zeolite reduces N leaching while sustaining crop growth. Naturally occurring zeolite and synthetic materials having nano pores are loaded with ammonium nitrate and potassium nitrate by an occlusion process. This was found to more or less double the nitrogen content of the slow release fertilizer. Nano porous synthetic layered double hydroxide and anionic clays with nitrate ion in their interlayers also acts as slow release nitrate fertilizer (Komarneni, 2010). Use of slow release fertilizer made out of nano clay polymer composite (NCPC) resulted in 38% more N recovery than conventional urea fertilizer and 62% more P recovery than conventional DAP fertilizer respectively (Datta, 2011). In a green house experiment use of NCPC enhance N uptake by 32% and P uptake by 30% more than conventional urea and DAP fertiliser, respectively. Surface modified zeolite has been found to be a good sorbent for PO$_4^{3-}$ and slow release of P is achievable.

Nano technology application in soil and water contaminants remediation

In recent years, a great deal of attention has been focused on the application of nano structured materials as adsorbent or catalyst to remove toxic and harmful substances from contaminated soil, waste water and air. Reactive nano particles are useful in removing pesticide and herbicide from
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ground water. Practical application of ion nano particles has been used in various type of hazards and waste management cum remediation options. Iron nano particle are valuable for the treatment of ground water and surface water contaminants. Such as chlorinated organic compound like pesticide and polychlorinated biphenyls (PBCs) organic dyes and various other inorganic compound (Agrawal and Joshi, 2010). The use of nano zero valent iron (ZVI), bimetallic nano particles and emulsified zero valent nanoparticles has applied in soil and ground water remediation. Also recently developed carbon nano tubes may also prove to be a most effective tool in remediating contaminated wastewater (Li et al.2007). The mode of transport of engineered nanoparticle in soil is similar to colloidal suspension. These nano particle may be designed to be more stable and less sticky than colloids to improve their effectiveness in soil.

Development of prediction models for transport of nanoparticles in soil, and their interaction with soil pollutants, as a function of soil properties, nanoparticle properties and pollutants properties would enable soil scientists and engineers to design highly effective, low cost soil remediation strategies (Montas and Shirmohammadi 2004). In the remediation of contaminants from soil, surface and ground water the application of nanotechnology holds great promise. The search for new and advanced materials is an important task of contemporary research.

Use of nano technology for crop nutrition

We know fertilizer have played a pivotal role in enhancing the food grain production in India especially after the introduction high yielding and fertiliser responsive crop verities during the green revolution era. In spite the alarming success in grain yield, it has been observed that the yields of many crop have began to stagnate as a consequence of imbalanced fertilization and declining in organic matter content of soil. The excessive use of nitrogenous fertiliser affects the ground water and causes eutrophication in aquatic ecosystem. The use efficiency of fertilizer is 20-50% for N and 10-25% for P. By using the nano fertiliser emerging as a alternative to conventional fertilizer to build up of nutrients in soil and thereby eutrophication in drinking water contamination may be eliminated. In fact nano technology has opened a new opportunity to improve nutrient use efficiency and minimize cost of environmental protection. Slow release of nano fertiliser and nano composites are excellent alternatives to soluble fertilizers. Nutrients are release with slow rate throughout crop growth period and plants becomes able to take the nutrients with any waste. Slow release of nutrients in the soil environment could be achieved by using zeolite which are group of naturally occurring minerals like crystal layered structure. Zeolite work as reservoir for nutrients that are slowly release on plants nutritional demand. Fertilizer particles can be coated with nano membranes that facilitates slow and steady release of nutrients. Some of the reports and patent suggested that there is a enormous scope for formulation of nano fertilizer. There is significant improvement have been found in yields with foliar spray of nano particles fertilizer. (Tarafdar et al. 2012). A case study on farmers field the application of 40ppm of nano P and 10 ppm of nano Zn resulted in about 70 percent increase in flower yield of cauliflower and also caused in advancement in maturity of crop by 18-21 days (Tarafdar, 2016).

Advantages of nano materials

The nano scale materials show the extra ordinary properties of the bulk materials. Some properties such as surface area, cation exchange capacity, ion adsorption and many more functions of clays would multiply if they are brought to nano scales. There is one principle ways which a nano particle differs from bulk material with a high proportion of atoms in a nano particles are present on the surface (Maurce and Hochella, 2008). Due to small size the physical, chemical and electronic properties of nano structure may change and very different from there bulky materials. As the surface area increases in comparison to volume, the behaviour of the atoms on the surface of the particles become more powerful as compared to the atoms that are inside the particles become small enough the exhibit quantum mechanical behaviour.
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Because of small size, there are more atoms on the surface compared to the interior of the nano particles. This leads to large surface to volume ration which in turn leads higher charge density and higher reactivity of nano particles. As the size is smaller the order of wavelength, nanoparticles do not obstruct the light. The surface area of different nanoparticles of various shapes leads to differences in atomic distribution across the nano particles. Nanoparticle have higher catalytic activity when they present in tetrahedral structure followed by spherical and cubic structure which help in enhancing in chemical reaction at sharpe edge and corner (Adhikari et al, 2010).

Strategies for Future thrust areas of research

Some researchable issues pertaining to nano technology application in soil science are

1. Study of the effect of soil physical, chemical and biological and hydrological variable on the NP crystal structure, formation, stability, aggregation and kinetic’s of phase formation and transformation

2. Study on molecular scale mechanisms of adsorption/desorption of engineered nano product (ENP) to and from contaminants nutrients quantifying and predicting bioavailability of NP

3. Study of the impact of nano technology application of the environment and human health.

In the field of agriculture, in near future nano technologies feel quite interesting and promising and probable risks in using nano particles in agriculture are diverse than those in any other work. With the quick distribution of nano particles of food products, whether it is in the food or part of packaging, nano particles will virtually come in direct and indirect contact with everyone. The probability of nanotech on soil, health, biodiversity and the environment. There is no standardization for the use and testing of nano technology, products in incorporating the nano material are being produced without check. There is circumstances in use of nano particles the studied are required to understand the mechanism for nano particles materials toxicity and there affects in natural environment.

Conclusion

In soil science the application of nanotechnology is at nascent stage of development and large gaps exists in our knowledge on the subject. In the fourth coming years and decades will see and exciting time of realisation, discovery and change. Scientists and The technologists will have to explore the benefits that humanity can derived from the mother earth by taking advantage out of this frontier technology. Multidisplinary efforts are needed for successful utilization of the modern technology to rewarding future of great social relevance/

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BIODRAINAGE: A SUSTAINABLE APPROACH TO CONTROL LAND DEGRADATION

Anshu Gangwar, Bhaskar Pratap Singh, Dinesh Kumar, Raj Bahadur
Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, Uttar Pradesh
Corresponding author Email: anshu.knight@hotmail.com

Abstract

Sustainable agriculture required a proper balance of water, air and salt present in the rootzone of plants. Due to improper planning and management of water in agriculture sector, the area under waterlogged and salinity increasing every decade. These problems can be effectively tackled by installing conventional engineering drainage systems, which are very expensive. Biodrainage i.e. pumping of excess soil water from the root zone of vegetation by deep-rooted plants using their own bioenergy, is an appropriate substitute to this engineering solution which is sustainable, economically beneficial and ecologically safe. For biodrainage Eucalyptus has emerged as choice of the tree and found to be effective in lowering shallow groundwater tables and reducing the salinity level.

Irrigation is an essential input for the substantial increases in agricultural production all over the world during the recent 50 years. During this period, the net irrigation potential has increased due to the introduction of canal irrigation all over the world as well as in the country (India). However, the introduction of canal irrigation system causes a rise in groundwater table, which leads to serious problematic conditions like waterlogging and salinization. Improper drainage management and obstruction in natural surface/subsurface drainage are also the causes of above-said problems. At present, about one-third of the global irrigated area (260 Mha) meets the serious problem of waterlogging, in which about 60 Mha are waterlogged in addition to 20 Mha is salt-affected, separately (Heuperman et al., 2002). An estimated area 2.46 Mha land is suffering from waterlogging and 3.30 Mha land is under salt-affected condition in canal command areas of the country (MOWR, GOI 1991). For the reclamation of problematic soils, the conventional engineering based subsurface drainage system is relatively more expensive and causes harmful environmental problems. Due to these limitations subsurface drainage system invokes for an alternative approach which must be effective, socio-economic, long-lasting and non-hazardous to the environment. A worthwhile substitute to the conventional engineering system could be biodrainage, which is ‘pumping of excess soil water from the root zone of crops by deep-rooted plants by means of their own bioenergy’. The term biodrainage was first introduced by Gafni (1994), however earlier Heuperman (1992) used the term bio-pumping in which trees are used for controlling the groundwater table. Biodrainage is basically an agronomic approach which removes excess water from the root zone of plantations through the evapotranspiration and relies on several factors i.e. plant species, plantation density, depth to water table and climatic conditions. During the process of transpiration, the trees draw water as well as salts and minerals from the soil and use them in biomass production. The absorbed saline water is translocated to different parts of trees or plants, lastly, more than 98 per cent of that absorbed water is transpired into the atmosphere through the stomatal activities i.e. evapotranspiration, which help to reduce subsoil salinity. Some plants could draw groundwater from as deep as 20 meters due to their deep root system, Anonymous (1988). George et al., (1999) studied data from some 80 sites in the medium-rainfall (550-700 mm/year) southwest of Western Australia, for which data were gathered to evaluate the effect of trees on water tables and reported that low groundwater salinity shows greatest water table response to trees planted in the discharge areas and thus made two major outcomes: (1) Significant reduction in water tables were highly correlated to the area under vegetation and, (2) Rate of water table response was related to the proportion of plantation and their subsequent growth in age.
Biodrainage can also help in maintaining the water balance as well as salt balance in the soil. Therefore, the approach of biodrainage can be utilized for the prevention of land degradation due to waterlogging and help to reclaim thousands of hectares of land for effective and sustainable agriculture.

**Merits of biodrainage**

The merits of non-conventional biodrainage systems are given below (Ram *et. al.*, 2008, Singh and Lal 2018):

i. Raising of biodrainage plantations is relatively low cost and affordable.

ii. Not required any additional energy for the operation, as the plants use their bio-energy to drain out the excess groundwater into the atmosphere.

iii. Increasing in the worth with age of plant instead of depreciation.

iv. No environmental hazard because it does not produce the drainage effluent.

v. The in-situ solution of the problems like waterlogging and salinity.

vi. A preventive as well as a curative system for waterlogging and salinity.

vii. Moderates the temperature of surrounding areas by transpiration thereby proofing against heat and cold waves.

viii. A useful strategy for carbon sequestration and to earns carbon credits.

ix. Mitigates the problem of climate change to some extent by absorbing carbon dioxide and releasing oxygen.

x. To avoid the anaerobic condition in the crop root-zone due to the high-water table.

xi. Acts as windbreak/shelterbelt and protects crops in an agroforestry system.

xii. Provides an additional income to the farmers through the production of food, fodder, fuel-wood, timber, and other valuable products.

xiii. Maintaining soil temperature and reduces soil erosion by maintaining balanced moisture in the field.

xiv. Provides recreational areas and green open spaces, supporting beekeeping (Hadas 2001).

xv. Increase in cropping intensity and soil organic carbon build-up.

xvi. Higher crop yields and nutrient use efficiency.

xvii. Increased employment generation and poverty reduction.

**Limitations of biodrainage**

i. Land required for tree plantations. Consequently, it may be tough for small farm holders, to set a part of the farm for biodrainage actions.

ii. Lowering of groundwater table may not be effective during the initial stage of tree plantation.

iii. Competition of light, water and nutrients between trees and crops and effects on coexisting crops i.e. productivity and growth.

iv. With passing age there would be gradual reduction in capacities of trees for extracting and transpiring water and thus reducing extent of biodrainage.

v. Salt accumulates in soil profile at the discharge sites, which will affect tree growth.

**Management mechanisms**

The process of biodrainage can be classified based on land use and it may be established under both rainfed and irrigated conditions.

1. **Dryland/rainfed systems**

When implemented in the dryland or rainfed land, the plant roots loosen the soil and enhance groundwater recharge capacity by creating a storage buffer to accommodate the rainfall. The roots also draw a part of the subsurface flow and reduce water load down to the slope. It is beneficial when there is occurrence of perched water table and the water cannot easily move down due to the presence of an impermeable layer below (Dash *et. al.*, 2005). The following techniques may be adopted in the above situation:

**Recharge control or recharge planting**

Plant functions responses to the sustainability of natural environments on the balance between
recharge and discharge or hydrological balance. Water passing below the rootzone system of vegetation are laterally discharged through regional subsurface aquifer systems (Heuperman et. al., 2002). Thus, the clearing of natural vegetation for land development disturbs the natural maintenance of the hydrological balance under rain fed conditions. Despite evidence of groundwater recharge generally concentrated in the lower areas of the landscape, groundwater management strategies operate on the assumption that recharge occurs primarily in the higher areas of landscape, particularly along ridgelines (Dean et. al., 2015). The method to curtail deep seepage losses in the higher regions of the landscape and to reduce discharge lower down the slope is frequently referred as recharge control.

**Groundwater flow interception or slope break planting**
For this reason, the establishment of tree plantations at the slope of land where it breaks. (i.e. the slope changing from convex to concave) and is becoming a popular technique which intercept flow to low lying areas as well as rainfall recharge occurring upslope, and subsequently reduce the drainage problems by reducing volume of rainfall that is subjected to overlying low-permeable strata. Effectiveness of this concept is depending on the location of the tree plantations, which is based on a thorough understanding of the underlying stratigraphy of the land.

**Discharge enhancement or discharge planting**
Despite the general belief that discharge plantings are most suited for the immediate reclamation of waterlogged areas due to shallow water tables and more access to groundwater. Low-lying landscape or depressions having closed basins in which percolation to deeper aquifers is inhibited and consequently invite the problems like water logging, salinization. For waterlogged discharge areas, the use of biodrainage is basically based on enhancement of evapotranspiration. Smedema (1997) recommended that the biodrainage meant for waterlogged area and canal seepage interception could be applied in ‘parallel field drainage’ arrangements as a substitute to conventional drainage systems.

![Different biodrainage systems](Denecke, 2000).

2. **Irrigated systems**
In irrigated areas, with flat topography and shallow water tables, the difference within recharge and discharge is less delineated and often areas that are discharging groundwater by means of evapotranspiration among irrigation events provisionally turned into recharge areas in the course of irrigation and instantly after irrigation. In irrigated and low lands, highly transpiring tree varieties are selected and planted along the canals, which mitigates waterlogging due to canal seepage in irrigated areas and also control the salinization (Dash et. al., 2005).

**Water table control:** Shallow groundwater tables cause root zone soil salinization which adversely affects agricultural crop growth. The management of irrigation areas often aims to keep water tables lower than the ‘critical depth’ (2 m from surface is commonly recognized as a safe depth), which is well-defined as the depth at which capillary salinization is insignificant. Trees growing on shallow
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Water tables have the capacity to extract water either through direct extraction from the saturated zone under the water table or extraction from unsaturated capillary fringe directly above the water table, resulting in a drop of groundwater table and salinization. A final equilibrium of salinity level will be formed which depends on several aspects i.e. salts in water applied, hydraulic conductivity of soil, hydraulic gradients (vertical and lateral) and vegetation type (salt tolerable).

Channel seepage interception: High seepage rate through the channel will result in rise of the groundwater table in irrigated areas and invite the problems like waterlogging and salinity in the adjoining land. The quality of seepage water in supply channels are normally good which can be productively used by vegetation and commercial crops through the interception and if it is not intercepted and left to evaporate it enhances salinity.

Bio drainage along with conventional drainage systems: For the ideal growth of biodrainage crops, salt balance is necessary for their rootzone. Where biodrainage consequences for salt accumulation, engineering assistance is needed to make the system sustainable.

Planning and design consideration for biodrainage system

The primary requirement for planning and deciding the location of drainage planting is the precise identification of recharge and discharge areas to maintain groundwater balances below the rootzone of the agricultural crops. The following issues need to be considered for the effective development of biodrainage systems (Kapoor, 2000 and Heuperman et. al., 2002):

i. Water balance: The objective of biodrainage scheme is to achieve water balance such that the water table is kept below the critical depth rootzone. Plantations of deep-rooted trees with high rates of transpiration are able to extract water from the ground should equal the net recharge.

ii. Salt balance: The salt balance determines the sustainability of plant water use and lowering of the groundwater table (Singh and Lal, 2018). To achieve a salt level below the critical level for the optimum growth of plants, the quantity of minerals removed annually should be nearly equal to the quantity of mineral import by a large volume of irrigation water having relatively low salinity.

iii. Area under plantation for water balance: For a sustainable water balance, the area to be covered under biodrainage plantations should be a minimum but large enough so that amount of water removed through evapotranspiration equals the total annual recharge.

iv. Salt tolerance: In general, salinity decreases both yield and quality in crops. Salt tolerance will be an imperative measure for saline discharge situations, and water use considerations will conquer in recharge control circumstances where salinity is of no concern and in channel seepage situations with low salinity water supply (Singh and Lal, 2018). The water use capacity of trees declines with rise in water salinity. In the case of Eucalypt species, it cuts to about one-half of potential after the water salinity increases to about 8 dS/m (Oster et. al., 1999). Hence, biodrainage crops need to be salt lenient.

v. Effect on lowering ground water table: Crops, together with trees, act as biopumps; they can lower the groundwater table directly beneath plantation extents as well as surrounding expanse. The efficacy of drawdown depends on different parameters i.e. water use capacity of vegetations, amount of recharge in surrounding areas, soil hydraulic conductivity, depth of deeper barrier layers, root system of plants and salt tolerance of plant species. Biodrainage plantations would be established in blocks or strips and spaced to keep water table levels in the irrigated farmland in between the plantings under the rootzone.

vi. Economic aspects: Biodrainage plantations should be of high economic value so that the costs associated with planting and maintenance can be recovered from the sale of tree produce. Indirect benefits of planting trees on farmlands in terms of organic carbon buildup, carbon sequestration in biomass and other ecosystem services should also be considered.

vii. Social acceptance: The introduction of tree plantations impacts on rural peoples. Some issues can be occurred like misappropriated pruning or cutting for fuelwood and fires may destroy the results.
of numerous long stretches of work in an exceedingly single day. Therefore, an active participation of native communities within the development of tree plantation-based biodrainage systems is extraordinarily necessary to overcome the issues and ascertain that the benefits of the biodrainage systems are reaped to the most extent.

Components of Biodrainage system

The following general components of biodrainage system helps directly or indirectly sustainable biodrainage and provide favourable situations to increase agricultural production by controlling waterlogging and salinization in the field (NIH, 1999):

1. Infiltration through fall and Stem Flow
2. Transpiration
3. Runoff and soil loss
4. Water use

Suitable tree species for sustainable management of biodrainage

Trees having an incredible capacity of transpiration which seems to be a capable and effective technique for enhancement of drainage conditions through the amputation of excess water and thereby resolves the complications like waterlogging and salinization. The transpiration capacity of a tree differs with its species, root depth and spread, age, canopy area, soil water, salinity, leaf area and leaf structure and climatic circumstances. Numerous plant species may be accepted for biodrainage technique consequentially as soil type, salinity level, transpiration rate, which are following: *Terminalia arjuna*, *Pongamia pinnata*, *Morus alba*, *Prunus armeniaca* L., *Eucalyptus tereticornis* C-3, *Callistemon lanceolatus*, *Populus euphratica* Oliv, *Populus nigra*, *Ulmus pumila* L., *Eucalyptus tereticornis* C-10, *Eucalyptus tereticornis* C-130, *Prosopis juliflora*, *Elaeagnus angustifolia* L., *Eucalyptus camaldulensis*, *Eucalyptus fastigata*, *Eucalyptus rudis*, *Corymbia tessellar*, *Melia azedarach*, *Salix nigra*, *Catalpa bignonioides*, *Fraxinus pennsylvanica*, *Eucalyptus angustifolia*, *Lycium barbarum*, *Puccinellia chinamponsis*, *Populus deltoides*, *Casuarina glauca*, *Terminalia arjuna*, *Pongamia pinnata*, *Syzygium cumini*, *Prosopis juliflora*, *Tamarix dioca*, *Saccharum munja*, *Eucalyptus occidental*.

Suitable plant species for sustainable management of biodrainage in Saline Soil

Salinity is a chief constriction which effect plant growth in addition to crop plant productivity. Salinity acts like death on plants, thwarting roots from carrying out their osmotic action where water and nutrients transfer from a zone of lower concentration into a zone of higher concentration. Plant types vary in how well they abide salt-affected soils. Few plants will bear high levels of salinity while others can accept little or no salinity. The comparative growth of plants in the existence of salinity is called their salt tolerance. Based on their salt tolerance limit many plant types are appropriate in saline soils, which are specified in the below Table:

**Table 1. Suitability of tree spices for saline soils**

<table>
<thead>
<tr>
<th>Tolerance Level</th>
<th>Suitable Plant Species</th>
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<tbody>
<tr>
<td>Tolerant (ECe 25–35 dS m⁻¹)</td>
<td><em>Tamari troupii</em>, <em>T. articulata</em>, <em>Prosopis juliflora</em>, <em>Pithecellobium dulce</em>, <em>Parkinsonia aculeata</em>, <em>Acacia farnesiana</em></td>
</tr>
<tr>
<td>Moderately tolerant (ECe 15–25 dS m⁻¹)</td>
<td><em>Callistemon lanceolatus</em>, <em>Acacia nilotica</em>, <em>A. pennatula</em>, <em>A. tortilis</em>, <em>Casuarina glauca</em>, <em>C. equisetifolia</em>, <em>Eucalyptus camaldulensis</em>, <em>Leucaena leucocephala</em></td>
</tr>
<tr>
<td>Moderately sensitive (ECe 10–15 dS m⁻¹)</td>
<td><em>Casuarina cunninghamiana</em>, <em>Eucalyptus tereticornis</em>, <em>Acacia auriculiformis</em>, <em>Guazuma ulmifolia</em>, <em>Leucaena shannonii</em>, <em>Samanea saman</em></td>
</tr>
</tbody>
</table>
**Conclusion**

Biodrainage is an ecofriendly and feasible option to reclaim and manage waterlogging through the process of transpiration by vegetation and thereby reducing the problem of secondary salinization caused by agricultural development and use of irrigation. Its main merits are economy in cost and environment improvement. To one side from the advantages, biodrainage also has its restrictions as it requires of land for tree plantations, inadequate evacuation of salts from the system and susceptibility of trees to high saline environments. The necessity of land for tree plantations may be about 10 per cent of the area, which should be no problem, mainly in semi-arid and arid zones. Biodrainage can be effectively used for groundwater table management in both dry lands and irrigated areas. For proper planning of biodrainage activities, assessment of the water and salt balance in the landscape is a major requirement. Where biodrainage results in salt accretion, engineering aid is desirable to make the system workable. Plantation of suitable salt-tolerant deep-rooted fast-growing trees with high transpiration rates provides benefits in terms of reclamation of waterlogged areas, controlling water tables, improving crop productivity, providing shelter belts, providing additional wood and forest products, and biodiversity. The plantation of some species appropriate for biodrainage are, *Casuarina glauca*, *Eucalyptus*, *Pongamia pinnata* and *Syzygium cuminii*, *E. tereticornis*. Meant for biodrainage under such situations *Eucalyptus* has appeared as a choice. Therefore, biodrainage plantations could be utilized to manage soil and water salinity for sustainable agriculture.

**References**


**Integrated Farming System: The Future of Agriculture**

**FARMING SYSTEMS APPROACH (FSA) – CONCEPTS, SCOPE AND APPLICABILITY FOR SUSTAINABLE DEVELOPMENT**

Anil Kumar Malik¹, Babu Lal Dhayal¹, Krishan Yadav² and Sunil Kumar³

¹Department of Extension Education, ²Directorate of Extension Education, ³Department of Seed Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India., 125004

**Corresponding author Email:**

**Abstract**

The farming system approach, assumes great importance for sound management of farm resources to enhance farm productivity, reduce the degradation of environmental quality and improve the quality of life of farmers and above all to maintain sustainability in farm production and productivity.

**Historical Perspective**

Prior to the mid-1960's, active research collaboration between technical agricultural scientists (i.e., predominantly working on experiment stations), agricultural economists (i.e., mostly in planning units) and anthropologists/rural sociologists (i.e., generally in academia), was limited. By the mid-1960s, the Green Revolution was beginning to have a major impact on crop production in parts of Asia and Latin America through the introduction of fertilizer-responsive, high-yielding varieties of rice, wheat, and maize in favourable and relatively homogeneous production environments where there was assured soil moisture, good soils, ready access to cheap fertilizer, and relatively efficient output markets. However such conditions did not exist in most of Sub-Saharan Africa and in certain parts of Latin America and Asia, and as a conclusion, these areas were bypassed. The reductionist approach failed in terms of developing technologies for resource-poor farmers in less favourable heterogeneous production environments or agricultural areas. This led to the incorporation of a systems perspective in the identification, development, and evaluation of relevant improved technologies. Hence in the mid to late 1970s, the farming systems research (FSR) approach evolved, a basic principle of which was the need to create new types of partnerships between farmers and technical and social scientists. FSR thus became very popular with donor agencies, to the extent that, by the mid 1980s, about 250 medium- and long-term externally funded (i.e., in addition to those domestically funded) projects worldwide were implementing FSR-type activities. Between 1978 and 1988, The United States Agency for International Development (USAID) alone had funded 76 bilateral, regional, and centrally funded projects containing a farming systems orientation. Forty-five of these were in Africa. Most of these projects supported the establishment of separate FSR units, which often were poorly integrated into, or poorly linked to, mainstream technology development activities. Although it is probably true to conclude that few of these projects succeeded in producing new technologies that were widely adopted, the approach of looking at farmers’ constraints and needs for technical change from within was eventually mainstreamed into most national and international agricultural research programs by the late 1980s. Therefore although donor support for supporting explicit FSR activities dwindled towards the end of the 1980s, most national agricultural research systems (NARS) had adopted major components of the FSR philosophy and approach, and the spirit of the FSR approach lived on. Since then there has been considerable evolution in the methodologies employed (e.g., new farmer participatory research (FPR) techniques, gender analysis, environmental impact analysis, and statistical techniques adapted to on-farm research). Also participation has been broadened to include a wider set of agricultural stakeholders, including extension, development, and sometimes even planning/policy staff. Perhaps even more significant has been incorporating the underlying principles
of the farming systems approach into the priorities of donors and nationally based agricultural programs. These include increasing emphasis on participatory approaches and empowerment of farmers and their families and a new focus on ecological sustainability and sustainable livelihoods.

India

Public sector extension in India has undergone several transformations since independence in 1947. Initially, the focus of extension was on human and community development, but during the remainder of the 20th Century there was a steady progression toward technology transfer within the policy framework of food security. The most significant development during the mid-seventies was the introduction of the Training and Visit (T&V) Extension management system. By the 1990s, the Indian Extension system was at a crossroads. Since Extension had focused on disseminating Green Revolution technology for the major cereal crops for the past two decades, extension activities were largely carried out by state Departments of Agriculture (DOA). Other line departments, like Animal Husbandry (DAH), Horticulture (DOH) and Fisheries (DOF), had very limited extension capacity and primarily focused on the provision of subsidized inputs and services to farmers. In addition, these line departments operated largely independently, with very little collaboration between the departments and their field staff. In the late-1990s, the Government of India (GOI) and the World Bank pilot-tested a new, decentralized, market-driven extension model under the National Agricultural Technology Project (NATP). This new approach was designed to help farmers diversify into high-value crops and livestock enterprises as a means of increasing farm incomes and rural employment (i.e. poverty alleviation). The key institution in implementing this new approach was the Agricultural Technology Management Agency (ATMA), which was to facilitate and coordinate “farmer-led” extension activities within each district. The key elements of the ATMA model included:

1. organizing small-scale farmers, including women, into farmer interest groups (FIGs).
2. linking these groups to markets
3. decentralizing extension decision-making down to the district and block levels;
4. taking a more “farming systems” approach, requiring the integration of extension activities across the different line departments.

Now let us understand the farming system approach (FSA) through concept and definitions.

Concept of Farming System

“Farming system” is a set of agricultural activities organized while preserving land productivity, environmental quality and maintaining desirable level of biological diversity and ecological stability. The emphasis is more on a system rather than on gross output.

Farming system is a decision making unit comprising the farm household, cropping and livestock system that transform land, capital and labour into useful products that can be consumed or sold (fresco and westphal,1988)

or

Farming system is a resource management strategy to achieve economic and sustained production to meet diverse requirement to farm household while presenting resources base and maintaining a high level environmental quality (Lal and Millar 1990).

In other words “farming system” is a resource management strategy to achieve economic and sustain agricultural production to meet diverse requirement of the farm household while preserving the resource base and maintaining high environmental quality. The farming system in its real sense will help in subsequent ways to lift the economy of Indian agriculture and standard of living of the farmers. The farming system conceptually is a set of elements or components that are interrelated which interact among themselves. At the center of the interaction is the farmer exercising control and choice regarding the types of results of interaction. The income from cropping alone from small and marginal farm is
insufficient now to sustain the farmers’ family. A judicious mix of any one or more of these enterprises with agronomic crops. Should complement the farm income and help in recycling the farm residues / wastes. The selection of enterprises must be based on the cardinal principles of minimizing the competition and maximizing the complementary between the enterprises. Of late, the researchers on multi disciplinary approach greatly realized and started developing the various farming systems models in accordance with the agro-eco systems zones. Since 1978, both scientists, extensionists, anthropologists, social workers, administrators have been publishing many articles on FSRE in different journals.

**Farming System Approach**

Farming system approach introduces a change in farming technique for high production from a farm as whole with the integration of all the enterprises. The farm produce other than the economic products for which the crop is grown can be better utilized for productive purposes in the farming system approach. A judicious mix of cropping system with associated enterprises like dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio economic status of farmers would bring prosperity to the farmer. Simmonds (1984) clarifies the Farming System Approach as follows: It is an academic activity comprising of theory, concepts, principles, approaches etc. It creates an opportunity for developing diversified models for different type of farmers and different category of farmers. New farming system approach models could be developed by means of on farm research and extension. It causes consequential a complex change which demands for Government interventions for farming systems development. Biggs (1985) explained the concept of FSA as follows: it is a problem solving approach for the farmer. Farming system approach requires commonly homogenous type of farmers. It is an inter-disciplinary approach. It is a participatory and bottom up planning. It requires on farm trials. It depends on the concept learning by doing and farming system approach needs socially desirable technologies.

Thus the concept of Farming System Approach can be summarized as it is a holistic approach, complex in nature, interrelated of components, matrix of soils, plants, animals, power, implements, labour, capital and other inputs, influenced by political, economic, institutional and social forces.

**Definition:**

Farming systems approach relates to the whole farm rather than individual elements; it is driven as much by the overall welfare of farming households as by goals of yield and profitability. Farming systems are closely linked to livelihoods because agriculture remains the single most important component of most rural people’s living and also plays an important role in the lives of many people in semi-urban areas. Farming system is a unique and reasonably stable arrangement of farming enterprises that a household manages according to well defined practices in response to the physical, biological and socio-economic environment and in accordance with the household goals preferences and resources.

Farming system represents an appropriate combination of farm enterprises (cropping systems horticulture, livestock, fishery, forestry and poultry etc.) and the means available to the farmer to raise them for profitability. It interacts adequately with environment without dislocating the ecological and socioeconomic balance on one hand and attempts to meet the national goals on the other.

**Need for Farming System Approach**

The need for Farming Systems Approach in the present scenario is mainly due to high cost of farm inputs, fluctuation in the market price of farm produce, risk in crop harvest due to climatic vagaries
and biotic factors. Environmental degradation, depletion in soil fertility & productivity, unstable income of the farmer, fragmentation of holdings and low standard of living add to the intensity of the problem.

**Scope**

It is an approach for developing farm-household systems, built on the principles of productivity, profitability, stability and sustainability. All the components are complimentary and supplementary to each other. And the development process involves the participation of rural communities. The farming system approach emphasizes understanding of farm household, community inter linkages, reviews constraints and assesses potentials. And it combines improvements desired from better technology. It needs efficient support services and requires better policies. It is continuous, dynamic and interactive learning process based on analysis, planning, testing, monitoring and evaluation.

**Why Farming Systems Approach**

- To integrate different production systems like dairy, poultry, livestock, fishery, horticulture, sericulture, apiculture, etc. with agricultural crops production as the base.
- To increase farm resource use efficiency (land, labor and production/by-products) so as to increase farm income and gainful employment opportunity.
- To promote multi-cropping, for multi-layered crops of economic value so as to sustain land productivity.
- To maintain environmental quality and ecological stability.

Sustainable agriculture means an integrated approach to increasing farm yield and managing resources in order to address all three critical aspects of sustainability: economic, environmental and social. An intensive integrated farming system addresses two issues, reduction in risk with the monoculture activities and promoting enterprise diversification, value addition and development of alternative income sources with efficient utilization of farm resources. And it brings about enterprise diversification for sustainability and additional benefits, better management of important farm resources like land, labor and capital etc. Provides an opportunity for effective recycling of the product and by-products, helps to generate flow of cash to the farmers round the year by way of disposal of milk, fruits, fuel, manure etc., beside other agricultural output.

**Advantages of Farming System Approach (FSA)**

**Productivity:** FSA provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.

**Profitability:** Use waste material of one component at the least cost. Thus reduction of cost of production and form the linkage of utilization of waste material, elimination of middleman interference in most input used. Working out net profit B/C ratio is increased.

**Potentiality or Sustainability:** Organic supplementation through effective utilization of byproducts of linked component is done thus providing an opportunity to sustain the potentiality of production base for much longer periods.

**Balanced Food:** We link components of varied nature enabling to produce different sources of nutrition.

**Environmental Safety:** In FSA waste materials are effectively recycled by linking appropriate components, thus minimize environment pollution.
Integrated Farming System: The Future of Agriculture

Recycling: Effective recycling of waste material in FSA.

Income Rounds the year: Due to interaction of enterprises with crops, eggs, milk, mushroom, honey, cocoons silkworm. Provides flow of money to the farmer round the year.

Adoption of New Technology: Resources farmer (big farmer) fully utilize technology. FSA farmers, linkage of dairy / mushroom / sericulture / vegetable. Money flow round the year gives an inducement to the small/ original farmers to go for the adoption technologies.

Saving Energy: To identify an alternative source to reduce our dependence on fossil energy source within short time. Effective recycling technique the organic wastes available in the system can be utilized to generate biogas. Energy crisis can be postponed to the later period.

Meeting Fodder crisis: Every piece of land area is effectively utilized. Plantation of perennial legume fodder trees on field borders and also fixing the atmospheric nitrogen. These practices will greatly relieve the problem of non – availability of quality fodder to the animal component linked.

Solving Fuel and Timber Crisis: Linking agro- forestry appropriately the production level of fuel and industrial wood can be enhanced without determining effect on crop. This will also greatly reduce deforestation, preserving our natural ecosystem.

Employment Generation: Combing crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problems of under employment to a great extent FSA provide enough scope to employ family labour round the year.

Agro – industries: When one of produce linked in FSA are increased to commercial level there is surplus value adoption leading to development of allied agro – industries.

Increasing Input Efficiency: FSA provide good scope to use inputs in different component greater efficiency and benefit cost ratio.

Farming Systems Strategy
In view of serious limitations on horizontal expansion of land and agriculture, only alternative left is for vertical expansion through various farm enterprises required less space and time but giving high productivity and ensuring periodic income specially for the small and marginal farmers located in rainfed areas, dry lands, arid zone, hilly areas, tribal belts and problem soils.

The following farm enterprises could be combined:
- Agriculture + Livestock
- Agriculture + Livestock + poultry
- Agriculture + Horticulture + Sericulture
- Agro-forestry + Silvipasture
- Agriculture (Rice) + Fish culture
- Agriculture (Rice) + Fish + Mushroom cultivation
- Floriculture + Apiary (beeckeeping)
- Fishery + Duckery + poultry

For meaningful execution of integrated farm-enterprises, the following activities should be undertaken by a multi-disciplinary team of extension professionals with farmer’s participation and involvement at all stages.

✓ Thorough understanding of existing farming systems and their components
✓ Assessment of resource availability in the farm environment and identification of bio-physical, socio-economic, institutional, administrative and technological constraints.
✓ Developments of economic viable and efficient integrated farming systems suitable for various domains.
Integrated Farming System: The Future of Agriculture

- Diffusion of improved technology and receiving ‘feedback’ for further improvement of the system as a whole.
- Continuous improvement in components technology to fit into a given farming system.
- Improvement in quality of farming system.
- Research Extension linkage through “On farm Adaptive Research”.
- Development of National and International linkages.

Limitations in implementation of FSA
A limitation in general means a fact or situation that allows only some actions and makes others impossible. These are some following factors which inhibit the implementation of FSA.

- Lack of awareness about sustainable farming systems.
- Unavailability of varied farming system models.
- Lack of credit facilities at easy and reasonable interest rate.
- Non-availability of ensured marketing facilities especially for perishable commodities.
- Lack of deep freezing and storage facilities.
- Lack of timely availability of inputs.
- Lack of knowledge/education among farming community especially of rural youth.

Methodology adopted for grounding the concept of FSA
I. Identification of major socio-economic situations
   - Understanding dominant enterprises and most common existing farming system
   - Analysis of economic viability of existing farming systems
   - Understanding relationship between different enterprises
   - Analysis of linkages between different farming systems

II. Understanding the modifications made in existing farming system by innovative farmers
   - Understanding the changing scenario in rural areas and its impact on existing farming system.
   - Identification of new market opportunities and its impact and relevance to socio-economic situation. Suitable modification made by innovative farm families in existing farming system
   - Type of modification made (diversification or intensification of the enterprises)

III. New options recommended by the Researchers/Extensionists
   - Identification of new suggested options by researchers/extensionists around each dominant enterprise.
   - Understanding the technological details about new options

IV. Economic analysis of recommended options and working out alternatives:
   - Analysis of relative profitability of recommended options as compared to existing farming system
   - Understanding of implications of each options with regard to reallocation of resource

V. In the absence of any recommendations, work out an alternate model by fine tuning the existing model (without major changes) considering the resources, market, profitability and sustainability
   - Propose an alternate model by fine-tuning the existing farming system by working out the possibilities of diversification or intensification of an enterprise.
   - Work out the economic analysis and benefits of alternate model compare to existing and identify the gaps in knowledge and skill so as to adopt the new model.
   - Develop strategies and activities to overcome the gaps in knowledge and skills.
   - Testing the effectiveness of recommended options over a period of time.
Conclusion
The prosperity of any country depends upon the prosperity of its people. Food, clothing, shelter, health, education, security, roads, electricity and drinking water are the today’s basic needs. Farmers produce food. About 70% of Indian population is engaged in farming. Therefore, prosperity of India would depend upon the prosperity of its farmers. This in turn depends upon the adoption of improved technology and judicious allocation of resources (land, labour, capital, machinery etc). Human race depends more on farm products for their existence than anything else since food and clothing – the prime necessaries are products of farming. But due to ever increasing population and decreasing in per capita availability of land in India, there is little scope for horizontal expansion of land for food, feed, fuel and fibre production. Only vertical expansion is possible by integrating various farm enterprises requiring less space and time and ensuring periodic income to the farmer. The farming system approach, therefore, assumes great importance for sound management of farm resources to enhance farm productivity, reduce the degradation of environmental quality and improve the quality of life of farmers and above all to maintain sustainability in farm production and productivity.

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RECENT ADVANCES IN MANAGEMENT OF MICRONUTRIENT DEFICIENCY (ZN) IN ACID SOILS

Premaradhya N1, Santosh Korav2, and Chandramohan Reddy3

1School of Natural Resource Management, College of PG-Studies Umiam-793103, Meghalaya
2Department of Agronomy, 3Department of Fruit Science, College of Agriculture, CCS HAU, Hisar-125004, Haryana
Corresponding author Email: premaradhya@gmail.com

Abstract

Micronutrients (MNs) are important to world agriculture and human health. Over 3 billion people across the world suffer from micronutrient deficiencies. Zinc (Zn), Iron (Fe), Boron (B), Manganese (Mn) and copper (Cu) have become yield-limiting factors and are partly responsible for low food nutrition. Although crops use low amounts of MNs (<2.4 kg/ha), about half of the cultivated world’s soils are deficient in plant bioavailable MNs, due to their slow replenishment from the weathering of soil minerals, soil cultivation for thousands of years and insufficient crop fertilization.

Human nutrition is directly linked to that of plants, the production of nutritious foods requires a balanced content of essential macro-, meso- and micronutrients. Macronutrients are required in large amounts and include nitrogen (N), phosphorous (P) and potassium (K). The meso- or secondary nutrients include calcium (Ca), magnesium (Mg) and sulfur (S). Micronutrients or trace elements are required in smaller amounts and include iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), boron (B), chloride (Cl), molybdenum (Mo) and nickel (Ni) (Panuccio et al., 2009). Micronutrients play a significant role in plant growth and metabolic processes associated with photosynthesis, chlorophyll formation, cell wall development and respiration, water absorption, xylem permeability, resistance to plant diseases, enzyme activities involved in the synthesis of primary and secondary metabolites and nitrogen fixation and reduction (Adhikary et al., 2010; Vitti et al., 2014).

Micronutrients and crop yield

There are numerous examples of the positive effects of micronutrient addition to crops growing in micronutrient deficient soils. The use of fertilizer-micronutrients in crops can increase grain yield up to 50% as well as increase macronutrient use efficiency (Malakouti, 2007). Published information reporting agronomic performance data from different countries, soils and climate indicates that micronutrients applied alone or together with macronutrients have a significant effect on crop yield and MN content in grain (Intiaz et al., 2010).

Table 1. Relative yield increases for various crops as influenced by the soil addition of micronutrients.

<table>
<thead>
<tr>
<th>Nutrient Added</th>
<th>Crop</th>
<th>Relative yield Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>Rice</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Sunflower</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Potato</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Sugarcane</td>
<td>8</td>
</tr>
<tr>
<td>Zinc</td>
<td>Wheat</td>
<td>4-11</td>
</tr>
</tbody>
</table>

The addition of zinc increased grain yield of various crops from 8% to 30%, or from 4% to 11% when zincmicronutrientwas added to a soil planted with wheat (Malakouti, 2000) (Table 1). Other studies have shown that the addition of Fe and/or Zn to deficient soils planted with peanut, potato, chickpea,
rice and beans increased the average yield from 15% to 30% (Adhikary et al., 2010; Welch, 1986; Moraghan, 1980).

**Causes for Soil Mironutrient Deficiencies**

The MN use efficiency (MUE) of most commercial fertilizers added to soils or foliage is 2.5% to 5% of applied, because, once micronutrient fertilizers are added to soils, the trace elements react rapidly to form chemical precipitates, or interact with clay colloids and the organo-mineral matrix of soils, rendering them unavailable for synchronized uptake by plants during crop growth. And also due to their rapid stabilization by soil components, low leaf penetration and low mobility in plants. In soil-plant systems, micronutrient fertilizers interact with macronutrients resulting in synergistic, antagonistic or neutral response affecting yield and food quality.

Deficiencies of metals are caused by inadequate replenishment in the soil from the parent material and from the adsorbed and complexed fractions. Deficiency of micronutrients during the last three decades has grown in both, magnitude and extent because of increased use of high analysis fertilizers, use of high yielding crop varieties and increase in cropping intensity also due to natural factors, such as highly acidic or alkaline soils and due to human activity, such as soil depletion caused by farming without adequate fertilization.

**Zinc deficiency**

Zinc (Zn) deficiency is the most widespread micronutrient deficiency problem globally (Alloway, 2008) and more particularly in India (Takkar, 1996; Singh, 2001; Behera et al., 2009) over the years. The problem of Zn deficiency is more acute in sandy acid soils because these are leached and heavily weathered (Alloway, 2008) and characteristically low organic matter content and deficient in available plant nutrients (Rautaray et al., 2003). In acidic soils, fundamental chemical properties for plant nutrition (e.g. cation exchange and buffer capacity) are largely governed by organic matter content (Moody et al., 1997).

**Role of zinc in plants**

- **Low Molecular weight complexes of Zinc** - In plant leaves soluble Zinc occurs mainly as anionic compound possibly associated with amino acid.
- **Carbohydrate metabolism** - Zinc is a constituent of Carbonic anhydrase enzyme, alcoholic dehydrogenase and superoxide dismutase which have role in CO₂ fixation.
- **Photosynthesis** - Zinc is necessary for the activity of RNA polymerase enzyme and it protects ribosomal RNA from attack by the enzyme ribonuclease.
- **Protein metabolism** - Zinc is necessary for the activity of RNA polymerase enzyme and it protects ribosomal RNA from attack by the enzyme ribonuclease.
- **Membrane integrity** - The role of Zinc in maintaining the integrity of cellular membranes involving chlorophyll synthesis, structural orientation of macromolecules and maintenance of ion transport systems.
Auxin metabolism - Zn is important in the synthesis of tryptophane (precursor of auxins) a component of some protein and a compound needed for the production of growth hormones (auxins) such as indoleacetic acid and metabolism of gibberellic acid. Zn influences translocation and transport of P in plants.

Deficiency symptoms
In dicotyledonous plants, symptoms include short internodes (rosetting) commonly in fruit and citrus trees, decrease in leaf expansion (mottle leaf or little leaf) in cotton, White bud of maize and coppery brownish appearance (Khaira disease) in rice. The 1st symptoms of Zn deficiency appear in 3 to 4 weeks old seedling when the young leaves develop reddish-brown pigmentation. Tissues become papery, necrotic and under conditions of acute deficiency, whole mass collapses with arresting of the plant growth.

Zinc deficiency symptoms in different crops are
- Khaira disease in Rice
- White bud of maize
- Little leaf of cotton
- Mottled leaf of citrus or frenching of citrus

Fig. 3: deficiency of zinc noticed in different crops

Management techniques
- Soil application
- Foliar Spray
- Integrated Nutrient Management (INM) approach
- DRIS approach
- Nano based formulations

Soil Zn fertilization
The three main classes of commercial zinc fertilizer are inorganic, synthetic chelates and organic (Table.2). The inorganic sources include water-soluble sulfate salts of Zinc. Other inorganic products comprise of commercial oxysulfates (i.e., mixture of ZnO and ZnSO4) and oxides of zinc that are less
readily available to plants relative to sulfate salts. Synthetic chelates of ethylenediaminetetraacetic acid (EDTA) consist of a ring-type structure that binds Zn or other elements within its structure. Organic acids, such as citric acid, are also used to chelate zinc. Chelated zinc sources stay available for plant uptake over long periods by preventing rapid reactions of the elements with soil clay colloids.

**Table 2: Commonly used Zinc fertilizers**

<table>
<thead>
<tr>
<th>Sources</th>
<th>Zinc content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic fertilizers</td>
<td></td>
</tr>
<tr>
<td>Zinc sulphateheptahydrate</td>
<td>21-23</td>
</tr>
<tr>
<td>Zinc sulphatemonohydrate</td>
<td>33-3</td>
</tr>
<tr>
<td>Zinc oxysulphate</td>
<td>40-55</td>
</tr>
<tr>
<td>Zinc oxide</td>
<td>55-70</td>
</tr>
<tr>
<td>Zinc chloride</td>
<td>50</td>
</tr>
<tr>
<td>Zinc carbonate</td>
<td>50-56</td>
</tr>
<tr>
<td>Zinc nitrate</td>
<td>22</td>
</tr>
<tr>
<td>Zinc fritts</td>
<td>10-30</td>
</tr>
<tr>
<td>Chelated and Organic Zinc fertilizers</td>
<td></td>
</tr>
<tr>
<td>Zn-EDTA</td>
<td>12-14</td>
</tr>
<tr>
<td>Zn- HEDTA</td>
<td>9</td>
</tr>
<tr>
<td>Sodium zinc EDTA</td>
<td>9-13</td>
</tr>
<tr>
<td>Zinc polyflavonoid</td>
<td>5-10</td>
</tr>
<tr>
<td>Zinc ligunosulphonate</td>
<td>5-8</td>
</tr>
</tbody>
</table>

(Source: Arunachalam et al., 2013)

Zinc application methods and sources are aimed at improving Zn availability for plant uptake. Most common method of Zn fertilization is through soil application. Zinc can be applied to soil by broadcasting, banding in vicinity of seed, or via irrigation. For soils, having low zinc content band placement is beneficial. Band placement of Zinc fertilizers is superior over broadcasting. Efficiency of zinc fertilizer increases when it is applied with acidic fertilizers (Ammonium Sulphate) and placed in band. Zinc is commonly applied in rice under lowland condition before flooding or after transplanting to prevent Zn deficiency and for increased grain yield (Dobermann and Fairhurst 2000; Naik and Das 2007).

**Foliar Zn application**

Zinc can be absorbed by leaf stomata when applied as foliar spray and then transported via the vascular system to where it is needed (Marschner, 1995). A number of Zn sources [ZnSO₄, Zn(NO₃)₂, Zn-EDTA] have been used as foliar fertilizers in a number of crops. Significant increases in grain yield, straw and grain Zn contents were observed with foliar application of Zn as Zn-EDTA and ZnSO₄, but the highest increase was observed with Zn-EDTA application (Karak and Das, 2006). Although foliar application is effective in increasing seed Zn content (Welch, 2002; Yang et al., 2007), time of foliar Zn application is an important factor in this regard (Stomphet et al., 2011). Generally, large increases in grain Zn occur when it is foliarly applied at later stages of plant development. Jiang et al., (2007) evaluated Zn translocation towards rice grains in a nutrient solution using aerobic rice genotypes when Zn was applied to roots or as foliar spray; under sufficient Zn supply, Zn partitioning from grain was greater from root-supplied than foliarly-applied Zn. Similarly, higher translocation of Zn from flag leaves to grains occurred when Zn had been applied at booting or
anthesis stage in a nutrient solution when genotypes with high or low grain Zn were used (Wu et al., 2010).

**DRIS approach**
DRIS developed by Beaufils (1973) is a dual ratio concept where the nutrient concentration ratios are considered rather than single nutrient value and are used for developing leaf/petiole nutrient norms/guides.

**DRIS Concept (Beaufils, 1973)**
Effect of aging on leaf composition
- N, P and K concentrations decrease with leaf aging
- Ca and Mg concentrations increase with leaf aging

To over these problems effect DRIS has come into exist. The main concept of DRIS is The ratios N/P, N/K, P/K, Ca/Mg and their reciprocal should remain constant. The product of N & Ca should also be fairly constant.

**Development of DRIS norm**
- The data bank of nutrient concentration vs. yield data are established from survey
- Nutrient concentrations are expressed in as many forms as possible.
- The whole population is divided into two sub-groups based on yield performance as high and low yielding.
- The mean of each sub-population are calculated for various forms of expressions.
- The variance ratios between yields of sub-population for all the forms of expressions are calculated together with the coefficient of variance.

**Advantage of Diagnosis and Recommendation Integration System**
1. DRIS is holistic approach and identifies yield limiting nutrients.
2. Ability to minimize the effect of leaf age.
3. It lists the nutrient elements in the order of importance in limiting.

**DRIS approach for N, P, K and Zn foliar diagnostic norms for Aonla in Central Indo-Gangetic plains**
In the present investigation, DRIS approach was employed for interpreting leaf nutrient analysis data collected from different aonla orchards in the Central Indo-Gangetic plains. The sufficiency and deficiency ranges were derived with the DRIS technique, and these were used to monitor the nutrient status of aonla trees. Geographically the sampling area lies in semi-arid subtropical region of central Indo-Gangetic plains.

<table>
<thead>
<tr>
<th>Nutrient Range</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficient</td>
<td>“Mean – 8/3 SD”</td>
</tr>
<tr>
<td>Low</td>
<td>“Mean – 4/3 SD to mean – 8/3 SD”</td>
</tr>
<tr>
<td>Optimum</td>
<td>“Mean – 4/3 SD to mean + 4/3 SD”</td>
</tr>
<tr>
<td>High</td>
<td>“Mean + 4/3 SD to mean + 8/3 SD”</td>
</tr>
<tr>
<td>Excess</td>
<td>“Mean + 8/3 SD”</td>
</tr>
</tbody>
</table>

(Source: Bhargava, 2002)

The optimum ranges are the values obtained from the mean ±4/3 SD and mean ±8/3 SD, respectively (Bhargava, 2002). The nutrient values <(mean – 8/3 SD) measured deficient, whereas their low range falls including all value between >(mean – 8/3 SD) and <(mean – 4/3 SD). Values between >(mean – 4/3 SD) and <(mean + 4/3 SD) are considered as optimum. The range between >(mean + 4/3 SD) and <(mean + 8/3 SD) were expressed as high. The leaf concentration >mean + 8/3 SD were considered as toxic (Table 4).
Table 5: Leaf nutrient standards for Aonla

<table>
<thead>
<tr>
<th>Element</th>
<th>Mean</th>
<th>SD</th>
<th>Deficient</th>
<th>Low</th>
<th>Optimum</th>
<th>High</th>
<th>Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>1.468</td>
<td>0.129</td>
<td>&lt;1.13</td>
<td>1.13-1.30</td>
<td>1.30-1.64</td>
<td>1.64-1.81</td>
<td>&gt;1.81</td>
</tr>
<tr>
<td>P (%)</td>
<td>0.073</td>
<td>0.014</td>
<td>&lt;0.036</td>
<td>0.036-0.054</td>
<td>0.054-0.092</td>
<td>0.092-0.11</td>
<td>&gt;0.11</td>
</tr>
<tr>
<td>K (%)</td>
<td>0.518</td>
<td>0.091</td>
<td>&lt;0.28</td>
<td>0.28-0.40</td>
<td>0.40-0.64</td>
<td>0.64-0.76</td>
<td>&gt;0.76</td>
</tr>
<tr>
<td>Zn (ppm)</td>
<td>39</td>
<td>5.219</td>
<td>&lt;25.0</td>
<td>25.0-32.4</td>
<td>32.4-45.9</td>
<td>45.9-52.9</td>
<td>&gt;52.9</td>
</tr>
</tbody>
</table>

The sufficiency ranges for nitrogen vary from 1.30–1.64% with an average value of 1.47%. In the present study, it was observed that optimum values of P, K, and Zn ranged from 0.054–0.092%, 0.40–0.64% and 32.4–45.9 ppm with mean values of 0.073%, 0.52%, and 39.1 ppm, respectively (Table 5). Thus, when interpreted with respect to sufficient nutrient concentration ranges, on the basis of leaf N-content in aonla tree, among all surveyed orchards 18%, 35%, 37%, 10%, and 0% plants were found Deficient, low, sufficient, high and toxic respectively.

It is apparent from this study that leaf tissue analysis of aonla fruit trees can be interpreted by DRIS approach to generate positive or negative indices for each of the nutrients. A positive index indicates adequate and above levels of the nutrient under consideration, whereas a negative index indicates below a sufficiency level; thus the nutrient requirement can be ordered relative to one another. On the basis of DRIS derived sufficiency ranges, 34, 22, 18 and 27% of samples were low in N, P, K, and Zn, respectively. More than 25, 8, and 17% of aonla tree showed to deficient in N, P, and Zn, respectively.

Nano based formulations

Nanotechnology deals with the creation of useful materials, devices and systems using the particles of nanometer length scale and exploitation of novel properties (physical, chemical, and biological) at that length scale.

Nanoparticles are microscopic particles and Nanotechnology is the technology used to manipulate these nanoparticles for plant, human and industrial use.

“Nano-technology” mainly consists of the processing, separation, consolidation and deformation of materials by one atom or by one molecule.

The impact of Nanotechnology in Agriculture

- Nanotechnology is considered as one of the possible solutions to problems in food and agriculture.
- Just like biotechnology, issues of safety on health, biodiversity, and environment along with appropriate regulation are raised on nanotechnology.
- Decreased particle size of fertilizer results in increased number of particles per unit area applied.
- However, nanotechnology products such as anti-bacterial and suntan lotions have long been commercially available.

Nanomaterials and nanoparticles

Nanomaterials (NMs) are atomic or molecular aggregates with at least one dimension between 1 and 100 nm (Ball, 2002; Roco, 2003a). The physico-chemical properties of NPs can be drastically modified compared to the bulk material (Nelet al., 2006). NPs have all three dimensions on the nanoscale and can be produced from a variety of bulk materials, and the chemical composition as well as the size and/or shapes of the particles govern their main properties and reactivities (Brunner et al., 2006).

Nanomaterials and nanoparticles in soil-plant systems

The application of nanotechnology in agriculture is nascent. However, NMs and NPs can provide the basis of constructs and macro assemblies for developing new tools and technological platforms for the study and transformation of MNs in soil-plant systems. As stated earlier, NMs and NPs may become
part of intelligent technological systems to efficiently apply production inputs, such as fertilizers and pesticides for specific temporal and spatial scales.

**Nano fertilizer formulations**

The encapsulation of commercial fertilizers uses polymer films to protect the nutrients from rapid stabilization reactions in soils and control their release into the soil solution during plant growth. Nutrient release of coated micronutrient fertilizers occurs according to soil moisture content and/or temperature, pH and ionic content, among other factors. The nutrient release mechanism is based on either direct diffusion through a polymer film or by decreasing the rate of product hydrolysis, such as urea. A controlled-release micronutrient fertilizer containing Zn, was prepared after reacting and polymerizing phosphoric acid, zinc oxide, followed by neutralization of the polyphosphate (P-O-P) chain with ammonium hydroxide (Bandyopadhyay et al., 2014). The multi-micronutrient product was tested in different field trials and showed that the slow-release poly phosphate micronutrient (POP-MN) fertilizer increased rice yield from 10% to 55% over the control treatment (no MN added) and up to 17% over the conventional MN-sulfate salts.

Recent studies have reported the effect of zinc oxide (ZnO) (<100 nm) NPs on the germination, seedling growth and yield of many crop plants like peanut, mung, and gram (Prasad et al., 2012), cucumber (Zhao et al., 2013), Sweet basil (El-Keretiet et al., 2013), Cabbage, Cauliflower, Tomato (Singh et al., 2013) and Chickpea (Pandey et al., 2010) and tomato (Panwar et al., 2012) upon either seed treatment or foliar application helped to increase the Zn MUE of crops. Thus far, many of the effects of the new fertilizer materials on crop yield and quality, human health and environmental risks remain largely unknown. Nanobiotechnology will occupy a prominent place in transforming agricultural systems and food production worldwide in the coming years.

**Conclusion**

For millions of people around the world, a few extra milligrams of zinc each day can make the difference between illness or death and a healthy, productive life. By ensuring that crops receive an adequate supply of zinc, we can help address this global issue. Micronutrient deficiency in 50% of the world’s soils and many crops greatly reduces the amount and quality of food. The low (<5%) MUE by crops adversely affects human health, the economic status of farmers and the environment around the world. Adding zinc to crops not only increases crop nutritional value, but also increases crop yield and crop resistance to environmental hazards such as drought and disease. Increased yield leads to increased income for the farmers.

**References**


**Integrated Farming System: The Future of Agriculture**


**Integrated Farming System: The Future of Agriculture**


APICULTURE: A GROWING TREND IN INDIA

Manisha, Vijaya, Sangeeta Tiwari and Gulshan Kumar
Department of Entomology, Chaudhary Charan Singh Haryana Agricultural University, Hisar-125004, India
Corresponding author Email: payalsharma981994@gmail.com

Abstract
Apiculture or bee-keeping is a technique of rearing honey bees for honey, wax, royal jelly and propolis as well as for increasing the crop yield. India is one of the largest honey producer and exporter in the world that plays an important role in world honey production and trade. Selection of suitable sites for quality honey, protection of bees or combs from diseases and pests are the part of apiculture. In India Apiculture or Beekeeping is a growing trend. Honey bee farming in India can be done separately as a commercial honey bee farm or can be integrated with crops to increase the crop yield and get additional income from honey. This is because bees play an important role in pollinating many plants. Sunflowers, Cheery, Apple, Citrus, Lily, Lotus and such other crops are highly dependent on bees for pollination. In addition, it does not require huge investments, infrastructure or even a fertile land to start bee farming in India. In agricultural, honey bees do not compete with the crops for resources. The most valuable by product of apiculture is honey that has a long history of human consumption. It is consumed as medicine, taken as food, or incorporated as an additive in a variety of food and beverages. India has been known as ‘land of honey.’

Present scenario in India
Beekeeping is being practised traditionally in India since time immemorial. As per 2016-17 estimates, about 30 lakh bee colonies has been produced 94.5 thousand MT of honey. Yields of honey per colony with supers (20 frames) has increased to 25kg per annum in 2015-16 from 18 to 20 kg per annum in 2014-15. In 1953 the All India Khadi & Village Industry started the work of organizing the honey industry in India which was subsequently taken over by Khadi & Village Industry Commission (KVIC) in 1957. In 2015-16 KVIC targeted training of 2 lakh people in beekeeping and support new beekeepers under Entrepreneurship Development Programme under PMEGP. Like dairying, apiculture is also practised mostly by marginal and landless farmers. It also supplements income from agriculture, generates employment and also helps in improving nutritional intake of rural population. It provides employment to about 3 lakh rural people. Honeybees are vital in sustaining plant biodiversity and also improves yields of crops by cross-pollination. This increase has been shown to be in the range of 5 to 3000 % depending upon the type of crop. Value of additional yield from pollination services by honey bees alone is about 15-20 times more than the value of all hive products put together. There are only 4 States-West Bengal, Uttar Pradesh, Punjab and Bihar contributed about 61% to the country’s honey production in 2015-16. India is one of the major exporter of honey. Major destinations included USA, Saudi Arabia, UAE, Morocco, Bangladesh, Canada etc. In 2015-16 India exported 38.2 thousand MT of honey valued at 706 crores.

By-Products of Apiculture
There are other by-products like royal jelly, bees wax, pollen, propolis and bee venom, apart from honey which are commercially important.

Honey
It is a viscous fluid that is produced from the flower nectar and pollen by the bees. Commercially it is the most important product of apiculture since it is termed as complete food that contained sugars, enzymes, antibiotics, acids and minerals. Because of high sugar content, it is a high energy source. It is
a useful carrier for many ayurvedic and unani medicinal preparations. Honey is recommended for regular consumption in cases of malnutrition, ulcers and impaired digestion.

**Beeswax**
It is secreted in liquid form but solidifies when exposed to air. Generally the wax is white in color but the shade may vary depending on the pollen pigments. It is chiefly used in the candle industry. Beeswax is also important in other major places like for making creams, ointments, capsules, deodorants, varnish, shoe polish, etc.

**Royal Jelly**
It is secreted from the hypopharyngeal glands of worker bees. Queen larva and the young workers larva feed on royal jelly. It is milky in color and contains proteins, lipids, carbohydrates, minerals like iron, Sulphur, copper and silicon. It increases the vitality and vigor in humans.

**Propolis**
Propolis is the resin-like exudate collected by honey bees from the trees. They use propolis for sealing the cracks and crevices to prevent the entry of enemies and for the attachment of comb to surface. It has an adhesive quality and hence mixed with Vaseline. It also has burn healing property so, useful for preparing ointments that treats cuts, wounds, etc.

**Bee Venom**
It is an important poisonous secretion used by the worker bees as a defense mechanism. It contains active chemicals like histamine, hydrochloric acid, formic acid, calcium, Sulphur, apamine, etc. Commercially it is obtained by electric shock. The hives are connected to a live circuit of 12-15 volts. Whenever the bees get in touch with the wire they get irritated by the shock and in reaction deposit venom. Bee venom is used for patients which are suffering from rheumatism. There is no other method of curing. It also helpful in curing neuralgia, endoarthritis, necrosis, etc.

**Species of honey bee which are useful for honey production in India**
Five important species of honey bees are as follows:-

**Rock bee (Apis dorsata)**
They are giant bees found all over India in sub-mountainous regions up to an altitude of 2700 m. They construct single comb in open on tree branch, rock cliff, etc. about 6 feet long and 3 feet deep. Rock bees are ferocious and difficult to rear. About 36 Kg honey per comb per year is produced. These bees are largest among the described bees.

**Little bee (Apis florea)**
They build single vertical combs. They also construct comb in open of the size of palm in branches of bushes, hedges, buildings, caves and empty cases. These bees produce about half a kilo of honey per year per hive. Raring is not possible as they frequently change their place. Among four described Apis species the size of bees in this species is smallest. They distribute only in plains and not in hills.

**Indian hive bee / Asian bee (Apis cerana indica)**
These are domesticated species, which construct multiple parallel combs with an average honey yield of 6-8 kg per colony per year. These bees are larger than Apis florea but smaller than Apis mellifera. They are more prone to swarming and absconding. They are native of India/Asia.

**European bee / Italian bee (Apis mellifera)**
They are also similar in habits to Indian bees, which build parallel combs. They are bigger than all other honey bees except Apis dorsata. The average production per colony is 25-40 kg. They have been
imported from European countries (Italy). Unlike Indian bee these are less prone to swarming and absconding.

**Dammer bee**

Besides true honey bees, two species of stingless or dammer bees, viz. *Melipona* and *Trigona* occur in our country in abundance. These stingless bees have importance in the pollination of various food crops. These bees are much smaller than the true honey bees and build irregular combs of wax and resinous substances in crevices and hollow tree trunks. They bite their enemies or intruders. It can be domesticated but only 100 gms honey per hive per year can be harvested.

**Methods of Bee-Keeping in India**

The ultimate aim of bee keeping is to get more and more honey in pure form. The old method commonly used by old apiculture is very crude, cruel and of unplanned type. This old method is called as Indigenous method.

**Indigenous methods**

In this method two types of hives are used

a. **Inmovable structures**

It is practiced in villages. Small structures are made in secluded and protected places. During construction of dwelling houses, small permanent chambers are made in the outer wall of the house for bees to build combs. 

On the outer-side of the chamber a horizontal slit is made for the entry of bees, while on the inside wall a large opening is left for removal of comb.

b. **Movable structures**

Bee chambers are comprises of hollow bags, earthen pots, empty wooden boxes, etc. which can be moved from place to place, and put in a suitable location for the bees. There exist two holes one is for entrance and the other for exit of the bees.

**Extraction of honey in indigenous method**

For honey extraction, burning fire is brought near the bee hive at the night as a result of which bees are either killed or they escape off. Further the hive full of honey is being removed, cut into pieces and squeezed to get honey. Sometimes smoking is done so that the bees may escape from their hives. So These methods are not much satisfactory.

**Drawbacks of indigenous method**

The indigenous method of bee keeping suffers from a number of drawbacks due to which it is not recommended by present day panel. These drawbacks are:

(a) Honey becomes impure because at the time of squeezing, the brood cells, pollen cells, honey cells and larvae are also extracted.

(b) The colony becomes weak due to killing of the eggs and the larvae at the time of squeezing.

(c) Also scientific intervention is difficult in the indigenous method and thus improving of the bee race is impossible.

(d) The bees may not construct the new hive in the same place as the old one.

(e) The natural hives also have the danger of attack by the enemies like rats, monkeys, ants etc. The natural hives can also be damaged by the climatic factors.

**Modern methods**

**Beehive**

In the modern method of apiculture the honey bees are reared in movable artificial beehives. These were designed and invented by Longstroth in 1951. This invention has turned apiculture into a cottage industry and has provided employment to lakhs of unemployed people.

The hive is made up of wooden box with a two-tier structure. The chambers can be removed from or added to, as required. It has a basal plate known as bottom board on which a wooden box called brood chamber is placed. At the bottom of brood chamber a small opening present which permits passage for bees. Several frames hang vertically from the top inside the brood chamber. These frames can be
removed independently. The distance between the two frames, the bee space is narrow and serves as a
passage for the workers but small for building a comb. Another similar chamber is placed above the
brood chamber for storage of honey only and known as honey chamber. The queen is never allowed to
enter the chamber. In some cases two honey chambers are used. An inner covering is placed above the
honey chamber over which the roof lies.

Tools for Modern Bees Keeping
Comb foundation
A small piece of comb is necessary to tie with one of the frames from where the bees will start comb-
building.
Bee Brush
It gently removes bees from frames. A leafy twig or bunch of grass can do the same job and gives you
fewer tools to carry around.
Bee veil
A bee veil, made up of linen, is required to cover neck, face and head of the keeper during handling.
Bee gloves
To prevent bees from stinging during handling of the comb and bees, leather gloves are used.
Smoker
A smoker must be used while capturing bees in a hive. Smoke from Burlap, rotted wood, shavings,
excelsior, cardboard, or cotton rags makes the bees inactive. There is fire box in a smoker in which
smoke-producing materials and fire are put. A bellow system is fitted to blow the smoke.
Hive tool
It is a long, narrow and flat piece of steel with a slightly bent head and can be used to pry up the inner
cover, pry apart frames, scrape and clean hive parts, and do many other jobs.
Honey extractor
It is used for extraction of honey from the frames without damaging the comb. It consists of a metal
drum with several pockets around a rotating wheel. The frames are hanged from the pockets and the
pockets are made to rotate round a central axis. By rotation the centrifugal force is created that sepa-
rates honey from the comb which is collected in the drum. The honey is taken out from the drum
through a hole at the bottom. The combs and frames can be re-placed in the hive for further use.

The steps included in apiculture or commercial production honey
Catching a swarm
Swarm is an old queen accompanied by huge population of workers flying to start a new hive. The
swarm is generally collected with a straw basket called as skep with a lid.
Hiving a Swarm
It is the process in which the collected swarm is transferred to the hive to build up the colony and
produce honey.
Initial feeding
After the hiving of the swarm, they are fed with sugar syrup. This feeding will help the bees to settle
down to work in their new home.
Starting the work
After settling down in the new hive the bees start to work in their respective job roles in the new hive.
The worker bees move about in the surrounding flora collecting nectar and pollen. Consequently the
colony expands and starts the production.
Queen Rearing
Although queen bees can lay eggs for 3 years, on an average they can lay fertilized eggs for a year or
maximum two years. After this period they start laying unfertilized eggs. This affects the colony.
Generally farmers revive the colonies by placing another queen bee. This process is called re-
queueening. In apiculture, farmers are advised to re-queen their hives after every one and half year.
Conclusion
Beekeeping or apiculture in India is thus an important agri-business that not only promises good returns to the farmers but also helps increase agricultural productivity. Beekeeping in India can also be a good source of income for the farmers especially when the growth of crop is still under process. Honey bee farming may help in doubling farmers income by supplementing/complimenting agriculture/horticulture. Unemployed youth can start this business with minimal funds (Rs. 1.00 to 2.00 lakhs) and can get good returns. Export of honey/beehive products attracts foreign exchange that results in rural development and promotes small village industry. Beekeeping generates income without destroying habitat. However, a good amount of training and trials are required for a successful honey bee farm. Encouraging beekeeping encourages biodiversity.

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SERICULTURE INDUSTRY: WORLD, NATIONAL AND REGIONAL SCENARIO

Vikalp Sharma¹, Arushi Vyas², Arjun Singh Rajput¹, Anju Yadav¹

¹Department of Agril. Economics and Management, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan)-313001

²Department of Agricultural economics, Extension Education and Rural Sociology, CSKHPKV, Palampur, Himachal Pradesh-176062

Corresponding author Email:

Abstract

Sericulture is an agro-based multitudinous activity which involves cultivation of mulberry, production of laying, rearing of silkworms for cocoons, marketing and reeling of cocoons for value added benefits such as processing and weaving of the yarn. It is both art and science of raising silkworms for silk production. Sericulture including silk production is one of the most labour intensive and low capital intensive sectors of the Indian economy.

Sericulture as an enterprise has proven to be righteous under the Indian agro-climatic conditions. Sericulture stands for livelihood opportunity for millions owing to high employment generation and remunerative nature of its production. The finished silk fabric, undergoes a process which can be classified into two parts; one is sericulture which involves mulberry cultivation, silkworm egg production, silkworm rearing and disposal of cocoons. The other part consists of reeling, twisting, dyeing, weaving and printing. These processes are industrial in nature and mostly carried out in rural and semi-urban area or in large scale factoriestermed as filature (Singh 1994).

Historical Background

The history of silk as a weavable fiber dates back to 2640 BC by the Chinese empress Xi Ling Shi and its culture and weaving was a guarded secret for more than 2,500 years by the Chinese. The queen of the Chinese emperor Huang-ti, incidentally discovered it while studying the worms that were destroying the groves of mulberry trees in the royal gardens. She put the cocoons in hot water bowl and found a cobweb like tangle separating itself from cocoon which had one long slender thread. Royalty started wearing silk robes for all important ceremonies but the commoners were allowed to use silk only after 1150 BC. From China, sericulture spread to Korea in about 1200 BC and from there to Japan during the 3rd century BC. However, Chinese trade relations with southern Europe were established only by the first century BC. In Japan, the sericulture industry progressed till 1868 (Meiji restoration period) and the period saw introduction of improved techniques and research in sericulture in Japan. The route for transporting silk consignments from China to Mediterranean countries came to be known as the ‘Silk Road’ or ‘The Silk Route’. In India, it came via Tibet by about 140 BC on its way to Persia. According to some Indian scholars silkworms (Bombyxmori) were first domesticated in the foothills of the Himalayas. Evidences in ancient Sanskrit literature revealed that certain kind of wild silks were cultivated in India from time immemorial. According to Western historians, mulberry-tree cultivation and rearing of silkworms began in the areas flanking the Brahmaputra and Ganges rivers. The systematic progress was, however laid by the British East- India Company which exported large quantities of raw silk to England.

Since then the Indian silk industry has seen many ebb and flow. However, it suffered after the World War I due to severe competition from cash crops and uncontrolled imports of raw silk. But the Second World War was a boon to sericulture in India. However, the Persians held a monopoly on silk goods
for quite a while. The industry got introduced in Constantipole in 553 AD and for about 400 centuries was confined to the eastern parts of the Roman Empire and its west-ward journey was gradual and by 11th century the entire European demand was met by Venetian Republic. France saw the introduction of the sericulture industry during 1340 AD, but it really flourished during the 17th and the 18th centuries. However, with the break-out of pebrine (a disease affecting silkworms) in the 19th century, sericulture was wiped out in France, Europe and Middle East. Despite the discovery of Louis Pasteur in 1870, the industry though revived, could not sustain itself due to industrial revolution and on-going socio-economic changes in Europe (Chauhan and Kulshrestha 2000).

World scenario

Silk is the most elegant textile in the world with unparalleled grandeur, natural sheen, and inherent affinity for dyes, high absorbance, light weight, soft touch and high durability and known as the ‘Queen of Textiles’ the world over. At present over 60 countries are engaged in sericulture. The major silk producing countries in the world are: China, India, Uzbekistan, Brazil, Japan, Republic of Korea, Thailand, Vietnam, DPR Korea, Iran, etc. Few other countries engaged in the production of cocoons and raw silk in negligible quantities are; Kenya, Botswana, Nigeria, Zambia, Zimbabwe, Bangladesh, Colombia, Egypt, Japan, Nepal, Bulgaria, Turkey, Uganda, Malaysia, Romania, Bolivia, etc. The major silk consumers of the world are; USA, Italy, Japan, India, France, China, United Kingdom, Switzerland, Germany, UAE, Korea, Vietnam, etc. While the major producers are in Asia (90% of mulberry production and almost 100% of non-mulberry silk), sericulture industries have been lately established in Brazil, Bulgaria, Egypt and Madagascar as well. About 1 million workers are employed in the silk sector in China. Silk industry has provided employment to 7.6 million people in India, and 20,000 weaving families in Thailand. China has come up as the world's single biggest producer and chief supplier of silk to the world markets. India is the world's second largest producer. The Table 1 gives the global raw silk production of the important counties for a period of seven years.

Table 1. Global raw silk production (mt)

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<td>-</td>
<td>40</td>
<td>38</td>
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<td>43</td>
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<td>1177</td>
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<td>Uzbekistan</td>
<td>770.5</td>
<td>780</td>
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<td>980</td>
<td>1100</td>
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<td>Vietnam</td>
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<td>550</td>
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**Integrated Farming System: The Future of Agriculture**

<table>
<thead>
<tr>
<th>Madagascar</th>
<th>15</th>
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<td>120396.0</td>
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<td>139100.0</td>
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<td>2</td>
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</table>

Source: International Sericulture Commission

**Indian Scenario**

Sericulture and silk industry is an avocation in India from at least the second century BC. According to historians, raw silk was exported during the reign of Kanishka in 58 B.C. The modern silk history dates back to the 15th century, which was also famous for sculpture and paintings. During the 18th, 19th and early 20th centuries, sericulture flourished in the States of West Bengal, Mysore and Kashmir. Indian silk industry has improved manifold since independence from the raw silk production level of 1437 mt during First Plan period (1969-74) to 23679 mt by the end of March 2013.

**Table 2 Year-wise silk production in India (2004-05 to 2014-15)**

<table>
<thead>
<tr>
<th>Year (April-March)</th>
<th>Production (mt)</th>
<th>Change in production over base year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-05</td>
<td>16500</td>
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<tr>
<td>2005-06</td>
<td>17305</td>
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<td>2006-07</td>
<td>18475</td>
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<tr>
<td>2007-08</td>
<td>18320</td>
<td>-155</td>
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<tr>
<td>2008-09</td>
<td>18370</td>
<td>+50</td>
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<tr>
<td>2009-10</td>
<td>19690</td>
<td>+1320</td>
</tr>
<tr>
<td>2010-11</td>
<td>20410</td>
<td>+720</td>
</tr>
<tr>
<td>2011-12</td>
<td>23060</td>
<td>+2650</td>
</tr>
<tr>
<td>2012-13</td>
<td>23679</td>
<td>+619</td>
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<tr>
<td>2013-14</td>
<td>26480</td>
<td>+2801</td>
</tr>
<tr>
<td>2014-15</td>
<td>28708</td>
<td>+228</td>
</tr>
<tr>
<td>CGR (% p.a.) in 2014-15 over 2004-05</td>
<td>6.73</td>
<td></td>
</tr>
</tbody>
</table>

Source: International Sericulture Commission

According to statistics presented in Table 3, in India, major mulberry silk producing states are Karnataka (43%), Andhra Pradesh (32%), West Bengal (7%), Tamil Nadu (10%) and Jammu and Kashmir (0.62%) which together accounts for 93 per cent of the country’s total mulberry raw silk production. Clearly indicating that, major silk production is shared by Karnataka followed by Andhra Pradesh (Varmudy 2011).

India has a distinct advantage of practicing sericulture all through the year, yielding a stream of about 4 – 6 crops as a result of its tropical climate. Several socio-economic studies have affirmed that the benefit-cost ratio in sericulture is highest among comparable agricultural crops (Ganghopadhyay2008). Some results presented in Table 4 shows that the benefit-cost ratio from sericulture is 1.98 in comparison to 1.97 and 1.02 obtained from sugarcane and turmeric cash crop respectively.

**Table 1.3 State-wise raw silk production in India (mt)**

<table>
<thead>
<tr>
<th>State</th>
<th>2012-13</th>
<th>Per cent of total</th>
<th>2013-14</th>
<th>Per cent total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karnataka</td>
<td>8219</td>
<td>34.71</td>
<td>8574</td>
<td>32.38</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>6550</td>
<td>27.67</td>
<td>6912</td>
<td>26.10</td>
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</table>
The sericulture industry provides employment to more than 7.6 million people across 51,000 villages, which operate 328,627 handlooms and 45,867 power looms with 8,14,616 weavers. Its exports of silk are worth about US$ 360 Million of which 70 per cent comprises natural silk yarn and fabrics, 13 per cent made-ups and 26 per cent garments. Domestic demand stands at 28800 mt compared to production of 23679 mt annually thanks to the growing demand for silk fabrics and sarees from Indian women.

Sericulture in Himachal Pradesh

Sericulture in Himachal Pradesh is a land-based activity with good potential for generating productive rural employment. Himachal Pradesh is also quite well known countrywide for the quality of bivoltine silk cocoon production. This has been possible because of the suitable climate in the state for production of quality bivoltine silk cocoons. Sericulture activities are spread over in ten of the twelve
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districts. Sericulture has provided a fairly remunerative occupation to about 9000 families in 1900 villages and its major concentration is found in Bilaspur, Mandi, Hamirpur, Kangra, Una and Sirmaur districts. During 11th plan period and a year latter (2007-08 to 2012-13), silk cocoons production registered growth of 12.50 per cent p.a, which has been 183.76 metric tonnes during 2012-13 (Table 5). The revenue earned from sericulture during this period recorded a phenomenal growth of 90.71 per cent p.a. The growth in number of rural families adopting sericulture was found to be 0.64 per cent p.a. Similarly area under mulberry tree plantation also saw increase in growth to the extent of per cent 19.98 p.a which was 685 ha in 2007-08 and increased to 1780 ha during 2014-15. Among the districts practicing sericulture, district Bilaspur is the biggest producer of silk-cocoons, sharing 35.0 per cent production followed by Mandi (25.0 per cent), Kangra (22.0 per cent) and Hamirpur (16.0 per cent).

Table 5: Trends in production, revenue & employment generation from silk industry in Himachal Pradesh

<table>
<thead>
<tr>
<th>Year</th>
<th>Green cocoon production (mt)</th>
<th>Raw silk production (mt)</th>
<th>Value (Lakh Rs)</th>
<th>Employment to rural families (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-07</td>
<td>142.08</td>
<td>17.7</td>
<td>200.25</td>
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<tr>
<td>2007-08</td>
<td>105.00</td>
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<td>2008-09</td>
<td>152.29</td>
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<td>8450</td>
</tr>
<tr>
<td>2009-10</td>
<td>152.75</td>
<td>19.75</td>
<td>306.00</td>
<td>8606</td>
</tr>
<tr>
<td>2010-11</td>
<td>149.40</td>
<td>19.20</td>
<td>502.80</td>
<td>8634</td>
</tr>
<tr>
<td>2011-12</td>
<td>180.32</td>
<td>22.54</td>
<td>597.00</td>
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<tr>
<td>2012-13</td>
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<td>570.00</td>
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<td>191.77</td>
<td>25.20</td>
<td>654.00</td>
<td>9223</td>
</tr>
<tr>
<td>2014-15</td>
<td>229.49</td>
<td>30.40</td>
<td>1835</td>
<td>8753</td>
</tr>
<tr>
<td>CGR over 2006-07 to 2014-15 (% p.a)</td>
<td>6.84</td>
<td>7.97</td>
<td>90.71</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Source: Chauhan 2013 and www.himachal.nic.in

Reference

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ORGANIC FARMING FOR SUSTAINABLE DEVELOPMENT IN CHANGING WORLD SCENARIO: A REVIEW

Amit Tomar\(^1\) and Mahak Singh\(^2\)
\(^1\)Department of Genetics & Plant Breeding, Rani Laxmi Central Agricultural University, Jhansi, U.P., India.
\(^2\)Department of Genetics & Plant Breeding, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, U.P., India.

Corresponding author Email:

Abstract
In the pre-independence period, Indian agriculture was usually described as a gamble with monsoons. There used to be a great deal of uncertainty about crop prospects, as monsoons played a decisive role in determining agricultural output and their failures resulted in widespread famine and misery. In the last few years, Indian agriculture has made impressive progress and so is more resilient to the vagaries of the monsoon. The world population was increased day by day and the per capita availability of land was decreased day by day and food production also decreased rate. Hunger must be banished from the surface of earth, as a first responsibility of any civilised society to provide sufficient food for the people who are below the poverty line.

Indian agriculture before the green revolution
Our traditional farming systems were characterised mainly by small and marginal farmers producing food and basic animal products for their families and local village communities. Farming was highly decentralised with individual farmers deciding on the types of crops to grow depending on climate and soil conditions. These traditions consisted of methods of controlling pests and diseases, and for building soil fertility and structure in their own ingenious ways, since farming did not include the use of chemical pesticides or fertilizers. Rather, soil health and pest control were achieved using practices such as shifting cultivation, conservation, the use of animal manures and farm wastes and the introduction of legumes into crop rotations.

The green revolution
After the green revolution was launched in India, substantial increase in the production of food grains was achieved through the use of improved crop varieties and higher levels of inputs of fertilizers and plant protection chemicals. But it has now been realised that the increase in production was achieved at the cost of soil health and that sustainable production at higher levels is possible only by the proper use of factors which will help to maintain the fertility of the soil.

Impact of green revolution on the environment
To increase the agricultural production in the country and to meet the requirements of the expanding population. It becomes imperative to change the methodologies. These involved the use of high-yielding varieties and higher fertilizer dosages; increasing the irrigated area and intensive cropping; bringing large areas under one crop; growing crops in non-conventional areas; and changing the crop sequences. The green revolution followed the development of commercial agriculture in the developed countries after second World ward II. Chemical companies that developed highly toxic and life damaging chemicals for the purpose of welfare, decided to turn their attention on the chemical control of insects, pests and unwanted plants in the farmers fields. The following effects of green revolution are stated to be:

- Reduction in natural fertility of the soil,
- Destruction of soil structure, aeration and water holding capacity,
- Susceptability to soil erosion by water and wind
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Fig. 1.1: Difference between conventional and organic farming systems.

- Diminishing returns on inputs,
- Indiscriminate killing of useful insects, microorganisms and predators that naturally check excess crop damage by insect pests,
- Breeding more virulent and resistant species of insects,
- Reducing genetic diversity of plant species,
- Pollution with toxic chemicals from the agrochemicals and their production,
- Endangering the health of the farmers using chemicals and the workers who produce them,
- Poising the food with highly toxic pesticide residues,
- Cash crops displacing nutritious food crops,
- Chemicals changing the natural taste of food,
- High inputs increasing the agricultural expenses,
- Increasing the farmers work burden and tension,
- Depleting the fossil fuel resources,
- Increasing the irrigation needs of the land,
- Big irrigation projects often resulting in soil salinity and poor drainage.

Organic farming

Organic farming techniques will help to increase the organic matter content of soil, thus reducing the bulk density and decreasing compaction. Organic farming is an system of farming which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and livestock feed additives. Soil organic matter is one of the important components of the soil. The dead plant and animal remains and dead microbial tissues form the amin source of soil organic matter.

Components of organic farming

Green manuring

Crops grown for the purpose of restoring or increasing the organic matter content in the soil are called green manure crops. Their use in cropping system is called “Green Manuring” where the crop is grown in situ or brought from outside and incorporated.
Classification of green manures
It can be mainly classified into two groups viz., legumes and non-legumes and further sub-divided under two groups in each viz., green manure and green leaf manure.

Legumes
- Fix free nitrogen from the atmosphere.
- Physical condition of the soil is improved by cultivation and incorporation.
- They are more succulent than the non-legumes and less soil moisture is utilized for their decomposition.
- They serve as cover crops by their vigorous growth and weeds are smothered e.g., clover, dhaincha and cowpea.

Fig. 1.2: Different components of organic farming.

Non-legumes:
Free nitrogen is not fixed by non-legumes except in specific plants which have root nodules produced by bacteria or fungi, e.g., casurina, Elasagnus and Cycas. They are not as succulent as legumes and hence require more soil moisture and time for decomposition.

Advantages of green manuring
Green manuring has a positive influence on the physical and chemical properties of the soil. It helps to maintain the organic matter status of arable soils.

Green manure serves as a source of food and energy for the soil microbial population which multiplies rapidly in the presence of easily decomposable organic matter. The enhanced activities of soil organisms not only cause rapid decomposition of the green manure but also result in the release of plant nutrients in available forms for use by the crops. Green manuring improves aeration in the rice soils by stimulating the activities of surface film of algae and bacteria. Many green manure crops have additional use as source of food, feed and fuel.

Soil structure and tilth improvement
Green manuring builds up soil structure and improves tilth. It promotes formation of crumbs in heavy soils leading to better aeration and drainage. Depending on the amount humus formed, green manuring increases the water holding capacity of light soils. Green manure crops form a canopy over the soil and reduce the soil temperature and protect the soil from the erosion action of rain and water currents.

Fertility improvement of soils
Green manure crops absorb nutrients from the lower layer of soils and leave them in the soil surface layer when ploughed in, for use by the succeeding crops. Green manure crops prevent leaching of nutrients to lower layer. Leguminous green manure plants harbour nitrogen fixing bacteria, rhizobia, in the root nodules and fix atmospheric nitrogen. Green manure crops increase the solubility of lime phosphates, trace elements etc., through the activity of the soil microorganisms and by producing organic acids during decomposition. A crop of green manure on an average is reported to fix 60 to 100 kg nitrogen /ha in single season under favourable conditions.

Amelioration of soil problems
Green manuring helps to amelioration soil problems. Dhaincha, when applied to sodic soils continuously for four or five seasons, improves the permeability and helps to leach out the harmful sodic salts. The soil becomes fit for growing crops.
**Improvement in crop yield and quality**

Green manuring increases the yield of crops to an extent of 15 to 20 per cent compared to no green manuring. Vitamin and protein content of rice have been found to be increased by green manuring of rice crop.

**Fig.1.3: Green manure crops.**

**Pest control**

Certain green manure like Pongamia and Neem leaves are reported to have insect control effects.

**Stages of incorporation**

When the green manure crops are grown and incorporated in the same field, the best stage of incorporation is the flowering stage of the crop. However, when green leaf manuring is practiced by bringing in the green plants grown elsewhere, no definite stage can be fixed as the green leaf manuring is controlled by many other factors.

**Time of incorporation**

The success of green manuring depends on the correct time of trampling green matter into the soil and giving sufficient interval before or planting the crop. The manure, being a bulky one, is usually applied as basal dressing before the main crop is raised in the field.

**Fig.1.4: Green leaf manuring crops.**

**Biological nitrogen fixation**

Biofertilization or microbial fertilizers or more appropriately microbial inoculants are preparations containing live or latent cells of efficient strain of nitrogen fixing microorganisms used for seed or soil application with the objective of increasing the numbers of such microorganisms in soil or rhizosphere and consequently improve the extent of microbiologically fixed nitrogen for plant growth. They are used either to fix nitrogen or to solubilise plant nutrients like phosphates or to otherwise stimulate plant growth through synthesis of growth promoting substances (PGPR) or to collect availability phosphorous from remote places out of reach of plant root hairs by sending elongated filaments (VAM).

**Table-1.1: Microorganisms used as biofertilizers.**

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Contributing Plant nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbiotic Rhizobium (with legumes)</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Azolla</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Associate symbiotic Azospirillum</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Non-symbiotic Azotobacter</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Blue green algae</td>
<td>Nitrogen</td>
</tr>
</tbody>
</table>
Others
P solubilisers & Mineralisers Phosphorus
Fungi: Aspergillus, Penicillium
Bacteria: Pseudomonas, Bacillus
P absorbers (Root fungus symbiosis)
VAM (Vesicular Arbuscular Mycorrhiza) Phosphorus & Zinc

Vermiculture biotechnology
Biotechnology essentially involves a large scale application of bio-systems for economics and effective processing of materials to produce value added products. Vermiculture is culturing of earthworms. Vermiculture biotechnology is, therefore, an aspect of biotechnology involving the use of earthworms as versatile natural bioreactors for effective recycling of non-toxic organic wastes to the soil, resulting in soil improvement and sustainable agriculture. Earthworms play a key role in soil biology as versatile natural bioreactors. They effectively harness the beneficial soil microflora, destroy soil pathogens and convert organic wastes into valuable products such as biofertilizers, vitamins, enzymes, antibiotics, growth hormones and proteinous worm biomass. Hence, we can call the earthworms as “artifical fertilizer factories”.

Earthworms gut is an effective tubular bioreactor with raw materials entering from one end and the product coming out through the other end. They maintain a stable temperature through noval temperature regulation mechanisms, thus accelerating the rates of bioprocesses and preventing enzyme inactivation caused by high temperatures. Gizzard is a noval colloidal mill in which the feed is ground into particles smaller than 2 microns, giving thereby an enhanced surface area for microbial processing. They have an in house supply of enzymes such as protease. Lipase, amylase, cellulase and chitinase, which bio-degrade complex biomolecules into simple compoun ds utilizable by the symbiotic gut microflora. Earthworms have a built in oxygen plant which can separate aerial oxygen by chemical absorbotion into blood haemoglobin. They promote growth of microorganisms in their proportion gut by providing favourable conditions. Casting contain nutrients in a balanced proportion and are rich in vitamins, enzymes, antibiotics and growth hormones.

Composting of agricultural and industrial wastes
Composting is a process by which organic wastes are converted into organic fertilizers by means of biological activity under controlled. Composting is defined as a method of solid wastes management whereby the organic component of the solid wastes stream is biologically decomposed under controlled conditions to a state in which it can be handled, stored and applied to the land without adversely affecting the environment. It is an important technique for recycling organic wastes and for improving the quality and quantity of organic fertilizers. The objectives in composting are to stabilize the putrescibe organic matter in raw agricultural / industrial wastes to reduce offensive odours, to kill weed seeds and pathogenic organisms and finally to produce a uniform, slow release organic fertilizer.
which stimulates soil life; improves soil life; improves soil structure; helps plants to tolerate/resist pests and diseases.

**Agricultural wastes**
The major agricultural sources are livestock and human wastes, crop residues, tree wastes and aquatic weeds, green manures, urban and rural wastes, agro-industrial by products, marine wastes and tank silt.

**Industrial wastes**
Industrial wastes are those which come out as wastes from industries and factories, commonly known as effluents. These wastes contain considerable quantity of organic matter and nutrients in addition to non-compostible materials. The quantity of wastes available depends on the size of industries/factories. The sources of industrial and factories are given below: Textile industry, paper factories, cordite and ammunition factories, fertilizer plants, sugar factories and distilleries, food processing units, coir industry, tanneries, lignite and coal mines, petroleum industry, cosmetic factories, mushroom centres, chemical plants, electronic industries, photofilm industries, tinning plants, foundries, electroplating centres, cement factories, dyeing factories, automobile works, sago industry, heavy metal/electrical plants. The above list of available industrial wastes gives a good picture it is not exhaustive. Among the different industrial and factory wastes, tannery effluent causes serious hazards and environmental problems by affecting streams, fresh water bodies, ground water and agricultural lands.

**Weeds management in organic farming**
These methods are less expensive and less dangerous to neighbouring crops and orchards. As the long term and indirect efforts of weed control due to implementation of systematic changes become apparent, less intensive control is required. These practices are tillage, tillage combined with irrigation, timing of tillage, seeding rates and cultivar selection, cropping systems, use of animals, flooding, mulching, fire, composting, hoing and hand weeding, farmers care and straw disposal.

**Biological control of weeds (mycoherbicides)**
Fungal pathogens are considered to be the only group of microorganisms with potential for the classical biological control of weeds. These agents of living products control specific weeds in agriculture as effectively they could continue to survive on the weeds years after year over long period to be applied season after season. Mycorhygae are culturable in artificial media. It is cabale of abundant spore production. It is sable in storage, effective under field conditions, tolerant to variations in temperature and compatible with other chemicals/cultural practices.

**Pest management methods**
Pest management methods can be categorised as biological cultural and organically accepted chemical alteratives, with further subdivisions.

**Biological alteranatives**
Biological control by multicellular organisms including release of exotic parasites and predators, conservation and augmentation of natural enemies, genetic improvement and allelopathy. Biological control by microbial agents application of beneficial or antagonistics microorganisms or toxic synthesized by microbes. Management practices, including natural mulches, living mulches, trap crops and cover to enhance the population of natural enemies.

**Organically acceptable chemical alteratives**
Oils and soaps-some horticultural oils and various fatty acids. Botanical-toxins derived from plants such as pyretherum and ryania. Semio-chemicals- pheromones, allomones and kairomones includings ex attractants, feeding attractants and repellents produced by insects and affecting the behaviour of
other insects. Inorganic or elemental compounds such as elemental sulphur and some copper formulations.

**Cultural alternatives**
Crop rotation-rotation of crops and fallow periods. Physical controls-such as tillage, mowing, chopping and flaming. Sanitation-removing non-crop hosts and infected hosts. Pruning and canopy management-physically manipulating the structure of the host plant.

**Crop residue management**
Residues are that part of the substance that remain after its initial usage as in the case of nutrients as well as unutilized byproducts of crop cultivation with beneficial/harmful effects on subsequent cropping. Crop residues are defined as the non-economic plant parts that are left in the field after harvest and remains that are generated from packing sheds or that are discarded during crop processing.

**Organic plant breeding**
Organic plant breeding is still a small sector and the varieties used in organic farming are mainly derived from conventional plant breeding. This means, many varieties used in organic farming are quite old. Many “modern: varieties used in organic are selected under mainstream conditions using seed treatment, herbicides and mineral fertilizers, but the organic sector needs varieties bred for low input farming, adapted to local conditions and often aims for specific food qualities. Organic plant breeding often goes hand in hand with the conservation of traditional and local varieties-which is an important activity to keep a broad range of genetic resources alive. But conservation must not be confused with organic breeding, which is essential to provide organic farmers with modern varieties suited to serve the present organic food sector.

- The roots of authentic taste- a factsheet for consumers.
- Make your customers taste the difference- a factsheet for food chain operators.

Organic farming starts with breeding organic plant breeding is defined by the IFOAM standard, “Breeding of organic varieties and bears a high potential to provide farms with varieties perfectly adapted to organic farming. Organic plant breeding contributes to the organic farming goals such as the work in accordance with biological systems and to have a positive impact on biodiversity- as organic breeders work with a broader genetic base than conventional breeders.

**Keeping organic GMO free starts with the seed**
Organic farmers do not use genetically modified organisms (GMO). To keep GMO out of our food chain, seed plays a major role. New challenges come up with new gene technologies such as CRISPR-Cas and Talen.

**References**
Integrated Farming System: The Future of Agriculture


ORGANIC FARMING: THE FUTURE OF AGRICULTURE

Bhagwat Saran\textsuperscript{1}, Anil Kumar\textsuperscript{1}, Shreya Nivesh\textsuperscript{1} and Bhaskar Pratap Singh\textsuperscript{2}

\textsuperscript{1}Department of Soil and Water Conservation Engineering, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar-263145, (Uttarakhand), India
\textsuperscript{2}Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi -221005, (UP), India
Corresponding author email: saran.bhagwat007@gmail.com

Abstract

Organic farming is a farming which helps to cultivating the land without using toxic material and raising crops in a manner, as the soil alive and virtuous by use of different type of wastes (crop residue, animal wastages and farm wastes etc.) and many other biological materials with beneficial microbes to provide nutrients to crops for organic production with eco-friendly environment.

Indian economy is one of the rising economies amongst the emerging nations in the world. Agriculture contributes significantly role in the economy of any country and is an imperative source of raw material as well as demand for many industries. In 1965-66 the Green Revolution has been the backbone of Indian agricultural success and renovated the country from the stage of food shortage to self-dependent by using of high yield varieties with increased the used of fertilizers, pesticides and weedicide. Undifferentiating and extreme use of chemicals or fertilizers for crop grown has put forth a interrogation on sustainability of agriculture. To accomplish and address social, ecological in addition to economic issues together, organic agriculture plays a vital role. FAO recommended that organic farming is a healthy production management system of the crops which endorses and improves agro-ecosystem health, together with bio-diversity, improve soil health, soil fertility and biological activity, it is accomplished by using on-farm agronomic, biological, mechanical and other important approaches in omission of all synthetic off-farm inputs.

Concepts of organic farming

It is based on some important principles like: Natural conditions are the best role model for organic agriculture; it does not need any inputs not any demands. Overall system of this farming is based on closely related to the nature traditions. This farming system does not believed in losses of the soil nutrients and also do not degraded it in any circumferences. In this system the role of soil is a living entity, in soil living populations of different microbes and organisms the soil provide a natural conditions for living them. USDA study team of organic farming state that, organic farming is a eco-friendly cropping system which avoids excessive use of fertilizers and pesticides and mainly focus on the crop rotations, crop residues, animal manures and farm wastages.

Status of organic farming

In India lot of potential to produce all crop varieties of organic products due to its favourable agro-climatic zones. As per the available data, the position of India in terms of World’s Organic Agricultural land was 9th and was 1\textsuperscript{st} in terms of overall producers (FIBL & IFOAM Year Book 2018). In 2001, the Government of India has been announced the National Programme for Organic Production (NPOP). The programme takes in the endorsement for certification bodies, standards for organic products, advancement of organic farming etc. The NPOP standards for production and accreditation have been recognized by the European Commission and Switzerland for raw goods as
equal to their nation standards. All Indian organic products certified by the accredited certification bodies of India are accepted by the other importing countries.

Area of organic farming

India has been increased to 0.51 M ha and 5.18 M ha respectively in 2013 from 0.186 M ha organic area in 2005 and wild collection area was 2.386 M ha in 2005. In India about 528171 ha area is under organic agriculture with 44926 number of certified organic farms (P. Ramesh et al 2010). As on March 31st 2018, the total area under organic agriculture (registered under the National Programme for Organic Production) is 3.56 M ha (2017-18). This area includes 1.78 M ha about 50% of cultivable area and other remaining 1.78 M ha 50% of wild area. In India Madhya Pradesh has been covered highest area under organic agriculture followed by Rajasthan, Maharashtra and Uttar Pradesh. During 2016; Sikkim has achieved a remarkable distinction of converting its whole cultivable land (>76000 ha) under organic agriculture.

Production of organic products

India produced about 1.70 MT (2017-18) of certified organic products which consist of all varieties of foods viz. oilseeds, sugarcane, cereals and millets, cotton, pulses, medicinal plants, tea, fruits, spices, dry fruits, vegetables, coffee etc. The organic production is not restricted only the edible part but also produces organic cotton, fibre, food products and other similar products. In terms of export of organic products; Oilseeds (47.6%) lead among the products followed by Cereals and millets (10.4%), Plantation crop products like Tea and Coffee (8.96%), Dry fruits (8.88%), Spices (7.76%) and others. In India the total export of organic products during 2017-18 was 4.58 lakh MT. The organic products export was around INR 3453.48 crore (515.44 million USD). From India the organic products are exported to many countries of the Worlds like: United State America, European Union, Canada, Switzerland, Australia, Israel, South Korea, Vietnam, New Zealand, Japan etc.

Table 1. State wise area (excluding Forest Area) under Organic agriculture during (2013-14).

<table>
<thead>
<tr>
<th>State Name</th>
<th>Area (in Ha)</th>
<th>Jammu &amp; Kashmir</th>
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<th>Lakshadweep</th>
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**Integated Farming System: The Future of Agriculture**

<table>
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<tr>
<th>State</th>
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<td>Total</td>
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Source: APEDA (2013-14)

Government is inspiring organic agriculture under various schemes namely National Mission for Sustainable Agriculture (NMSA), Paramapragat Krishi Vikas Yojana (PKVY), Mission for Integrated Development of Horticulture (MIDH), Network Project on Organic Agriculture of ICAR, National Mission on Oilseeds and Oil Palm (NMOOP), Rashtriya Krishi Vikas Yojana (RKVY). Under the umbrella of Paramapragat Krishi Vikas Yojana (PKVY), fifty or more farmers will make a cluster having 50-acre land to take up the organic farming under the system. In India every farmer will be provided Rs.20,000 /acre in three years for seed to harvesting of crops and also to transport products to the market. In order to implement the Paramparagat Krishi Vikas Yojana (PKVY) in the year 2015-16, an amount of Rs.300 crore has been assigned by the government of India.

**Organic agriculture overall the world**

The provinces with the highest areas of organic farming managed agricultural land are Oceania (12.1 M ha), Europe (8.2 M ha) and Latin America (8.1 M ha). The countries with the highest organic agriculture land are Australia, Argentina and China. The maximum portions of organic farming managed agriculture land are in the Falkland Islands (36.9 %), Liechtenstein (29.8 %) and Austria (15.9 %). In whole world with the largest number of producers are India, Uganda and Mexico. When consider whole world, more than one third of organic producers are in Africa. In the whole world most of the countries, the organic agricultural land area is increased day by day. More than one-third of the world organically managed agricultural land is located in developing countries; this land is in Latin America, with Asia and Africa in second and third place. Practically two-thirds of the overall agricultural land is comes under organic management is grassland (22 M ha). The arable land and permanent crops covers about 8.2 M ha. About 50.9 M ha of agricultural land are organic (including conversion areas). 11 countries of the world cover about 10 % or more of the farmland is organic.

**Advantages of Organic Farming**

Organic agricultural observes a maximum harmonious relationship with natural farming aiming the not effected of the environment. Today’s there are more and more advantages of organic farming some of them discussed here;

**Improved Soil Quality**

Multiple cropping and crop rotation, organic manures, and minimum tillage these are the most important approaches to improve the soil quality. The improving of soil quality is also maintained our environment.

**Increased Crop Productivity and Income**

The expense of development of yields was lesser in the natural farming than in the advanced farming. The low costs were expected to the non-utilization of chemicals and fertilizers.
Low Incidence of Pests

Bio-control approaches like the neem-based pesticides to Tri-choderma are accessible in the nation. Indigenous innovative items, for example, Panchagavya which was tested at the University of Agricultural Sciences, Bangalore found to control successfully wither illness in tomato.

Employment Opportunities

According to many studies, organic agriculture involves more labour input than the conventional agriculture system. Thus, India which has a very large quantity of labour unemployment and under employment will find organic agriculture an attraction. Moreover, the problem of periodical unemployment will also get alleviated because of the diversification of the crops with their different planting and harvesting schedules resulting in the requirement of a relatively high labour input.

Organic Agriculture Discourages Environmental Exposure to Pesticides and Chemicals

Pesticides and Chemicals and synthetic concoctions splashed on plants pollute the dirt, water supply, and air. At times these harmful pesticides stick around for quite a long time. The Organic Trade Association takes note of that if each agriculturist in the U.S. changed over to natural generation, we could kill 500 million pounds of unsafe pesticides from entering the earth every year.

Organic farming Builds Healthy Soil

A 9 years study of USDA: Agricultural Research Service (ARS) shows that the organic farming builds up healthy soil and organic soil matter better than conventional farming. According to scientist Elaine Ingham ”just one teaspoon of compost-rich organic soil host as 600 million to 1 billion bacteria from more than 15,000 species.

Organic Agriculture Helps Combat Erosion

Natural horticulture helps battle genuine soil and land issues, for example, soil erosion. A major study comparing organic and chemically treated wheat fields showed that the organic field featured eight more inches of topsoil than the chemically treated field and also had only one-third the erosion loss. Organic agriculture practices do help discourage erosion from occurring.

Organic Agriculture Fights the Effects of Global Warming

Rodale Institute Agriculture Systems Trial is America's longest running, one next to the other correlation of customary and natural farming. The preliminary, running since 1981, has demonstrated that a sound natural horticulture framework can really diminish carbon dioxide and help moderate environmental change.

Organic Agriculture Supports Water Conservation and Water Health

Wellbeing American Rivers takes note of that a noteworthy water contamination danger to U.S Rivers is spill over from non-natural ranches, for example, unsafe pesticides, harmful fertilizers. Natural farming helps keep our water supplies clean by ceasing that dirtied overflow. Organic agriculture also helps conserve water. Organic farmers, in general, tend to spend time amending soil correctly and using mulch - both of which help conserve water.
Organic Agriculture Supports Animal Health and Welfare

Insects and birds, fishes all of other experience problems when humans destroy their natural habitat. Organic farming not only helps in preserving natural habitat areas but also encourages birds and other natural predators to live happy on farmland. Additionally, animals that live on organic farms are exposed to clean, chemical-free grazing that helps keep them naturally healthy and resistant to illness.

Organic Agriculture Encourages Biodiversity

In most of the cases more biodiversity is on agriculture farm, the more stable farm of Organic farming. Agriculture boost healthy biodiversity which plays a important role in how buoyant, or not, a farm is to problems like bad weather, disease, and pests. Moreover, reduced biodiversity may directly associate with a rise in infectious diseases, which of course, isn't good for people or the earth planet.

Challenges in organic agriculture

For organic agriculture a main challenge at the moment is undoubtedly its entry into the strategy making arena, its pass into anonymous universal market and the conversion of organic products into commodities. During the last two decades, there has also been a noteworthy sensitization of the global community in the direction of environmental conservation and guaranteeing of food excellence. Passionate promoters of organic agriculture deliberate that it can meet both these demands and turn out to be the mean for complete development of rural areas. After almost a huge time span of progress, organic agriculture is now being incorporated by the mainstream and displays great potential commercially, communally and environmentally. While there is continuum of thought from earlier days to the present-day, the current organic program is fundamentally different from its original form. It now has environmental sustainability at its principal in addition to the founders concerns for healthy soil, healthy food and fit people.

References


VITAL ROLE OF NITRIC OXIDE IN HUMANS AND THEIR NATURAL SOURCES

Manne Hemanthkumar and Yenkokpam Supriya

Department of Biochemistry and Agricultural chemistry, Assam Agricultural University, Jorhat.

Corresponding author email: hemanthyah72@gmail.com

ABSTRACT

Nitric oxide is a biologically active compound that is considered as a universal messenger, which can communicate between cell-cell throughout all the body. It is synthesized by a family of Nitric oxide synthase enzymes from L-Arginine / L-citrulline. Nitric oxide maintains the blood pressure by dilating the blood vessels, helps to kill foreign invaders as an immune response, acts as a blood thinning medication and it is also a major biochemical component of long lasting memory. It is having a role in decreasing the plaque growth and blood clotting. Nitric oxide has strong cancer fighting properties and anti-inflammatory function.

In atmosphere nitric oxide is a noxious chemical, but small controlled doses does the extraordinary benefits to the human body. In mammals, including humans, nitric oxide (the Molecule of the year 1992) is a signalling molecule in many physiological and pathological processes. In the year 1998 Nobel prize was awarded in the field of Physiology or Medicine for discovering nitric oxide’s role as a cardiovascular signalling molecule, it was reported that nitric oxide synthase (NOS) enzyme catalyze a complex reaction leading to nitric oxide formation from the substrates of L-arginine and molecular oxygen, which is a NOS dependent pathway. Soon, after discovery of an alternative NOS-independent pathway of NO synthesis, just based on simple reduction of nitrate & nitrite, the main oxidation products of NO. This interest led a revolution in pharmacological and physiological research. L-arginine is an essential/semi-essential amino acid, the immediate precursor of NO, an important secondary messenger, as well as an intercellular messenger which regulates vasodilation. Additionally, it has been suggested that L-citrulline could be a donor of NO, due to the fact that it can increases the levels of L-arginine.

Functions of Nitric Oxide

Neurotransmitters are endogenous chemicals that communicate information between our brain and our entire body. Nitric oxide serves as a neurotransmitters between two neurons/nerve cells. An increased content of NO in our body leads to improved sleep quality. Blood flow is very important in our body because our muscles & tissues need to receive healthy supply of oxygen & nutrition through blood circulation. Nitric oxide increases the blood flow by widening the inner muscles of the blood vessels (vasodilation). Nitric oxide reduces the platelet stickiness thus, it eliminates the clotting of blood. Nitric oxide decreases the release of super oxide dismutase radicals, which in over release causes the destruction of the own cell itself. A decreased multiplication of smooth cells of the artery wall have been reported by the increased content of the nitric oxide in the body. Arginine and its product nitric oxide plays an important role in cancer as both are important mediators in the immune function and defense against the tumor cells. The additional supplement of Nitric oxide to the human body helps in the muscular building. Nitric oxide lowers the blood pressure. L-citrulline is an amino acid that may help treat erectile dysfunction by increasing the production of nitric oxide.
Natural ways to increase the nitric oxide

Increase your intake of antioxidants

The antioxidant vitamin C helps your body to form connective tissues, including skin, bones, tendons & cartilage. It also produces brain chemicals that help nerve cells to communicate with each other and to transfer the chemical information. Vitamin E protects cells from damaging effects of the free radicals, which thought to contribute to aging & disease. Glutathione, the mother of all the antioxidant, act as detoxifier of every cell in our body. Antioxidants help to decrease the breakdown and extend the life of nitric oxide in our body.

Eat vegetables high in nitrate content.

Beet: This red root vegetable has been praised from long time for its ability to almost immediately lower blood pressure upon ingestion. This is due to high nitrate concentration. Studies, shows that nitrates has a relaxant effect on the veins and coronary vessels, enabling them to enlarge and allow more oxygen-rich blood to flow.

Spinach: Nitric oxide in the spinach is rich for massive muscle forearms. If you are interested in NO mainly for its muscle building benefits, then you are far benefited to use spinach i.e., high in the testosterone activating mineral magnesium.

Garlic: This herb is so beneficial that it’s worth having a few minutes of bad breath. It supports the synthesis of NOS. NOS by itself doesn’t do much. NOS is able to convert arginine to NO by vitamin B2 as factor. Garlic is also high in the sulfuric compound allicin. Studies shows allicin reduces inflammation and also avoid the risk of coronary disease.

Watermelon: L-arginine is perhaps the most famous amino acid associates with having a vasodilation effect. While watermelon doesn’t contain arginine, it is high in the amino acid L-citrulline, which is converted into arginine under the right conditions.

Citric fruits: Vitamin C is precursor for NOS synthesis. Vitamin C is also an antioxidant known to fight harmful free radicals.

Pomegranate: Crimson red pomegranate is one of the high nitric oxide containing food. Its high polyphenol content helps to convert dietary nitrite into nitric oxide and also prevents NO from turning black into nitrite. The polyphenol also fight oxidative stress, there by significantly lowering risk of heart disease. This fruit is especially high in a protein called monocyte chemoattractant, which helps to strengthen the blood vessel lining.

Rhubarb: It is a stem vegetable, where only the stem part is edible and consumption of leaves are really toxic because due to the presence of high levels of oxalic acid. The rhizomes of rhubarb contains stilbenoid compounds, which seem to lower the blood glucose levels in the diabetic mices.

Spirulina: Spirulina has powerful antioxidants and anti-inflammatory properties. Oxidative damage can harm our DNA and cells. This damage can drive chronic inflammation, which contributes to cancer. Spirulina is a good source of antioxidants which can protect against the oxidative damage. The main active compound is called phycocyanin. This antioxidant substance also gives spirulina its unique blue-green color. Phycocyanin can fight free radicals and inhibit production of inflammatory signalling molecules.
These are the natural availability of sources of nitric oxide to our body. However, other supplements, like pycnogenol, have also been shown the increased nitric oxide levels.

**Bottom line:** The regular intake of nitric oxide results in good and healthy life, in severe conditions like cardiac arrest the high dosage of nitric oxide is given for immediate recovery.

**References**


Crop production requires management of physical environment to produce necessary favorable condition from plant growth. Tillage operations in various forms have been practiced from the very inception of growing plants. Hence tillage practice is as old as agriculture. Primitive man used tools to disturb the soils for placing the seeds. Jethro Tull is considered as father of tillage. He has written a book on tillage titled “Horse hoeing husbandry”. He proposed that ploughing and other tillage operations were necessary for making soil into fine particles.

Tillage is the physical manipulation of soil with tools and implement for obtaining conditions ideal for seed germination, seedling establishment and growth. Tilth is the physical condition of soil resulting from tillage.

**Characteristics of Ideal Tilth**

Tilth indicates two properties of soil i.e., the size distribution of aggregates and mellowness or friability of soil. Size distribution of soil aggregates refers to the relative proportion of different sized soil aggregate. For irrigated agriculture ideal tilth of soil should have higher per cent of larger soil aggregates (75 mm in diameter) so as to have good drainage while for dryland and rainfed agriculture ideal tilth should consist of higher per cent of smaller soil aggregates (1-2 mm in diameter) for conservation of rain water. The size distribution of aggregates depends on soil type. Soil moisture content at the time of tillage operation and subsequent cultivation. Mellowness or friability is that property of soil by which the clods when dry become more crumbly. Soil with ideal tilth is quite porous and has free drainage. The capillary and non-capillary pores should be the equal proportion so that sufficient amount of water is retained in the soil as well as free air.

**Objectives of Tillage**

The main objective of tillage are To prepare a good seed bed which helps the germination of seeds. To create conditions in the soil suited for better growth of crops. To conserve the soil and moisture through higher infiltration, reduced runoff and increased depth of soil for moisture storage. To control the weeds effectively, which is the important object of tillage. To improve soil aeration. To break hard pans and compact layers so as increase depth of root penetration. To incorporate crop residues and farmyard manure into soil by inversion action of tillage. To reduce the pest attack on the succeeding crop by removing stubbies of previous crop and by exposing the dormant pupoe to sun heat or to brids during tillage.

**Types of Tillage**

Tillage operations are grouped into two types based on the time at which they are carried out
1) on Season tillage  2) off Season tillage

**On season tillage**

Tillage operations which are carried out for raising crops in the same season or at the onset of the crop season are known as on season tillage. They are of two types a) Preparatory tillage and b) inter tillage

**Preparatory tillage**

Tillage operations which are carried out from the time of harvest of a crop to the sowing of the next crop are known as preparatory tillage. Term preparatory tillage/cultivation and seedbed preparation are
Integrated Farming System: The Future of Agriculture

used synonymously. Preparatory cultivation consist of three operations viz; primary tillage, secondary tillage and layout of seedbed.

Primary tillage
Tillage operations that is done after harvest of crop to bring the land under cultivation is known as primary tillage. Ploughing is a primary tillage operation done for opening of the compacted soil with the help of ploughs.

Optimum time for ploughing
Correct time for ploughing depends on soil moisture. When soil is dry it is difficult to open the soil, more energy is used and results in large sized clods when soil is ploughed under wet conditions, the soil stick to plough, the soil below the plough becomes compact and on drying becomes hard pan, soil structure is destroyed and the colds on drying becomes very hard. The optimum range of soil moisture for effective ploughing is 25 to 50 per cent depletion of available soil moisture.

Depth of ploughing
Depth of ploughing depends on the effective root zone depth of the crops. Crops of long duration with tap root system requires greater depth of ploughing and shallow rooted crop required shallow ploughing. Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad classified ploughing of 5-6 cm depth as shallow, 15-20 cm depth as medium deep and 25-30 cm depth as deep ploughing.

Number of ploughing
Number of ploughing depends on soil conditions, time available for cultivation between two crops, type of cropping system when weed growth and plant residues are higher, more number of ploughings are required.

Secondary tillage
Tillage operations that are performed on the soil after primary tillage to bring a goal soil tilth are known as secondary tillage. Lighter and finer operations. Operations which is done to clean the soil break the clods and incorporate the manures and fertilizers. Disc narrows, cultivators, blade narrows etc. are used for secondary tillage operation. Sowing operations are included in secondary tillage.

Layout of seed bed
After the seedbed preparation, the field is laid out properly for irrigation and sowing or planting seedings. These operations are crop specific

Inter tillage/After tillage
The tillage operations that are done in the standing crop after the sowing or planting and prior to the harvesting of the crop plants are called as after tillage. It is also known as inter tillage or inter cultivation or post seeding planting cultivation. It includes hoeing, weeding, earthing up, drilling or sied dressing of fertilizer etc.

Off-season tillage
Tillage operations done for conditioning the soil suitably for the forthcoming main season crop is called as off season tillage. Off season tillage may be.

a. Post harvest tillage  
b. Summer tillage  
c. Winter tillage  
d. Fallow tillage

Special Purpose Tillage
Tillage operations intended to serve special purposes are soil to be special purpose tillage such special purpose tillage are of following types.

Sub Soiling
To break the hard pan below the plough layer a special tillage operations are performed to reduce the compaction. When a hard pan is to break just below plough layer subsoil plough is used but when deep hard pan need to be break at 60-70 cm depth than chisel plough is used.
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Advantages of sub soiling
Greater volume of soil may be obtained for cultivation of crops. Excess water percolate downward. Reduce runoff and soil erosion. Roots of plants can penetrate deeper to extract moisture from the water table.

Clean tillage
It is the working of soil of entire filed in such a way that no living plant is left undisturbed. It is practiced to control weeds, soil borne pathogen and pests.

Blind tillage
It is the tillage operation done after sowing or planting of crop but before the emergence of crop or while they are in the early stage of growth so that crop plants do not get damaged but extra plants and broad leaved weeds are uprooted.

Wet tillage or puddling
Tillage operations that are done in a land with standing water is called wet tillage or puddling. Puddling is the repeated ploughing of land in a standing water until the soil becomes soft and muddy. Puddling creates an impervious layer below the surface to reduce deep percolation losses of water and to provide soft seedbed for planting of rice.

Mouldboard plough
This plough leaves no unploughed land as the furrow slices are cut clean and inverted to one side resulting in better pulverization. Animal drawn mouldboard plough is small and plough to a depth of 15 cm while tractor drawn mouldboard plough is big in size and two mouldboard ploughs are attached to a tractor and plough upto depth of 25 to 30 cm.

Disc plough
Disc plough has a large, revolving, concave steel disc, which is of 60 cm in diameter and turn 35 to 30 cm furrow slice. Disc plough is used in a land where spreading type weed infestation is more as disc cut and incorporate weed into soil no narrowing is necessary in a field after disc ploughing.

Secondary Tillage Implements
Different types of implement’s like cultivators, narrow and plank are used for secondary tillage.

Tractor Drawn Cultivator
Cultivator is also known as tiller or tooth narrow. It is used to further loosen the previously ploughed land before sowing. It also destroy weeds that germinate after ploughing.

Sweep Cultivator
Sweep cultivator is used in stubble-mulch farming. It consist of large inverted ‘V’ shaved blades attached to a cultivator frame. They are arranged in two rows and staggered. It runs parallel to surface at a depth of 10 to 15 cm it.

Harrors
They are used for shallow cultivation like seedbed preparation, covering seeds and destroying weed seedlings. They are of two types disc and blade harrows.

Disc harrows
It has number of concave discs of 45 to 55 cm diameter fitted 15 cm apart on axles. They cut through soil and effectively pulverize the clods.

Blade harrow
They are used for removal of weeds and stubbles, crushing of clods, working of soil to shallow depth, covering of the seeds, inter cultivation and harvesting of groundnut.

Plank
It is a heavy wooden beam of 2m in length. It is used for clod crushing and micro-levelling and compaction necessary after sowing.

Implements for Layout of Seedbed
For making ridges and furrow or to layout irrigation channels, country plough and ridge plough are used. Bund farmer is used to make bunds. It consist of a pair of iron mouldboards fixed in opposite direction facing each other.
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**Implements for Sowing**
Country plough, seed drill and ferti-cum-seed drill are used for sowing operations.

**Plough**
Seeds are dropped by hand in the furrow formed by country plough but seeds falls at uneven depth. To avoid this a hallow bamboo tube which is sharpened at one end and with wide hopper at anther end. It is tied to country plough with help of rope and seeds dropped in hopper. It is variously called as saratha, pora, kera, akkachi etc.

**Seed drill**
It consist of a wooden bean with 3 to 6 tynes attached to it. Tynes the furrow into which seeds are dropped. Holes are made into tynes to which seed tubes are attached which are connected to a seed hopper.

**Ferti-cum-seed drill**
It is used for seed drilling and fertilizer application at a time. It is similar to seed drill with extra tynes and hopper for drilling fertilizers.

**Implements for intercultivation**

**Modern Concept of Tillage**
Conventional tillage involves opening of soil with plough followed by secondary tillage operation for making seedbed for sowing or planting. In this process energy is often wasted and sometimes, soil structure is destroyed. The important object of tillage is weed control and with the introduction of herbicides the concept of tillage is changed. The need of planting zone or row zone and inter-row zone is different.

Fine tilth in row zone for easy sowing and conducive to rapid and complete germination and seedling establishment is necessary. While inter-row zone should be rough and cloddy with coarse and open structure so that weeds do not germinate and more water infiltrate into soil. Rather incorporating the crop residues it should be left over surface as stubble mulch prevent evaporation and erosion losses. All these reasons led to development of modern concept in tillage like minimum tillage, zero tillage and stubble mulch farming.

**Minimum tillage**
Minimum tillage aims at reducing tillage operations to the minimum necessary for making a good seed bed. It can be done in two ways by omitting operations which do not give much benefit when compared to cost and by combining agricultural operations like seeding and fertilizer application advantages of minimum tillage over conventional tillage are:

1. Soil compaction is less
2. Less resistance to root growth due to improved structure
3. Soil structure is not destroyed
4. Improved soil conditions due to decomposition of plant residues in field
5. Higher infiltration and water storage
6. Less soil erosion compared to conventional tillage but these advantage are observed after two to three years of practicing minimum tillage.

Disadvantages of minimum tillage are

1. Seed germination is lower with minimum tillage
2. More nitrogen has to be added as rate of decomposition of organic matter is slow
3. In leguminous crops like peas and broadbean nodulation is affect
4. Sowing operation is difficult with ordinary equipment
5. Continuous use of herbicide causes pollution problem

Minimum tillage can be practised by following methods.

**Row zone tillage**
Mould board plough is used for primary tillage and secondary tillage operations like discing and harrowing is done only in row zone.
Plough plant tillage
Primary tillage is done. After that a special planter is used and in one run over the field row zone is pulverized and seeds are sown.

Wheat track planting
Primary tillage is done as usual. Tractor is used for sowing and the weeds of the tractor pulverize the row zone. In all these systems, primary tillage is done as usual and secondary tillage is reduced/replaced by direct sowing in which seed is covered in the row zone the equipment used for sowing.

Zero tillage (No tillage)
It is an extreme form of minimum tillage. In minimum tillage, primary tillage operation is done as usual but in zero tillage it is completely avoided and secondary tillage is restricted to row zone only. It is also known as no tillage or no till. It is followed in ears where problems due to wind and water erosion are high along with high energy and labour requirement zero tillage can be followed where soil is coarse texture, having good drainage along with biological activity of soil fauna and adequate crop residue as mulch. Zero tillage can be practiced by Till Planting. A special machine is used which perform four task in one operation. It clean harrow strip over the crop row, open the soil for seed insertion, place the seed and cover the seed properly. In zero tillage herbicides are used extensively. Mostly broad spectrum and non-selective herbicides are used like Paraquat and Diquat to destroy vegetation.

Advantages of zero tillage
1. Zero tilled soils are homogenous in structure with more number of earthworm.
2. Organic matter content increase due to less mineralization.
3. Surface runoff is reduced due to presence of mulch.

Disadvantages
1. Higher amount of nitrogen has to be applied for mineralization of organic matter in zero tillage.
2. There may be a problems of perennial weeds.
3. High number of volunteer plants and build up to pests.
4. More dependence on herbicides to control weeds may cause soil pollution.
5. Seedling establishment is 20 per cent less than in conventional tillage methods.

Stubble mulch tillage
It is a new approach in which soil is protected all the times either by growing a crop or by crop residues left on the surface during fallow periods. It is also known as stubble mulch farming soil is tilled to control weeds during the interval between two crops. Sweeps or blade are generally used to cut the soil upto 12 to 15 cm depth and for subsequent operations depth is reduced. Disc type of implements are used when amount of residue is large. Two methods are followed for sowing in stubble mulch tillage.

1. Similar to zero tillage, a wide sweep and trash-1 are used to clear a strip and a narrow planter shoe opens a harrow furrow into which seeds are placed.
2. A narrow chisel of 5 to 10 cm width is worked through the soil at a depth of 15 to 30 cm leaving all plant residues on the surface. The chisel shatters tillage pans and surface crusts. Planting is done through residues with special planters.

Advantages
1. Due to mulch surface runoff is reduced.
2. Soil erosion due to water and wind is reduced.
3. Organic matter content of soil is more.
4. Soil is more homogenous.

Disadvantages
1. Residues left on the surface interfere with seed bed preparation and sowing operations.
2. Traditional tillage and sowing implements or equipment’s are not suitable under such conditions.
INCREASING NITROGEN USE EFFICIENCY THROUGH INDIGENOUS MATERIALS

Montrishna Rajkhowa¹ and Nitumoni Mahanta²*
¹Department of Soil Science ²Department of Agronomy, Assam Agricultural University, Jorhat, Assam 785013, India
Corresponding author email: Nitumon154@gmail.com

Abstract
Nitrogen (N) is a primary major nutrient, required in large quantity for crop growth and development. The type of nitrogenous fertilizer and rate of application are very important factors that determine the N-use efficiency of applied fertilizer. Due to higher solubility in water, the applied fertilizer nitrogen gets lost from the crop field through runoff, leaching, volatilization and denitrification. As a result the efficiency of N-fertilizers is very less and it adversely affects the environment. However, it is possible to improve the efficiency of N-fertilizers by using some external agents along with the N-fertilizers. Nitrification inhibition is the property by which some groups of locally available, indigenous materials can increase the N-use efficiency (NUE) and it can become the cost effective way for the Indian farmers to boost the crop productivity.

Fertilizer nitrogen is a key component to address food security and it is continuously playing a prominent role to consolidate the gains of Green Revolution in India. The improved agronomic practices and high-yielding crop varieties mainly contribute to food security in India. Among various agronomic practices for stabilizing and enhancing the performance of traditional as well as improved crop varieties, use of nitrogenous fertilizer has been the centre of attention and research in the country. With the continuous increasing demand for nitrogenous fertilizers to support its food production, agricultural scientists of India have been working constantly to improve the nitrogen use efficiency of the crops with minimal adverse affect on the environmental system. The applied fertilizer nitrogen easily gets lost from the soil through different ways as the nitrogenous fertilizers are soluble in water. Moreover, application of organic manures to the agricultural systems is not adequate. As a result of these factors, the status of nitrogen in Indian soil is low i.e. 0.02 to 0.1% (Prasad, 2007). With the increasing demand of the ever growing population for more and more food, increasing and maintaining the food production through efficient use of chemical fertilizers, especially nitrogenous fertilizers has become the primary necessity.

Scenario of nitrogen use efficiency (NUE)
Efficiency of applied nitrogen is found to be very low. However it varies depending upon crop, season and area of cultivation. The nitrogen use efficiency (NUE) for different crops are given below

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Crop</th>
<th>NUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rice</td>
<td>In India, ranges from 20 to 50% (Prasad et al., 1998a) Globally, it ranges from 21 to 55% (Ladha et al., 2005)</td>
</tr>
<tr>
<td>2</td>
<td>Wheat</td>
<td>Less than 40% In India (Singh et al., 2007) Upto 33 % in India (Ladha et al.,2005).</td>
</tr>
<tr>
<td>3</td>
<td>Cereal crops</td>
<td>Ranges from 44 to 50% globally (Ladha et al.,2005).</td>
</tr>
<tr>
<td>4</td>
<td>Field crops</td>
<td>Ranges from 25 to 50% (Prasad, 2013)</td>
</tr>
</tbody>
</table>

From the above table, it is clear that more than half of applied fertilizer nitrogen gets lost from the soil and the crops can uptake a smaller amount of applied nitrogen for growth and yield.

Fate of applied fertilizer nitrogen in soil
In any agro-ecosystem, the movement of applied fertilizer nitrogen occurs through three principal routes:
(i) Crop removal
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(ii) N losses from soil-plant system through different mechanisms such as leaching, run-off, NH$_3$ volatilization, denitrification and loss from crop canopy and
(iii) N storage in soil mostly in organic forms as the highly reactive inorganic forms is easily lost from the soil.

Measures to improve efficiency of applied fertilizer
To improve the efficiency and minimize adverse environmental impacts of applied N fertilizers, following measures as suggested by Prasad (2007) can be adopted:
1. Reducing N losses from farm fields
2. Developing and using more efficient nitrogenous fertilizers (Such as slow-release N fertilizers, nitrification inhibitors and modified urea materials such as urea supergranules)
3. Adopting integrated nutrient management (INM) or supplying N through sources other than chemical fertilizers
4. Balanced fertilization and
5. Better agronomy of crops (Such as good crop husbandry, proper methods of N application i.e. placement, foliar application and proper time of N application based on proper physiological stages, using methods such as chlorophyll meter and leaf colour chart.)

Indigenous materials for increasing N-use efficiency
Indian agriculture is blessed with a rich diversity of traditional plant types and varieties, sources of nutrients, pest control measures, minerals and animals. Along with these traditional sources, utilization of their waste materials and products has great potential in improving the agricultural productivity. There are some indigenous materials that can effectively increase the N-use efficiency. Research has been conducted by Indian scientists on such indigenous materials and discovered some materials having nitrification-inhibitory property which can increase N-use efficiency of applied N-fertilizers. Different classes of indigenous materials for enhancing N-use efficiency are:
1. Neem and Pongamia products
Nitrification- inhibiting property of neem (Azadirachta indica) was first reported by Reddy and Prasad (1975) and later it was confirmed by several studies done across the country. Neem cake coated urea (NCU) soon became a popular source for increasing N-use efficiency of fertilizers in different crops. Government of India also allowed fertilizer firms to produce 100% neem coated urea to help farmers boost farm income. Another product ‘Karanjin’ from karanja (Pongamia glabra) has been tested as nitrification inhibitor (Sahrawat et al., 1974). But due to lack of extensive field experiments and suitable products for field application, farmers do not prefer this material.
2. Pyrites
Iron pyrite (FeS$_2$), commonly called as ‘fool’s gold’ has nitrification inhibitory properties and it was first reported by Blaise and Prasad (1993). It can also retard the volatilization of NH$_3$ from the fertilizer urea (Blaise et al., 1997). Mixing urea with pyrite and broadcast application lowers the potential for NH$_3$ loss through volatilization.
3. Essential oils and terpene compounds
Essential oils contain a number of terpenes, which possess antimicrobial properties (Patra et al., 2001). Due to this, it has a great role in nitrification inhibition and can be used for increasing N-use efficiency. The essential oils and their products and by-products extracted from some medicinal and aromatic plants can be used as coating on prilled urea for inhibition of nitrification of urea in soils and for increasing NUE.

Conclusion
To obtain higher productivity with the limited resources, increasing the efficiency of applied fertilizer, especially N-fertilizer is primarily important. With the discovery and availability of traditional and indigenous sources which can enhance the N-use efficiency (NUE) of applied N-fertilizers, the adverse affect of nitrogenous fertilizers on environment can be minimized. Among the indigenous sources, neem coating on urea has been successful all over India and it is widely used by farmers.
However, there is a need for extensive field evaluations of other indigenous and locally available sources for increasing the efficiency of fertilizer N in diverse crops or cropping systems and agro-climatic regions and their industrial upscaling.

References
CUSTOMIZED FERTILIZER: PROMISING TOOL FOR MANAGING MULTINUTRIENT DEFICIENCY

Natumoni Mahanta¹ and Montrishna Rajkhowa²
¹Department of Agronomy, ²Department of soil science, Assam Agricultural University, Jorhat, Assam 785013, India
Corresponding author email: Nitumon154@gmail.com

Abstract
For increasing the crop growth and productivity, NPK fertilizers are the prime focus in India. But with the heavy application of NPK fertilizers for extracting higher yield and minimal use of organic manures, occurrence of the problem of secondary and micronutrient deficiencies has been a common scene in the modern intensive agricultural systems. As a result of this, there is every possibility of development of negative balance in the intensive agricultural systems. Balanced fertilization through site specific nutrient management and customized fertilizer can play a very important role in achieving the higher yield goal of the modern agriculture. The development of crop and site specific customized fertilizers and appropriate application of these fertilizers may prove to be very effective to enhance nutrient use efficiency and hence crop productivity. In long run, such practice can arrest the decline in soil fertility and boost the crop yields.

The objective of nutrient use is to increase the overall performance of cropping systems by providing economically optimum nourishment to the crop and supporting agricultural system sustainability through contributions to soil fertility or other soil quality components (Mikkelsen et al., 2012). But due to different types of losses of nutrient elements, the nutrient use efficiency (NUE) is low in Indian agricultural systems. Hence, improving NUE has been listed among today’s most critical and daunting research issues (Thompson, 2012). The mobility of the nano-particles is very high which lead to transport of the nutrient to all parts of the plant (Torabian et al., 2017). Fertilizers encapsulated in nano-particles will also increase availability and uptake of nutrient to the crop plants (Tarafdar et al., 2012). The effectiveness of nano-fertilizers may surpass the most innovative polymer-coated conventional fertilizers due to a high surface area to volume ratio (Naderi and Danesh, 2013). Hence, the fertilizers prepared with nanotechnology i.e. nanofertilizers can be very helpful in increasing NUE and minimizing harmful environmental impacts.

In modern agriculture, fertilizer plays a crucial role in improving the crop growth and productivity. India is the second largest consumer of fertilizer in the world, next to China (Tiwari, 2010). But still the per hectare consumption of fertilizer is not adequate and mining of nutrients continues to take place from the soil at an alarming rate. Continuous use of high analysis fertilizers coupled with imbalanced and inadequate use of fertilizers has resulted in increasing deficiencies of secondary and micronutrients, which in turn limiting the response of crops to the applied NPK fertilizers. Despite of applying adequate quantity of NPK fertilizers, the crop yield remains low due to this deficiency of the micronutrients like Fe, Mn, B, Zn and Cu. Within the time frame of 1960 to 2005, multiple nutrient deficiencies in crops were reported for N, N+P, N+P+Fe, N+P+Fe+Zn, N+P+Fe+Zn+K, N+P+Zn+K+S, N+P+Zn+K+S+B and N+P+Zn+K+S+Mn+Mo. Multiple nutrient deficiencies are also emerging in swell-shrink soils for Zn + Fe, in alluvial soils of Indo-Gangetic plains for Zn+Mn or Zn + Fe + Mn or Zn + Fe, in highly calcareous soils of Bihar and Gujarat for Zn + B, in acid leached alfisols, red and lateritic soils of India for Zn + Fe + B and Zn + B (Singh and Bahera 2007). Therefore, there is a need to develop and use multinutrient mixtures that can facilitate the application of the wide range of plant nutrients in right proportion and suit the specific crop requirements in different growth stages.
Customized fertilizers are multi-nutrient carriers and can facilitate the application of the complete range of plant nutrients to suit the specific requirements of a crop during its stages of growth in right proportion. Customized fertilizers are ready to use granulated fertilizers, formulated on the principles of sound scientific plant nutrition. It is integrated with extensive laboratory studies, soil information and evaluated through field research.

**Features of customized fertilizers**

Increasing farmers’ income by achieving the goal of maximum economic yield of crops is the aim of promoting customized fertilizer. Main features of this unique customized fertilizer includes the following –

- Adjustment in the application of nitrogen, phosphorus and potassium fertilizer to the season and location specific needs to the crop.
- Site-specific application of secondary and micronutrients based on soil tests.
- To be effective, customized fertilizers should ensure adoption of all the components of integrated crop management viz. use of quality seeds, optimum plant population, good water management and integrated pest management.
- Promotion of customized fertilizers should provide guidelines for selection of the most economic combinations of nutrients.
- Promotion of customized fertilizers should also ensure recommendations for wise and optimal use of existing indigenous sources of nutrient such as manures and crop residues.

**Formulations of customized fertilizers**

The formulations for different customized fertilizers are prepared by using the most economical mixture of available ingredients. The minimum nutrient content should be 30 units by combining all nutrients. For basal application, the customized fertilizers should be granular with minimum 90 per cent of the material remains between 1-4 mm IS sieve. The material passing through sieve of size less than 1 mm IS sieve should not exceed 5 per cent and the moisture content should be less than 1.5 per cent. However for foliar application, the grades should be 100 per cent water soluble. There are about 36 commercial formulations of customized fertilizers approved by fertilizer control order of India. The formulations are denoted by individual levels of the primary, secondary and micro nutrients as-

- N:P:K:S:Zn:B
- N:P:K:Zn
- N:P:K:S:Mg:Zn:B:Fe
- N:P:K:S:Zn:B

Examples of formulations for customized fertilizer include 15:15:15:9:0.5:0.2 meant for groundnut in Anantapur and 20:0:15:0:0:0.2 meant for maize in Warangal districts of Andhra Pradesh.

**Procedures for customized fertilizer grades**

There are certain procedures that were used to arrive at soil and crop specific customized fertilizer grades (Jeevika, 2016). These are

- a. Geo referencing of chosen area.
- b. Selecting sampling points on appropriate statistical procedures.
- c. Actual sampling of the sites.
- d. Analyzing sampling of the sites.
- e. Analyzing soil, plant and water samples for nutrient status and some other characteristics.
- f. Defining management zones and yield targeting in major management zones.
- g. Computing crop removal of nutrients.
- h. Calculating the amount and ratio of required nutrients.
- i. Blending of nutrients based on the generated information.
Advantages of customized fertilizers
Customized fertilizers supply plant nutrients in adequate amount and in proper proportion. It is less influenced by soil, plant and climatic conditions that lead to less loss and more uptake of nutrients. Apart from primary nutrients, it also supplies secondary and micronutrients. It reduces the cost of fertilizer application that lead to reduced cost of cultivation. Customized fertilizer is a major component of precision agriculture and site specific nutrient management and thus it promotes maximum fertilizer use efficiency of the applied nutrients. By developing crop and site specific fertilizers, the soil health can be improved.

The smart Fertilizers: Nanofertilizers for increasing nutrient use efficiency
Nanotechnology can be one of the most powerful tools for improving the plant production in modern agriculture and is estimated to become a driving economic force in the near future. Nanotechnology have greater role in crop production with environmental safety, ecological sustainability and economic stability. The nano-particles produced with the help of nanotechnology can be exploited in the value chain of entire agriculture production system (Tarafdar et al., 2012a). These nanoparticles are having high surface area, high activity, better catalytic surface, rapid chemical reaction, rapidly dispersible and can adsorb abundant water. One of the principal ways in which a nanoparticle differs from a larger or bulk material is that a high proportion of the atoms that are associated with a nanoparticle occur at the surface. In addition, nanoparticles may have different surface composition, different types and densities of sites and different reactivates with respect to processes such as adsorption and redox reactions. So nanofertilizers may increase the efficiency of nutrient uptake, enhance yield and nutrient content in the edible parts and also minimize its accumulation in the soil. Nanomaterials hold great promise regarding their application in plant nutrition due to their size-dependent qualities, high surface-volume ratio and unique optical properties. During the last decade, some studies tried to examine the potential of nano-biotechnology to improve nutrients use efficiency and strategies that result in the design and development of efficient new nano-fertilizer delivery platforms for use at the farm level. Indeed nanotechnology has provided the feasibility of exploiting nanoscale or nanostructured materials as fertilizer carriers or controlled-release vectors for building of so-called “smart fertilizer” as new facilities to enhance nutrient use efficiency and reduce costs of environmental protection (Chinnamuthu and Boopathi, 2009).

The Nanofertilizer
Nano-fertilizer may be defined as the nano-particles, which can directly supply essential nutrients for plant growth, have higher nutrient use efficiency and can be delivered in a timely manner to a rhizosphere target (Subramanian and Tarafdar, 2011). Nano fertilizers are synthesized or modified form of traditional fertilizers, fertilizers bulk materials or extracted from different vegetative or reproductive parts of the plant by different chemical, physical, mechanical or biological methods with the help of nanotechnology used to improve soil fertility, productivity and quality of agricultural produces. Encapsulation of fertilizers within a nanoparticle is one of these new facilities which are done in three ways-

a) The nutrient can be encapsulated inside nanoporous materials, b) Coated with thin polymer film, or

c) Delivered as particle or emulsions of nanoscales dimensions

Properties of nanofertilizers
Nanofertilizers have high solubility in different solvent such as water. Particles size of nanofertilizers is less than 100 nm which facilitates more penetration of nano particles in to the plant from applied surface such as soil or leaves. Nano fertilizer have large surface area and particle size less than the pore size of root and leaves of the plant which can increase penetration into the plant from applied surface and improve uptake and nutrient use efficiency of the nanofertilizer. Fertilizers encapsulated in nano-particles will increase availability and uptake of nutrient to the crop plants. Particle size below 100 nm nano-particles can use as fertilizer for efficient nutrient management which are more eco-friendly and reduce environment pollution
Advantages of nano fertilizers over traditional fertilizers
Nanofertilizers are nontoxic and less harmful to environment and humans. They minimize cost and maximize profit. Nanoparticles increase nutrients use efficiency and minimizing the costs of environment protection. Improvement in the nutritional content of crops and the quality of the taste. Enhance plants growth by resisting diseases and improving stability of the plants by antibending and deeper rooting of crops. Balanced fertilization to the crop plant may be achieved through nanotechnology.

Nanofertilizers and nutrient use efficiency
Nutrient use efficiency in various crops can be increased by the use of nanofertilizers by the following ways –
- Nano particles can actively participate in biochemical reactions inside the plant and hence lead to production of more photosynthets inside the plants.
- More opportunity to contact within the plant system as the size is very small size and higher surface to volume ratio.
- As the size is much smaller than the pores in plant roots and leaves, there is more penetration in to the plant system.
- Due to a number of surface properties, some of the nanoparticles are easily soluble in water and other solvents and hence leads to more mobilization of immobile nutrients.
- Increase availability and uptake through encapsulation of nano particles
- Zeolite based nano-fertilizers are slow release type in nature and thus they prevent loss of nutrients.

Conclusion
Customized fertilizer is very promising technique that can lead to efficient management of all the required plant nutrients for balanced plant nutrition. It provides the best nutritional package specific to crops for optimum growth and yield of the crops. The problems of hidden hunger or deficiency of major as well as micro nutrients can be managed effectively by application of multinutrient customized fertilizer. Therefore, all necessary efforts are required to promote site specific nutrient management in proportion to present yield targets through customized fertilizers for nutritional and food security. Nanofertilizers are an attractive alternative for greater effectiveness and agronomic efficiency compared to traditional sources of fertilizers. Application of the nanofertilizers have greater role in enhancing crop yield and this will also reduce the cost of fertilizer for crop production. Hence with effective use of nanofertilizers, nutrient use efficiency in crop production can be enhanced in a cost effective way. But exceeding the limit of optimum dose can have inhibitory effect on crop plant which may lead to reduced growth and yield of the crops. With the optimization of doses for different nanofertilizers and for different crops, the nanofertilizers can lead to a greater efficient, eco-friendly production system in near future.

References


CROP DIVERSIFICATION THROUGH MILLETS- AN UNEXPLOITED TREASURE TROVES OF INDIAN FOOD SECURITY

Premaradhya N1, Santosh Korav2, Naveenkumar K. L3 and Mahanthesha M4
1School of Natural Resource Management, College of PG-Studies Umiam-793103, Meghalaya
2Department of Agronomy, College of Agriculture, CCS HAU, Hisar-125004, Haryana
3Department of Genetics and Plant Breeding, College of PG-Studies Umiam-793103, Meghalaya
4Department of Genetics and Plant Breeding, College of Agriculture, CCS HAU, Hisar-125004, Haryana
Corresponding author Email: premaradhya@gmail.com

Abstract
Nutrition security implies awareness and access at affordable cost to balanced diet, safe environment and drinking water and health care outreach. Millets contribute towards balanced diet as well as safe environment. They are nature’s gift to humankind.

The Food and Agricultural Organization (FAO) states that “Food security emerges when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”. Food security has three important and closely related components, which are availability of food, access to food, and absorption of food (world summit, 1996). Food security is thus a multi-dimensional concept and extends beyond the production availability and demand for food. There has been a definite and significant paradigm shift in the concept of food security from mere macro level availability and stability to micro level household food insecurity, and also from an assessment of energy intake to measures and indicators of malnutrition. According to the FAO’s latest food security report, micronutrient and vitamin A deficiency were the prime determinants to child health and nutrition in India. It is reported that nearly 57 percent of pre-school children suffered from vitamin A deficiency, a significantly higher level as compared to even Sub Saharan Africa. India is one of the south–Asian developing countries. A large majority of the poor and food insecure people live in this part of the world and the incidence of malnutrition is very serious [World Bank, 2009].

Food security scenario in India
In a developing country like India, food security means making available minimum quality of food grains to the entire population. Despite the fact that India has made a satisfactory achievement in food grains production, its population growth has nullified the benefits of production (Parvathi and Arulselvam, 2013). Today, five decades after the start of the “Green Revolution,” India’s food grain production has increased fivefold and the country is one of the world’s largest producers of staples like rice and wheat. However, its hunger and malnutrition levels are still extremely high, and great inefficiencies remain within the agricultural sector, which employs about half of the population, including 70% in rural areas (NBR, 2014). The Green Revolution is showing signs of tiredness and the increase in farm productivity has flattened out. The main constraints to Indian agricultural productivity is because of changes in the weather conditions, limited water supplies, small holdings, subsistence nature of farming adopted, poor land conditions, factors like drought, saline soil, heat etc. most of the crop is lost due to diseases, weeds and pests alongside improper storage and transportation. Attaining food security is a matter of prime importance for India where more than a-third of its population is estimated to be absolutely poor, and as many as one half of its children have suffered from malnourishment over the last few decades. In India the status of food security has undergone a significant change. After Green Revolution, due to substantial increase in the production of food grains, the country is largely self-sufficient in food production and imports only a very small part of the food requirement. After Green Revolution per capita availability of food grains has increased in the country but since 1990s it is declining. But the per capita per day net availability of pulses has declined since the Green Revolution. However, even after achieving adequate food supply at the macro level, there is widespread poverty and malnutrition (Saxena N.C., 2011)
A closer look at the experience in the last two decades however indicates a tapering off or decline in both production and yields. It has been observed that during the period 1996-2008 as compared to the years 1986-97, the growth rate in food grain production declined very sharply from nearly 3 percent to around 0.93 percent. Moreover the growth in production was much less than the growth in population in the latter period, having a serious impact on per capita availability. The growth rate of yields in food grain also declined from 3.21 percent to 1.04 percent (Mahendra Dev and Sharma, 2011). There was thus a decline in rates of production and yields for cereals, pulses, oilseeds, rice and wheat as seen in Table 2.

Table 2: Growth rate and yields of food grain, oilseeds and pulses (percent per annum)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Food grains</td>
<td>2.93</td>
<td>0.093</td>
<td>3.21</td>
<td>1.04</td>
</tr>
<tr>
<td>Cereals</td>
<td>3.06</td>
<td>0.097</td>
<td>3.36</td>
<td>1.19</td>
</tr>
<tr>
<td>Coarse cereals</td>
<td>1.19</td>
<td>1.53</td>
<td>3.66</td>
<td>2.25</td>
</tr>
<tr>
<td>Pulses</td>
<td>1.32</td>
<td>0.36</td>
<td>1.49</td>
<td>-0.02</td>
</tr>
<tr>
<td>Oilseeds</td>
<td>6.72</td>
<td>1.99</td>
<td>3.32</td>
<td>1.49</td>
</tr>
<tr>
<td>Rice</td>
<td>3.06</td>
<td>1.02</td>
<td>2.37</td>
<td>1.22</td>
</tr>
<tr>
<td>Wheat</td>
<td>4.09</td>
<td>0.65</td>
<td>2.93</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Several studies have attempted to estimate the future demand and supply scenario for food in the country (Kumar, P., 1998; Bhalla, G.S. et al, 2001; Dyson, T. and Hanchate, A., 2000). Most of these studies have predicted a comfortable demand-supply balance for food grain during the coming decade. While India is expected to be self-sufficient in food grains, it would have to continue importing pulses and oilseeds to meet its future requirements. The projected demand and supply for the year 2020 has been estimated by the Ministry of Agriculture as seen in Table 3.

The figures in Table 3 indicate that while the balance in food grain is expected to be maintained with enough supply to meet the projected demand in 2020, there is likely to be a shortfall in the case of coarse cereals, pulses, oilseeds as well as sugarcane. Thus the reliance on imports is likely to continue in pulses and oilseeds in particular till the year 2020.

Above discussion shows that despite having surplus food production at national level, the country is facing food insecurity situation at micro level and future of food security in the country also
seems dark due to increase in population, parallel with climate change phenomenon such as rising land degradation, loss of soil fertility and water logging, the fall in ground water levels and decline in surface irrigation are being faced in several regions.

**Climate Change; its impacts on crop production and food security**

Climate change is profoundly impacting the conditions in which agricultural activities are conducted. In every region of the world, plants, animals, and ecosystems are adapted to the prevailing climatic conditions. When these conditions change, even slightly, even in a direction that could seem more favourable, the plants and animals present will be impacted, some will become less productive, or even disappear. Some of these impacts can be easily predicted, like the direct impact of a heat wave on a specific plant at a specific moment of its growth (provided that it has been well studied enough). Others are more complex to predict, like the effect of a certain climatic change on a whole ecosystem, because each element will react differently and interact with the other. For instance, many cultivated plants react favourably, in controlled conditions, to an increase of CO$_2$ in the atmosphere. But at the same time many weeds also react favourably. The result, in the field, can be an increase or decrease in yield of the cultivated plant depending on weeds competing for nutrients and water and on remedial agricultural practices.

**Fig.3. Climate changes and its impact on agro-ecosystems, agricultural production and food and nutrition security**

The effect of climate change on crop yield will depend on many parameters: temperature, precipitation patterns and atmospheric CO$_2$ increase given the stimulatory effect of elevated atmospheric CO$_2$ on plant growth (increasing the rate of leaf photosynthesis and improving the efficiency of water use) in most cases, especially for C$_3$ crops like wheat and rice. There are uncertainties related to the interactions between CO$_2$, nitrogen stress and high temperature effects. The response of crops is genotype-specific. Recent results also confirm the damaging effects of elevated tropospheric ozone on crop yields, with estimates of losses for soybean, wheat and maize in 2000 ranging from 8.5 to 14 percent, 4 to 15 percent, 2.2 to 5.5 percent, respectively (Porter et al., 2014). The diversified cropping systems have not only minimized the climatic and market risks, but has also resulted in providing diverse and nutritious food at the household level (Kale and D’souza, 2014).

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nutritional security is paramount. Millets with their superior nutritional quality and hardy nature will be a major answer for this situation.
Integrated Farming System: The Future of Agriculture

Millets

A number of different small-grained cereal grasses are collectively described as ‘Millets’. Millets are one of the oldest cultivated foods known to humans. Two main groups of millets are major millets (sorghum and pearl millet) and small millets based on the grain size. Off late, the classification is also an indication of the area under these crops. Both major and small millets have traditionally been the main components of the food basket of the poor people in India. The term millet is employed for several related genera, some used to produce grain, or forage or both. Millets are cereal species growing in an equally broad range of environments. The group of small millets is represented by six species, namely finger millet (Eleusine coracana), little millet (Panicum sumatrance), kodo millet (Paspalum scrobiculatum), foxtail millet (Setaria italica), barnyard millet (Echinochloa frumentacea) and proso millet (Panicum miliaceum), representing the area grown in that order.

Table 5: Common Names of Millets

<table>
<thead>
<tr>
<th>English</th>
<th>Hindi</th>
<th>Telugu</th>
<th>Kannada</th>
<th>Tamil</th>
<th>Bengali</th>
<th>Marathi</th>
<th>Gujarathi</th>
<th>Oriya</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnyard</td>
<td>Sanwa</td>
<td>Udhalu</td>
<td>Oochalu</td>
<td>Kuthiravally</td>
<td>Shyama</td>
<td>-</td>
<td>-</td>
<td>Khira</td>
</tr>
<tr>
<td>Proso</td>
<td>Chena</td>
<td>Varga</td>
<td>Baragu</td>
<td>Pani Varagu</td>
<td>Cheena</td>
<td>Vari</td>
<td>Cheno</td>
<td>Bachari Bagmu</td>
</tr>
<tr>
<td>Kodo</td>
<td>Kodon</td>
<td>Arkelu</td>
<td>Haarika</td>
<td>Varagu</td>
<td>Kodo</td>
<td>Kodra</td>
<td>Kodra</td>
<td>Kodua</td>
</tr>
<tr>
<td>Little</td>
<td>Kutki</td>
<td>Samalu</td>
<td>Same</td>
<td>Samai</td>
<td>Sama</td>
<td>Sava</td>
<td>Gajro</td>
<td>Suan</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Jowari</td>
<td>Jonna</td>
<td>Jola</td>
<td>Cholam</td>
<td>Jowar</td>
<td>Jawari</td>
<td>Jawari</td>
<td>Juara</td>
</tr>
<tr>
<td>Pearl</td>
<td>Bajra</td>
<td>Satja</td>
<td>Saige</td>
<td>Kanbu</td>
<td>Bajra</td>
<td>Bajri</td>
<td>Bajri</td>
<td>Bajra</td>
</tr>
<tr>
<td>Finger</td>
<td>Ragi</td>
<td>Ragi</td>
<td>Ragi</td>
<td>Keppai</td>
<td>Marwa</td>
<td>Nagli</td>
<td>Nagli</td>
<td>Mandia</td>
</tr>
<tr>
<td>Foxtail</td>
<td>Kakum</td>
<td>Korra</td>
<td>Navane</td>
<td>Tenai</td>
<td>Kaon</td>
<td>Kang</td>
<td>Kang</td>
<td>Kanhku</td>
</tr>
</tbody>
</table>

Source: (http://www.swaraj.org)

Geographical Distribution and Production of Millets

Relative to wheat, rice, maize and barley, sorghum ranks fifth in importance, in terms of both production and area planted, accounting for 5% of the world cereal production (Obilana 2004). India is the top most producers of millets followed by Nigeria for the year 2000 and 2009 (Table 2.2). In India, eight millets species (sorghum, finger millet, pearl millet, foxtail millet, barnyard millet, proso millet, kodo millet and little millet) are commonly cultivated under rain fed conditions. Similarly, sorghum is sown as major crop in the Telangana (Andhra Pradesh), Maharashtra and parts of Central India, while it is considered as fodder crop in some of the Southern regions. Likewise, Finger millet is a primary crop in Tamil Nadu and Gharwal, while the same is a minor crop in Telangana. Hence, the spatial distribution of millets either as a primary crop or as allied crops largely depends on the growing habitat and the amount of rainfall the region receives. While sorghum predominates in areas receiving annual rainfall beyond 400 mm, pearl millet rivals it in areas with annual rainfall of 350 mm. Further, the small millets like finger millet, foxtail millet, barnyard millet, little millet and proso millet are found in most of the southern and central states in India especially wherever annual rainfall is below 350 mm, perhaps where no other cereal crop can grow under such moisture stress. However, in spite of a rich inter/intra-species diversity and wider climatic adaptability cultivation of diverse millet species/varieties is gradually narrowing in the recent past. In a way, a lack of institutional support for millet crops in contrast to the institutional promotion of rice and wheat continue to shrink the millet-growing region.

Chemical Composition of Millets

By any nutritional parameter, millets are miles ahead of rice and wheat. In terms of their mineral content, compared to rice and wheat. Each one of the millets has more fibre than rice and wheat. Some as much as fifty times that of rice. Finger millet has thirty times more Calcium than rice while every other millet has at least twice the amount of Calcium compared to rice. In their Iron content, foxtail and little millet are so rich that rice is nowhere in the race. While most of us seek a micronutrient such as Beta Carotene in pharmaceutical pills and capsules, millets offer it in
abundant quantities. The much privileged rice, ironically, has zero quantity of this precious micronutrient. In this fashion, nutrient to nutrient, every single millet is extraordinarily superior to rice and wheat and therefore is the solution for the malnutrition that affects a vast majority of the Indian population.

**Sorghum**
Sorghum contains 10.4% protein, 1.9% fat (Table 2.4) and around 8.3% total dietary fiber. Sorghum contains 6.5 – 7.9% insoluble fiber and 1.1 – 1.2% soluble fiber. Insoluble dietary fiber increased during food processing due to increased levels of bound protein mainly kafirins, and enzymes-resistant starch. Kafirins (the sorghum prolamin proteins) and glutelins comprise the major protein fractions in sorghum. These fractions are primarily located within the protein bodies and protein matrix of the endosperm, respectively. Sorghum is an important source of minerals that are located in the pericarp, aleurone, and germ. Phosphorus is the mineral found in greatest amounts, its availability is negatively related to the amount bound by phytates. The scutellum of sorghum is where α – amylase is formed and diffuses into the endosperm. Sorghum does not respond to gibberellins to enhance production of amylases during malting. α – amylase activity in sorghum starts 24–36 h after germination. Limit dextrinases and proteases are found mainly in the endosperm, whereas, carboxypeptidases are located primarily in the germ. Sorghum malt has high levels of α – amylase activities but it has reduced β – amylase activities. Condensed tannins (proanthocyanidins) are not present in all sorghums; however, all sorghums contain phenolic acids, and most contain flavonoids. Kernels that contain condensed tannins have a thick, highly pigmented testa. These sorghums were referred to as brown sorghums but are not classified as tannin sorghums. Tannins protect the kernel against pre-harvest germination and attack by insects, birds and molds. Birds consume brown sorghum when other food is unavailable. Animals fed tannin sorghum rations eat more feed and produce about same amount of gain, so feed efficiency is reduced. There is no toxicity problem but feed efficiency is reduced by the condensed tannins. Tannin sorghums can also be transformed into excellent whole grain snacks by extrusion. The extrusion process significantly reduced the degree of polymerixation of tannins, which may be beneficial in human foods (Waniska et al 2004). Sorghum and millet have considerable further potential to be used as a human food and beverage source. In developing countries the commercial processing of these locally grown grains into value-added food and beverage products is an important driver for economic development (Taylor 2004).

**Finger millet (Eleusine corucana)**
Finger millet also known as ‘ragi’ in India is an important staple food for people belonging to the low socio-economic group of world, Africa and India in particular. Finger millet, a chief dry land crop has the ability to withstand adverse weather conditions when grown in soils having poor water holding capacity. It is grown in arid regions of Eastern and Southern Africa, India and Nepal. The small millet seeds can be stored safely for many years without insect damage, which is invaluable in farmers risk avoidance strategies in drought prone areas. In Karnataka, it is grown in an area of 0.8 Mha with an annual production of 1.34 mt. Finger millet grown on marginal land provides a valuable resource in times of famine. Its grain tastes good and is nutritionally rich (compared to cassava, plantain, polished rice and maize meal) as it contains high levels of calcium, iron and manganese. It has a carbohydrate content of 81.5%, protein 7.3%, crude fiber 4.3% and mineral 2.7% that is comparable to other cereals and millets (Table 2.4). Its crude fiber and mineral content is markedly higher than wheat (1.2% fiber, 1.5% minerals) and rice (0.2% fiber, 0.6% minerals); its protein is relatively better balanced; it contains more lysine, threonine and valine than other millets.

**Foxtail Millet (Setaria italica)**
Foxtail millet is commonly known as Italian millet, German millet, Chinese millet, Hungarian millet, Dwarf setaria, giant setaria, liberty millet, and Siberian millet. The seeds are small and measure around 2mm in diameter. They are encased in a thin, papery hull which is easily removed upon threshing. Seed color can vary greatly between varieties grown and range from a pale yellow, through to orange, red, brown and black. A thousand of these seeds weighs approx. 2 grams.
protein in Foxtail millet is known to be deficient in Lysine, and its amino acid scores are comparable to that of Maize. In different grain varieties, higher the protein content, lower is the Lysine content in the protein.

**Little Millet**

Little millet is a relative of Proso millet and is grown throughout India but is of little importance elsewhere and has received very little attention from plant breeders as a crop source. The plant varies in size between 30-90cm and its oblong panicles ranged from 14 to 40cm long. The seeds of little millet are much smaller than proso millet. It has reasonably good levels of protein, but very poor amino acid values. It also has the highest fat content of all the millets.

**Barnyard**

Barnyard or Japanese millet is a domesticated relative of barnyard grass and there exists several varieties. It is the fastest growing of all the millets and produces a crop in six weeks. In India, Japan and China it is often used as a substitute for rice when the paddy crop fails. In the U.S.A. it is grown primarily for forage, and can produce up to eight harvests a year. It is comparable to proso millet in protein and fat content, but the actual quality of the protein, like that of little millet have the poorest amino acid values of all the millets. It is very high in fiber.

**Kodo Millet**

Kodo millet is a minor grain crop in India but is of much greater importance in the Deccan Plateau. It is an annual grass species that grows to around 90cm high. Some varieties of Kodo millet are prone to attacks from mycotoxins. The grain varies in color from light red to dark grey and is enclosed in a tough husk that is difficult to remove. It has high protein content, being around 11% and the nutritional value of the protein is regarded as being slightly better than that of foxtail millet, but comparable to the other millets. It is however deficient in the amino acid tryptophan. It is also reasonably low in fat with high fiber content.

This table is a clear damnation of the PDS policy followed by the Indian Government for four decades. As the table indicates, on all parameters of nutrition, rice occupies the last place in the table. Therefore our discourse on agricultural productivity must make a paradigm shift. It must now stop asking how much does an acre of land produce. Rather the question should be how much nutrition is an acre of land producing. For a country that is 128th in the malnutrition index of the world this is the only road to salvation. And here millets lead the way all the way. They are, as the above table shows, not only leaders in all the major nutrients, but also top the list of micronutrients which the food specialists are now discovering is a major problem in India. But are tragically unaware of the fact that most millets are storehouses of micronutrients like Bt Carotene, Niacine, Thiamine, Riboflavine, Folic Acid etc. Incidentally the last named Folic Acid is a compulsory feed in the Indian ICDS system for pregnant mothers.

**Millets for Climate Crisis**

Millets are very hardy crops that can fight climate change. Traditionally, they are largely grown in a biodiverse environment [ along with many pulses and oilseeds] and can be a strong answer for the low carbon economy demanded by climate change. Some of the predictions for the coming
decades of climate crisis say that global warming is bound to increase from 2 degree centigrade to 5 degree centigrade by 2050. As and when this happens, we should be ready for extended droughts, unreliable rainfall and very high malnutrition. It is predicted that 70% of India will suffer from severe malnutrition. Even if temperatures rise by 2 degree centigrade, wheat may disappear from Indian farming since it is highly thermal sensitive. Thus one crop on which we excessively depend for India’s food security becomes unavailable. As simple as that. The way we grow rice for our PDS is a disaster already creating soil salination, leaching. Some places such as the Tungabhadra basin in Karnataka are already turning into deserts because of the uncontrolled water use and chemical fertilisers. If we continue to grow the Green Revolution model rice in India with 2” standing water and tonnes of nitrogenous fertilisers, the green house gases emanating from paddies will exacerbate global warming to severe extents. In the face of this challenge, rice farming might be forced to take a backseat.

In the event of the disappearance of our principal PDS grains our only alternative will be millets which will be central to Indian food and farming. Thus they will be the defenders of India’s food security. Millets can grow on some of the poorest soils in the country. They can grow under rainfed conditions. The traditional millet farming has always insured risks of excessive rainfall, low rainfall and erratic rainfall. Therefore under the climate crisis conditions, millets can survive strongly. Above all they are, as argued earlier, are extremely nutritious and can be the main tool to fight the malnutrition, especially among the poor who cannot compensate for the low nutrition grains such as rice. Thus millets do become central to the food and nutritional and health security of India.

**Millets are Foods of Future**

Millets are astonishingly low water consuming crops. The rainfall needed for Sorghum, Pearl Millet and Finger Millet is less than 25% of sugarcane and banana, and 30% that of rice. We use 4000 litres of water to grow one kg of rice while all millets grow without irrigation. This can turn out to be a tremendous national gain especially in the ensuing decades of climate crisis. In a future, where water and food crisis stares us in the face, millets can become the food of security.

**Millets are store-houses of nutrition**

By any nutritional parameter, millets are miles ahead of rice and wheat In terms of their mineral content, compared to rice and wheat. Each one of the millets has more fibre than rice and wheat. Some as much as fifty times that of rice. Finger millet has thirty times more Calcium than rice while every other millet has at least twice the amount of Calcium compared to rice. In their Iron content, foxtail and little millet are so rich that rice is nowhere in the race. While most of us seek a micronutrient such as Beta Carotene in pharmaceutical pills and capsules, millets offer it in abundant quantities. The much privileged rice, ironically, has zero quantity of this precious micronutrient.

**Millets grow on the poorest of soils**

Most millets can be grown on low fertility soils. Some in acidic soils, some on saline soils. Millets such as Pearl millet can also be grown on sandy soils, as is done in Rajasthan. In fact, finger millet grows well in saline soils. Barnyard millet too thrives in problem soils, where other crops like rice, struggle to grow in such soils. Many of them are also grown to reclaim soils. In fact, the capacity of millets to grow on poor soils can be gauged from the fact that they grow in Sahelian soil conditions in West Africa which produces 74% of all the millets grown in Africa and 28% of the world production. If they flourish in such ecological zones where average rainfall can be less than 500 mm using soils that are sandy and slightly acid, it is a testimony for their, hardness and extraordinary capacity to survive very harsh conditions. That is why millets can withstand drought like conditions in the Deccan and Rajasthan and produce food and fodder for people and livestock, respectively.
**Integrated Farming System: The Future of Agriculture**

**Millets do not demand synthetic fertilisers**

Millets do not demand chemical fertilizers. In fact, under dry land conditions, millets grow better in the absence of chemical fertilizers. Therefore, most millet farmers grow them using farmyard manure under purely ecofriendly conditions. In recent years farmers have also started using biofertilisers such as vermicompost produced in their backyard and growth promoters such as panchagavya, amrit pani etc. These practices make millet production not only ecofriendly but stays under the control of farmers.

**Millets are pest free crops**

Growing traditional local landraces and under ecological conditions, most millets such as foxtail are totally pest free. And hence do not need any pesticides. Even in storage conditions, most millets such as foxtail not only not need any fumigants, but act as anti pest agents to store delicate pulses such as green gram.

**Millets produce multiple Securities**

While single crops such as rice and wheat can succeed in producing food security for India millets produce multiple securities. They include securities of food, nutrition, fodder, fibre, health, livelihood and ecology. Most millets have edible stalks which are the most favoured fodder for cattle. Many a time, crops such as sorghum and pearl millet are grown only for their fodder value.

**Millets are climate change compliant crops**

Due to all the qualities mentioned above, Millets remain our agricultural answer to the climate crisis that the world is facing. Climate Change is expected to confront us with three challenges. Increase in temperature up to 2-5 degree Celsius increasing water stress Severe malnutrition Only millets have the capacity to meet this challenge: Since they are already capable of growing under drought conditions, they can withstand higher heat regimes. Millets grow under non-irrigated conditions in such low rainfall regimes as between 200mm and 500 mm. Thus, they can also face the water stress and grow.

**Recognising and retrieving millets: Policy matters**

Millets are water saving, drought tolerant crops. Therefore they must be viewed as climate change compliant crops. This quality makes them India’s food and farming future. This is the perspective from which the millet cultivation and its promotion must be regarded. Every millet farmer of India must be given a climate change bonus, biodiversity bonus, water conservation bonus. The urgent and immediate need is to Different parts of India grow diverse kinds of millets. Rajasthan is home to Pearl Millet (Bajra). Deccan plateau (Marathwada in Maharashtra, Telangana in Andhra Pradesh and North Karnataka in Karnataka) is well known for sorghum. Southern Andhra Pradesh, Tamil Nadu, Orissa and Southern Karnataka are the home of Finger millet. Uttarakhand and other hill and tribal areas cultivate a range of small millets such as Foxtail, Proso, Kodo and Barnyard. Compared to rice, they have 30 to 300% more nutritional elements such as Calcium, Minerals, Iron, Fibre, Beta Carotine and many other micronutrients. Therefore the based on the principle of local production, local storage and local distribution. This must be supported by the government, both in procurement and in storage. This will resolve the question of availability and keeping quality. This will overcome the problem of malnutrition of young children a problem where India fares worse than the sub Saharan region, the poorest in the world.

**Conclusion**

Unlike cereals, primary processing of millets poses some problems for want of proper machinery, particularly for small and medium scale enterprises. In recent years, a variety of traditional and non-traditional, millet-based processed foods and complementary foods have been developed. These can become income generation activity for women in household industry. Even while commercialisation is needed, primary effort should be to see that millets are consumed by the poor
and they are cultivated as mixed/relay cropping with legumes and vegetables in homestead gardens for home consumption to ensure household food and nutrition security.

Reference
http://www.wri.org
www.nbr.org
www.fao.org
STUDY OF DRIP IRRIGATION TECHNOLOGY IN INDIA: A REVIEW

Rahul Pippal¹, Swetal Rana¹ and Payal Rana²

¹College of Agriculture, RVSKVV, Gwalior (M.P.)
²College of Agriculture, Jorapali, Raigarh (CG)
Correspondence author Email: rahulpippal1@gmail.com

Abstract

Today’s drip irrigation is very useful water is limited. Drip irrigation is a form of irrigation that saves water and fertilizer by allowing water to drip slowly to the roots of many different plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. It is done through narrow tubes that deliver water directly to the base of the plant. It is chosen instead of surface irrigation for various reasons, often including concern about minimizing evaporation.

“In this paper main purpose to describe the irrigation method and how it is work in agriculture?”

It has been ten years since drip irrigation was introduced in California to be used on commercial agricultural crops. The initial work was started in an avocado orchard in San Diego County and from this small five-acre experimental orchard the acreage has increased tremendously. Many crops are under test with drip irrigation. Equipment used in drip irrigation systems is very important. There are many pieces of equipment required. They include plastic hose or pipe, spaghetti hose, emitters, pressure regulators, pressure gauges, valves, fertilizer tanks, filters sand and screen, time clocks, tensiometers, evaporative pans, meters, and fertilizer injectors. One of the most important items in the hardware for drip irrigation systems is the filter. An automated management of greenhouse brings about precise control needed to provide the most proper condition of plant growth. Timer for the automation of drip irrigation is set, which works accordingly to the sensors and combining all this features the flow of water in fields will be automatically controlled rather than manually. It also contains the temperature and moisture sensor. Sensors are installed in the root zone at the undisturbed soil. The soil moisture sensor is a sensor connected to an irrigation system controller that measures soil moisture content in the active root zone. Soil moisture sensor can reduce irrigation application by 50%. Water saving have been measured between 5% to 88% over typical timer - base irrigation system. Sensors are placed at least 5 ft from the downspouts for avoiding the high moisture areas. Tensiometer can be used to detect moisture content of the soil.

Drip Irrigation:

Drip irrigation is also called trickle irrigation, micro irrigation and localized irrigation. It is an irrigation method that saves water for future. Modern drip irrigation has arguably become the world's most valued innovation in agriculture since the invention of the impact sprinkler in the 1930s, which offered the first practical alternative to surface irrigation. Drip irrigation may also use devices called micro-spray heads, which spray water in a small area, instead of dripping emitters. These are generally used on tree and vine crops with wider root zones.

Components used in drip irrigation (listed in order from water source) include:

- Pump or pressurized water source
- Water filter(s) or filtration systems: sand separator, Fertigation systems (Venturi injector) and chemigation equipment (optional)
- Backwash controller (Backflow prevention device)
- Pressure Control Valve (pressure regulator)
- Distribution lines (main larger diameter pipe, maybe secondary smaller, pipe fittings)
- Hand-operated, electronic, or hydraulic control valves and safety valves
- Smaller diameter poly tube (often referred to as "laterals")
- Poly fittings and accessories (to make connections)
Most large drip irrigation systems employ some type of filter to prevent clogging of the small emitter flow path by small waterborne particles. New technologies are now being offered that minimize clogging. Some residential systems are installed without additional filters since potable water is already filtered at the water treatment plant. Virtually all drip irrigation equipment manufacturers recommend that filters be employed and generally will not honour warranty unless this is done. Last line filters just before the final delivery pipe are strongly recommended in addition to any other filtration system due to fine particle settlement and accidental insertion of particles in the intermediate lines. Drip and subsurface drip irrigation is used almost exclusively when using recycled municipal waste water. Regulations typically do not permit spraying water through the air that has not been fully treated to potable water standards. Because of the way the water is applied in a drip system, traditional surface applications of timed-release fertilizer are sometimes ineffective, so drip systems often mix liquid fertilizer with the irrigation water. This is called fertigation; fertigation and chemigation (application of pesticides and other chemicals to periodically clean out the system, such as chlorine or sulfuric acid) use chemical injectors such as diaphragm pumps, piston pumps, or aspirators. The chemicals may be added constantly whenever the system is irrigating or at intervals.

Fertilizer savings of up to 95% are being reported from recent university field tests using drip fertigation and slow water delivery as compared to timed-release and irrigation by micro spray heads. Properly designed, installed, and managed, drip irrigation may help achieve water conservation by reducing evaporation and deep drainage when compared to other types of irrigation such as flood or overhead sprinklers since water can be more precisely applied to the plant roots. In addition, drip can eliminate many diseases that are spread through water contact with the foliage. Finally, in regions where water supplies are severely limited, there may be no actual water savings, but rather simply an increase in production while using the same amount of water as before. In very arid regions or on sandy soils, the preferred method is to apply the irrigation water as slowly as possible. Pulsed irrigation is sometimes used to decrease the amount of water delivered to the plant at any one time, thus reducing runoff or deep percolation. Pulsed systems are typically expensive and require extensive maintenance. Therefore, the latest efforts by emitter manufacturers are focused toward developing new technologies that deliver irrigation water at ultra-low flow rates, i.e. less than 1.0 litre per hour. Slow and even delivery further improves water use efficiency without incurring the expense and complexity of pulsed delivery equipment.

In recent years, several modification of drip system has been developed in the continuing efforts to improve water use efficiency. Some of these methods are adaptable to the needs of small scale farmers in developing countries.

**Surface trickle irrigation**

In this system, the lateral lines are laid on the surface. It is most popular application method, particularly for widely spaced crops. Advantages of this system include the ease of installing, inspecting and changing and cleaning emitters. However surface trickle lines interfere with cultural operations.

**Sub-surface trickle irrigation**

These systems with lateral lines are buried below soil surface are gaining importance as problems with clogging have been reduce. Advantages of this system include freedom from necessity of anchoring of tubing at the beginning and removing at the end of growing season, little interference with cultural operations and longer economic life.
Low-head bubbler irrigation

It is a modification of drip irrigation, designed to reduce the energy requirements by using inexpensive thin walled, corrugated plastic pipes for minimizing pressure requirements, besides obviating the need for filtration altogether. It is designed to simplify the system and make it less dependent on components, which are likely to deteriorate with use. Bubblers resemble short orifice emitters used for surface trickle, except that discharge rates are higher and range from 1 to 4 min\(^{-1}\). As the emitter discharge rate normally exceeds the infiltration rate of soil, small basin is usually formed around the trees. It is particularly suited for irrigation widely fruit crops.

Zig-bee system for drip irrigation

ZIGBEE system is efficient for water management in the irrigated agricultural cropping systems. The system is based on soil condition identification and consists of zigbee module for communication purpose. In order to produce “More crop per drop” Zigbee is a low-cost, low-power, wireless mesh network standard. The low cost allows the technology to be diffused in room of controlling and watching petition. Mesh networking provides high reliability and more extensive range.

Advantages

Fertilizer and nutrient loss is minimized due to localized application and reduced leaching. Water application efficiency is high if managed correctly. Field leveling is not necessary. Fields with irregular shapes are easily accommodated. Recycled non-potable water can be safely used. Moisture within the root zone can be maintained at field capacity. Soil type plays less important role in frequency of irrigation. Weed growth is lessened. Labour cost is less than other irrigation methods. Variation in supply can be regulated by regulating the valves and drippers. Fertigation can easily be included with minimal waste of fertilizers. Foliage remains dry, reducing the risk of disease. Usually operated at lower pressure than other types of pressurised irrigation, reducing energy costs. Soil erosion is lessened.

Uses

Drip irrigation is used in farms, commercial greenhouses, and residential gardeners. Drip irrigation is adopted extensively in areas of acute water scarcity and especially for crops and trees such as coconuts, containerized landscape trees, grapes, bananas, guava, eggplant, citrus, strawberries, sugarcane, cotton, maize, and potatoes. Drip irrigation for garden available in drip kits are increasingly popular for the homeowner and consist of a timer, hose and emitter. Hoses that are 4 mm in diameter are used to irrigate flower pots.

Future Scope

In our work, we deploy 200 sensors for the delivery of water level information to the monitoring station. Hence the number of sensors is increased and then there is a large amount of power consumption by sensors to deliver the water/packet information to the monitoring station. So it is mandatory to minimize the power consumption by using optimization techniques.
Conclusion
The Intelligent Drip Irrigation using linear programming provides to be a real time feedback control system which monitors and controls all the activities of drip irrigation system efficiently, and by using this system one can save up to 50% of water and power. The present system is model to modernize the agriculture industries at the mass scale with minimize expenditure. This is the first of its kind in using linear programming for drip irrigation systems. Using this system, one can save manpower, water, energy/ power to improve production and ultimately profit.

References
IMPORTANCE OF AGROFORESTRY SYSTEM IN INDIA

Sarat Sekhar Bora¹, Karishma Borah² and Syed Wasifur Rahman³
¹Department of Agronomy, ²Department of Horticulture, AAU, Jorhat-13
³Department of Agricultural Biotechnology, AAU, Jorhat-13
Correspondence author Email:

Abstract
Agroforestry has emerged as a robust land use which advocates crop diversification, soil and soil-water conservation, cycling of organic matter and sequestration of CO₂ in plant and soil. This tree-crop combination provides shade to the field crop with making land productive and increasing revenue. Studying tree-crop interaction in agroforestry would help to devise appropriate ways to increase overall productivity of land. Increased productivity, improved soil fertility, nutrient cycling and soil conservation are the major positive effects of interactions, and competition is the main negative effect of interaction, which substantially reduces the crop yield. There are many research reports indicating significantly higher yield of crops in different agroforestry systems compared to sole crop yields.

The cultivation of trees in association with ground groups to create a biologically diverse polycultural land-use that mimics the ecological functions of the forest while producing various products of economic and environmental value. Agroforestry system is land management practice to cultivate woody perennial and agricultural crops on the same piece of land in temporal and spatial arrangement with sustainable production of crops and ecological and socioeconomic conditions. It is an ecologically sustainable land use option alternative to the prevalent subsistence farming patterns for conservation and development. According to Dhyani et al. [1], in India, the current area under agroforestry is estimated at 25.32 Mha, or 8.2 % of the total geographical area of the country. This includes 20.0 Mha in cultivated lands (7.0 Mha in irrigated and 13.0 Mha in rainfed areas) and 5.32 Mha in other areas such as shifting cultivation (2.28 Mha), home gardens and rehabilitation of problem soils (2.93 Mha). The science of agroforestry system centres around four factors – competition, complexity, sustainability and profitability – and there should be a balance among all these factors to get fruitful returns. Density of trees/shrubs varied from one agroforestry system to another, depending upon the availability of the resources. Agroforestry has much potential, such as the overall (biomass) productivity enhancement, soil fertility improvement, soil conservation, nutrient cycling, microclimate improvement, carbon sequestration, bio-drainage, bioenergy and biofuel. Agroforestry also has the potential to enhance ecosystems through carbon storage, prevention of deforestation, greater biodiversity, cleaner water and less land erosion. Agroforestry provides great opportunities to link water conservation with soil conservation; hence, the major focus has to be on this aspect. It is also noted that sustainable agroforestry can upsurge resilience against environmental change, to enhance carbon sequestration and also to generate income, which will result in improved livelihood of small and subsistence farmers. Traditional agroforestry practices involve planting trees in rows sparsely in crop field and/or along the allies (bunds). These trees provide food, timber, fuel, fodder, construction materials, raw materials for forest-based small-scale enterprises and other cottage industries and in some cases, enrich soil with essential nutrients Management practices for agroforestry are more complex because multiple species having varied phonological, physiological and agronomic requirements are involved. The most important factor for the compatibility of agroforestry is the selection of suitable tree and agricultural crop combination; usually trees that have multipurpose benefits like nitrogen fixing and are fast growing and adaptable to harsh conditions and economically important are preferred. Agroforestry systems can be expedient over conservative agricultural and forest production methods. Since agroforests are stereotypically less diverse than native forest, they support a substantial number of plant and animal species. Therefore, agroforestry, if properly developed, has the potential to improve socioeconomically a more sustainable and better landscape. In order to promote agroforestry, it will require appropriate
research intervention, adequate investment and suitable extension strategies; providing incentives to agroforestry, removing legal barriers in felling, transporting and marketing of agroforestry produce and developing harvest process technology of new products and market infrastructure; and above all, a forward-looking agroforestry policy to address these issues. The North-Eastern (NE) Region of India, occupying 8% of India’s geographical spread lies between 21.5°N to 29.5°N latitude and 85.5°E to 97.5°E longitude. This region comprising eight states (viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura) has a total cropped area of 5.3 million hectares and a population of around 39 million. The region falls under high rainfall zone and the climate ranges from subtropical to alpine. The region is characterized by difficult terrain, wide variations in slopes, altitude, land tenure systems and diverse cultivation practices. More than 70 per cent of total geographical area of the region is covered by hills and about 3 million hectare is estimated to be under soil erosion hazard as a result of practice of Jhum cultivation. In Assam alone, 83.2 per cent of area are suffered from erosion of slight (35.30%), moderate (37.70%), severe (10.00%) and very severe (0.30%) intensity. Many factors such as natural calamities, large number of smallholders, low availability of agri-inputs etc. are threatening the livelihood sustainability in the region. Besides, the region is dominated by the tribal population and the development of agriculture and production of food grains in the region is highly depends upon the custom, culture and the food habit of the local people. Thus, increasing the yield of crop in such a complex system and in an environmentally positive manner is a challenge in a place like NE region of India. Agroforestry is of great importance in recent times primarily because of meeting the diversified needs of people and for sustaining the frazzle ecosystem for generations to come. The area under agriculture and forest has been reduced drastically due to population pressure and this has resulted in a wide gap between demand and production of agricultural and forest products. Now-a-days, there is an acute scarcity and shortage of raw materials for most of the industries in India. Many industries like pulp, paper, ply-wood etc. in the country find it difficult to be internationally competitive. At the current level of consumption and production, India will need a minimum of 0.47 ha of forest land per capita against an actual of 0.08 ha. The per capita availability of agricultural land has also declined from 0.48 ha (in 1951-52) to 0.14 ha (in 2000) and it is expected that it will be reduced to 0.08 ha by 2020. Thus, there is remotest possibility of increasing forest and agricultural area separately. Agroforestry, in this context, holds great promise in augmenting wood production in our country in one way and increasing agricultural production in other, without much adverse effect on land and environment.

Components of agroforestry

Structurally, the system can be grouped as

1. Agri-silviculture system
2. Agri-horticulture system
3. Silvi-pastoral system
4. Agri-silvipastoral system

On the basis of nature of components :

- Agrisilviculture (trees + crops)
- Boundary plantation (tree on boundary + crops)
- Block plantation (block of tree + block of crops)
- Energy plantation (trees + crops during initial years)
- Alleycropping (hedges + crops)
Historical status of agroforestry in India

Agroforestry is as old as the origin of agriculture. But the scientific approach to this system has been realized recently. In India, research work on agroforestry (AF) was initiated during the late 1960s and 1970s by the Indian Grassland and Fodder Research Institute, Jhansi; Central Soil and Water Conservation Research and Training Institute, Dehradun; Central Arid Zone Research Institute, Jodhpur; and ICAR Research Complex for the North-Eastern Hill Region. The National Commission on Agriculture emphasized agroforestry education in the seventh five-year plan period, and all state agricultural universities have introduced it into the agriculture syllabus in accordance with the recommendation of the task force constituted during the first agroforestry seminar organized at Imphal, India, in May 1979. Indian Society of Tree Scientists (ISTS) organized a national seminar on ‘Agroforestry for Rural Needs’ in 1987. ICAR had already launched the All India Coordinated Research Project on Agroforestry which spread over 22 centres in the country in 1983. This programme was subsequently extended to 11 more centres covering all the 23 state agricultural universities, and it was decided that a National Research Centre for Agroforestry would be established during the seventh five-year plan of India (1985–1990). The Greening India mission under the National Climate Change Action Plan targets 1.5 Mha of degraded agricultural lands and fallows to be brought under agroforestry; about 0.8 Mha are under improved agroforestry practices on existing lands and 0.7 Mha of additional lands under agroforestry. Also, there are a number of schemes and programmes being discussed and likely to be initiated in the near future. As per the Government of India initiative to encourage crop diversification in the earlier ‘green revolution’ states, Punjab wants to bring an additional area of 2 lakh ha under agroforestry to its present 1.3 lakh ha has crop diversification strategy. Simultaneously, the post of Assistant Director General (Agroforestry) was also created at the ICAR headquarters in Delhi to coordinate the total research on agroforestry in India.

Scope of agroforestry in India

Agroforestry is an ideal land use option as it optimizes trade-offs between increased food production, poverty alleviation and environmental conservation. This system is adopted in a large hectare of boundaries, bunds and wasteland area and permits the growing of suitable tree species in the field where most annual crops are growing well. Agroforestry assures permanent sources of higher income even in extreme adverse conditions. The role and scope of agroforestry are also studied in way of biodiversity conservation, yield of goods and services to society, augmentation of the carbon storages in agroecosystems, enhancing the fertility of the soil and providing social and economic well-being to people. Realizing such scope, the All India Coordinated Research Project on Agroforestry was initiated in 1983 to initially operate at eight Research Institutes of the Indian Council of Agricultural Research (ICAR) and twelve agricultural universities, and now it is being extended to a large number of universities and institutes. Since agroforestry is a land use management system without deterioration of its fertility that results in more output, this adds to the national economy. Thus, a bright future of agroforestry in India is inevitable.

Practices of agroforestry in India

The practices of growing agricultural crops under scattered trees on farm land are old practices, for example, Prosopis cineraria in north-western India and poplars in north India, Prosopis cineraria and Zizyphus in arid area, Acacia nilotica in Indo-Gangetic plains, Grewia optiva and other tree species in the hills of Uttarakhand and Himachal Pradesh, Eucalyptus globules in the southern hill of Tamilnadu and Borassus flabellifer in the peninsular coastal region. Farmers retain tree of Acacia nilotica, Acacia catechu, Dalbergia sissoo, Mangifera indica, Zizyphus mauritiana and Gmelina arborea and are preferred in Gujarat with crops. In Bihar, Dalbergia sissoo, Litchi chinensis and mango are frequently grown on field, but for boundary plantation, Sissoo and Wendlandia exserta are
most commonly used. Farmers of Sikkim, grow bamboo (*Dendrocalamus, Bambus*) all along the irrigation channels. In Andaman, farmers grow *Gliricidia sepium, Jatropha spp., Ficus, Ceiba pentandra, Vitex trifolia* and *Erythrina variegata* as live hedges. In Chhattisgarh, *Acacia nilotica, Gmelina arborea* and *Albizia*-based agroforestry system are used. Under protein bank (silvopasture system), protein-rich fodder trees including *Acacia nilotica, Albizia lebbeck, Azadirachta indica, Leucaena leucocephala, Gliricidia sepium* and *Sesbania grandiflora* are planted. In south India (Kerala), home garden (agrisilvipastoral system) is used which is the combination of trees, shrubs, vegetables and other herbaceous plants with livestock animals. Farmers retain the suitable species like *Anacardium occidentale, Artocarpus heterophyllus, Citrus spp., Psidium guajava, Mangifera indica, Azadirachta indica, Cocos nucifera*, etc. [20].

**Potential of agroforestry in India**

India is a predominantly tribal region in the eastern part of India, comprising a total geographical area of 137.90 lakh ha. The geographical location of Chhattisgarh is from 17° 46’ north to 24° 5’ north latitude and from 80° 15’ east to 84° 20’ east longitude. The total area of agro-climatic zone (eastern plateau and hill region) in Chhattisgarh is 23.29 lakh ha, which is 24.90 % of the total geographical area of the state. The loamy and clayey soil of this plain area is very fertile, and climate generally varies from moist subhumid to dry subhumid. Chhattisgarh state is rich in forest and has a vast variety of minor forest products to favourable agro-climatic conditions resulting in good forest area, i.e. 43.6 % of the total. Rice is the main crop cultivated in Durg District of Chhattisgarh state, India [21-22]. Agroforestry model in Chhattisgarh state is very prominent and applied. Certain MPT’s like *Acacia nilotica, Butea monosperma, Terminalia arjuna, Albizia procera* and *Zizyphus mauritiana* are an integral part of the rural agroforestry practices of the region and have tremendous importance in poverty alleviation and income generation in the predominantly rainfed agrarian economy of the region. While traditional models with *Acacia nilotica* and *Butea monosperma* and homestead cultivation of horticultural crops have to be encouraged, extensive research inputs have to focus on increasing crop yields through better management of the tree crops and on minimizing competition for resources in the tree-crop interface. Agroforestry system affects the carbon storage capacity and biomass production other than sole crop and tree plantation. A comparative study was done at Forestry Research Farm of Indira Gandhi Agricultural University, Raipur, Chhattisgarh; the total stand biomass is substantially higher in plantations (35 %) than agrisilviculture system, and agrisilviculture system had also the least net C storage (soil + tree) as compared to *Gmelina arborea* monoculture stands. Agroforestry can also provide green fodder and supply fruits, oilseeds and other useful commodities important for nutrition and farm incomes. There are environmental benefits too from agroforestry, including the ability of trees to sequester carbon dioxide, conserve biodiversity and enhance soil health. India has been at the forefront of developing research capabilities in agroforestry, and for this reason it is fitting that New Delhi should host the World Congress on Agroforestry in February 2014, jointly hosted by the Indian Council of Agricultural Research (ICAR) and the World Agroforestry Centre. Still, many challenges facing agroforestry in India that impede the sector’s growth. These include a lack of uniformity in policies and regulations relating to felling and transporting farm-grown timber and other products in different states. Agroforestry ventures are not covered under agricultural insurance schemes or entitled to marketing support, and cannot access the soft bank loans available for crop farming. A national agroforestry policy is currently being developed which should address many of these issues and hopefully “optimize exploitation of the massive socio-economic and environmental potential of agroforestry”.

**Trees in Agroecosystems**

Agroforestry systems in India include trees in farms and a variety of local forest management and ethnoforestry practices11. India is estimated to have between 14,224 million12 and 24,602 million13 trees outside forests, spread over an equivalent area of 17 million ha14, supplying 49% of the 201
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million tonnes of fuelwood and 48% of the 64 million m³ of timber consumed annually by the country. Forest Survey of India earlier has estimated that 2.68 billion trees outside forests exist over an equivalent area of 9.99 million ha. More recent estimates suggest that an equivalent area of 92,769 km² (i.e., 2.82% of the geographical area) is under tree cover in India. The current growing stock has been estimated to be about 1.616 billion cubic metres. For these calculations the tree cover has been defined as tree patches less than 1 ha with the canopy density >10%. In some states where good analyses are now available, the Haryana and Kerala are a case in point. With merely 3.5 percent of Haryana’s area under forests, the state has become self-sufficient in small wood, fuel wood and industrial timber by establishing large-scale plantations on farmlands. Trees in agro ecosystems have increased the extent of area under forest and tree cover to 6.63 percent. These plantations sustain about 670 wood-based veneer, plywood and board, manufacturing units, one large paper mill and about 4,300 sawmills that depend on agroforestry produce. Similarly, the case of Kerala suggests that the state has a surplus of 0.027 million m³ of wood in terms of consumption. While the total wood production in the state is 11.714 million m³, the forests provide only about 10 percent and trees in home gardens and mixed cropping multi-tier agroforestry system contribute to the remaining 90 percent.

Agroforestry contribution

Agroforestry contributes a vital role in Indian economy and has potential to satisfy three objectives, viz. to protect and ameliorate the environment, enhance sustainable production of economic goods on a long-term basis and improve socioeconomic condition of rural people. It has many contributions like rehabilitation of degraded land, increased farm productivity and capability of conserving natural resource and it is an option to increase the forest cover to 33% in the country. Besides meeting the subsistence need of food, fruits, fibre and medicines, this farming practice meets almost half of the demand of the fuel wood, two-thirds of the small timber, 70–80% wood for plywood, 60% raw material for paper pulp and 9–11% of green fodder requirement of livestock. Also, agroforestry practices have enhanced overall biomass productivity from 2 to 10 t ha⁻¹y⁻¹ in rainfed areas in general and the arid and semiarid regions in particular. Agroforestry is also providing livelihood opportunities through lac, apiculture and sericulture cultivation, and suitable trees for gum and resin have been identified for development under agroforestry. Under agroforestry system, tree cultivation on agricultural land improves biomass productivity per unit area and also uses nutrients from different soil layers. Further, land such as bund and avenues that are hitherto not cultivated would increase the tree cover of the landscape.

Carbon sequestration

Active absorption of atmospheric carbon dioxide (CO₂) from the atmosphere through photosynthesis and its subsequent storage in the biomass of the growing trees or plants is referred to as carbon sequestration. The carbon sequestration capacity depends upon tree species and their growing condition and management practices under agroforestry system. Further, allocation of sequestered carbon in different tree components may also vary. Agroforestry is also an attractive option for climate change mitigation as it sequesters carbon in vegetation and soil, produces wood, serves as substitute for similar products that are unsustainably harvested from natural forests and also contributes to farmer’s income. Agroforestry is widely considered as a potential way and low-cost method to sequester atmospheric carbon and recognized as one of the strategies for climate change mitigation. In agroforestry system, tree components are managed and pruned materials are returned to soil to increase carbon biomass. By including trees in agricultural production systems, agroforestry can, arguably, increase the amount of C stored in lands devoted to agriculture while still allowing for the growing of food crops. The total C content of forests has been estimated at 638 Gt for 2005, which is more than the amount of carbon in the entire atmosphere. It was estimated that over 2 billion ha of
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degraded land exists globally, of which 1.5 billion ha is located within tropical lands. Restoration of these afforestation and agroforestry practices to sequester 8.7×10^9 Mg C year\(^{-1}\) in the tropical and 4.9 \times 10^9 Mg C year\(^{-1}\) in the temperate above-ground C pools is the major benefit to the ecosystem. Hence, the combining information on above-ground, time-averaged C stocks and the soil C values for the estimation of C-sequestration potentials in agroforestry systems is an obligation.

**Agroforestry for biodiversity conservation**

Agroforestry is not something new but a new set of old farming practices that integrate crops and/or livestock with trees and shrubs under which one set of practices provides multiple benefits either in a tangible or an intangible way including diversified income sources, increased biological production, better water quality and improved habitat for both humans and wildlife. Young described it as a collective name for land use systems in which trees are grown in association with agricultural crops and/or pasture either in a spatial arrangement or a time sequence with economic and ecological interaction between the tree and non-tree components of the system. It is a multiple land use system in which perennials are grown in conjunction with agronomic crops and/or livestock either simultaneously or in sequence with an ecological and economic interaction between the tree components of the system. This land use farming system has integration of variety of tree species with herbaceous crops increase the biodiversity and increase the overall productivity consumed by households, reduce soil loss and improve the physical and chemical properties of soil. Similarly as per Singh et al., agroforestry system has many diverse contributions comprised of biodiversity conservation, yield of goods and services to society, augmentation of the carbon storage in agro ecosystems enhancing the fertility of the soils and provision of social and economic well-being to people. Tree plays a diverse function under the different agroforestry models/systems. As per Muthappa, under the coffee agroforests, trees are mainly retained in the farm for shade and fuel wood (100 %), support for pepper and timber (98 %), religious value (96 %), food (76 %) and others (69 %), resulting in reduction in pressure on the natural forest. Agroforestry practices such as home garden (agrohortisiviculture) systems, live fences around farmlands, agrisilviculture system, agroforestry species for green manure, silvofishery system, trees in and around the agricultural fields and silvopasture system were found most promising for biodiversity and meeting the diverse needs to uplift the socioeconomic status of farmers. As per Murthy et al., agroforestry practices may use only 5 % of the farming land area yet account for over 50 % of the biodiversity, improving wildlife habitat and harbouring birds and beneficial insects which feed on crop pests. Therefore, under the agroforestry systems, trees can contribute nesting sites, protective cover against predators, access to breeding territory and access to food sources in all seasons and encourage beneficial species such as pollinators.

**Utilizing wasteland**

Wastelands are degraded lands that lack their life-sustaining potential as a result of inherent or imposed disabilities such as by location, environment, chemical and physical properties of the soil or financial or management constraints. It includes area affected by water logging, ravine, sheet and gully erosion, riverine lands, shifting cultivation, salinity, wind erosion, extreme moisture deficiency, etc. Due to complete loss of top soil, these degraded lands are ecologically unstable and are unsuitable for cultivation. The main causes responsible for development of wasteland include deforestation, shifting cultivation, overgrazing, unskilled irrigation, industrialization activities, etc. Deforestation on a vast scale has increased soil erosion, disturbed water regimes and resulted in scarce supply of fuelwood, fodder and small timber on which the vast majority of India’s rural population has been dependent for centuries. The degradation of wasteland can be overcome by participatory approach like social fore joint forest management, community forestry, etc., with the help of local people in the planning and management of lands through afforestation of suitable species like *Jatropha*, neem, *Acacias* species, etc. Further, these degraded, and wasteland are reclaimed and restored through a scientific plantation technique, either sole tree plantation under afforestation scheme or practices of different agroforestry
models based on specific location. Agroforestry models for fodder production, viz. silvopasture, hortipasture, hortisilvipasture and agrisilviculture system, are usually established in degraded cultivable lands. The wastelands could be effectively utilized for fodder production parallel to livestock production through agroforestry system, which is also an environmentally safe system of land use. As per latest agricultural statistics, about 173.6 million ha of land in India is degraded, and these lands may be utilized for some kind of tree plantations and agroforestry system to meet the requirement of forage, fuel, food and other forest products. In afforestation programme, forest plantation constitutes 5% of the world’s total forest area or around 187 million ha. The average rate of successful plantation establishment over the last decades was 3.1 million ha per year, of which 1.9 million ha was in the tropical area. Of the estimated 187 million ha of plantations worldwide, Asia has by far the largest area of forest plantation, accounting for 62% of the world total. In India, silviculturally, ANR (assisted natural regeneration) is used as an approach of afforestation. ANR forms the major strategy of treating degraded forest through joint forest management approach under the national afforestation plan (NAP) and externally aided forestry projects (EAP). It is the dominant plantation model of forest treatment in India. ANR in India is treated as a tool for afforestation. It forms the dominant component of the national afforestation plan (NAP), Government of India’s flagship afforestation program. NAP aims to support and accelerate the ongoing process of devolving forest protection, management and development functions to decentralized institutes of joint forest management committee (JFMC) at the village level. Degraded lands, i.e. unfruitful land, barren land and wasteland, are also reclaiming with the help of large-scale suitable plantation of suitable tree species. Generally, agroforestry practices increase the soil organic matter through leaf litter addition. It increases the population of beneficial microorganism and improves biological nitrogen fixation in soil. All microbiological activity in soil contributes to cycling of nutrient and other ecosystem functions, and all soil functions contribute to ecosystem services. Recycling in natural system is one of the many ecosystem services that sustain and contribute to the well-being of human society. Low soil fertility is one of the greatest biophysical constraints of production of agroforestry crops across the world. Cow dung is a very good source for maintaining the production capacity of soil and enhances the microbial population. It is one of the renewable and sustainable energy resources through dung cakes or biogas which replaces the dependence upon charcoal, fuel wood, firewood and fossil fuel. Besides it, application of cow dung in a proper and sustainable way can enhance not only productivity of yield but also minimizing the chances of bacterial and fungal pathogenic disease. Therefore, added organic matter acts as a source of energy and enhances nutrient cycling in soil. In addition, it moderates soil microclimate and improves soil aggregate system.

**Agroforestry systems increase inputs through nitrogen fixation**

Nitrogen-fixing trees can substantially increase nitrogen inputs to agroforestry systems. Many of the tree and shrub species selected for agroforestry are legumes belonging to the so-called fast-growing nitrogen-fixing trees, notably species of *Leucaena*, *Calliandra*, *Erythrina*, *Gliricidia* and *Sesbania*. *Leucaena leucocephala* is the important tree grown everywhere in arid, semiarid and humid regions and fixes nitrogen up to 100–500 kg N\(_2\) ha\(^{-1}\) yr\(^{-1}\). Similarly as per Dwivedi, several Leguminosae trees such as *Leucaena leucocephala*, *Acacia nilotica*, *Dalbergia sissoo*, *Gliricidia* spp., *Sesbania* spp., etc., and some nonlegumes, e.g. *Casuarina equisetifolia*, *Alnus* spp., etc., are important to fix about 50 to 500 kg of nitrogen per ha. Agamuthu and Broughton showed that nutrient cycling in oil-palm plantation where leguminous cover crops (*Centrosema pubescens* and *Pueraria phaseoloides*) were used was more efficient than in plantation where there was no cover crop. In coffee and cacao plantation with shade trees (some of which are N\(_2\)-fixing), 100–300 kg N ha\(^{-1}\) yr\(^{-1}\) is returned from litter and prunings, which is much higher than the amount removed during harvest or derived from N\(_2\)-fixation. Other nitrogen-fixing legumes include *Albizia*, *Inga*, *Prosopis* and the numerous *Acacia* species, together with *Faidherbia*
albida. The members of family Casuarinaceae and Alnus nepalensis are most widely used for plantations in tropics and temperate zones, respectively which are non-leguminous.

Water stress in relation with growth and productivity in agroforestry

One of the growing global concerns is to increase the water productivity for meeting the water demand of the rising population. According to the estimates of the World Commission on Water, demand for water will increase by approximately 50% over the next 30 years and about half of the world’s population will live in conditions of severe water stress by 2025. Due to rapid degradation of water catchments and climate change, there is a major threat in decreasing water supplies in many parts of the world. Further, global warming, climate change and deforestation are majorly responsible for the fluctuation in spatial and temporal distribution of rainfall which finally leads to water deficit. Water stress in plant is developed during periods of water deficiency because plants are unable to absorb adequate water to match the transpiration rate. A water deficiency exists when the amount of rainfall is less than potential evapotranspiration. Water stress may be either due to water shortage or due to excess of water. Water deficit is one of the key limiting factors for plant growth, productivity and survival and often adversely affects agroforestry practices in arid and semiarid areas. However, plants can normally acclimate to water stress through physiological and morphological responses. However, critical water stress leads to death of plants. Agroforestry has the potential to improve water productivity in two ways. Trees can increase the quantity of water used in farms for tree or crop transpiration and may also improve the productivity of the water that is used by increasing the biomass of trees or crops produced per unit of water used. The rate of depletion of land and surface water in our country is indeed alarming. So the rational approach is required, like by developing the suitable agroforestry model and/or integrating with the rain water harvesting unit for overcoming the water crisis in the country. So water stress in agroforestry can be minimized by developing the appropriate models in general and growing site-specific species in particular.

Socioeconomic upliftment through agroforestry

Agroforestry can improve the livelihoods of smallholder farmers as by providing various production Services, viz. fruit and nuts, fuel wood, timber, medicine, fodder for livestock, green fertilizers, assets that can be sold in time of need and additional/diversified income. It generates high income and minimizes risks in cropping enterprises. It provides long-term investment opportunity, diversified land use and commercial tree cropping and can generate diversified on-farm employment, wood and non-timber forest product (NTFP) and ensure raw-material supply to forest-based industries. Agroforestry has potential for poverty alleviation and tribal development and generating employment and providing women’s empowerment schemes. Farmers will be encouraged to take up farm/agroforestry for higher income generation by evolving technology, extension and credit support packages and removing constraints to development of agroforestry. Suitable species for commercial agroforestry may include Acacia nilotica, Bamboo species, Casuarina equisetifolia, Eucalyptus species, Populus deltoides and Prosopis cineraria for different climatic, edaphic and agricultural conditions. Agroforestry models for different site conditions have to be developed and demonstrated under different agro-ecological regions in the country. Agroforestry system prevailed in Chhattisgarh which depended on their potential to generate high income of farmers which is measured through their economic analysis. These economic analyses are sufficient to measure socioeconomic potential of different agroforestry models and give idea about whether this model be accepted or not.
Role of agroforestry in NTFP production

The trees in agroforestry practices generally fulfil multiple purposes, involving the protection of the soil or improvement of its fertility, as well as the production of one or more products. As per Leakey, agroforestry is a dynamic, ecologically based, natural-resource management system that, through the integration of trees in farmland and rangeland, diversifies and sustains smallholder production for increased social, economic and environmental benefits. These socioeconomically viable and biologically diverse systems suggest that agroforestry can produce NTFPs commercially and in a sustainable way. Non-wood tree products are used by people every day of their lives for their own need (food, fodder, medicines, building materials, resins, dyes, flavourings, etc.). Multipurpose trees play an important role to fulfil all needs as tangible and intangible benefits. As per ICRAF [83], multipurpose trees and shrubs are those that can produce food, fodder, fuelwood, mulch, fruit, timber and other products. New initiatives in agroforestry are seeking to promote poverty alleviation and environmental rehabilitation in developing countries, through the integration of indigenous trees, whose products have traditionally been gathered from natural forests, into tropical farming systems. Non-timber forest products (NTFPs) include a broad range of edible, medicinal, decorative and handicraft goods harvested from woodlands. Seeds, flowers, fruits, leaves, roots, bark, latex, resins, gum and other non-wood plant parts are categorized under NTFPs. The domestication of trees for agroforestry approaches to poverty alleviation and environmental rehabilitation in the tropics depends on the expansion of the market demand for their non-timber forest products. As per Leakey, the nutritive values of the flesh, kernels and seed oils of the fruit tree species, viz. *Irvingia gabonensis*, *Dacryodes edulis*, *Ricinodendron heudelottii*, *Chrysophyllum albidum*, *Garcinia kola*, *Adansonia digitata*, *Vitellaria paradoxa*, *Parkia biglobosa*, *Tamarindus indica*, *Sclerocarya birrea*, *Uapaca kirkiana*, *Zizyphus mauritiana*, *Vangueria infausta*, *Azanza garckeana*, *Inga edulis* and *Bactris gasipaes*, have been identified, in four eco-regions of the tropics, by subsistence farmers as their top priorities for domestication under agroforestry practices. As per Ike, *Irvingia* species (wombolu and *gabonensis*) are common among the trees planted under agroforestry practices, and their major importance to the farmers is the seed which is of significant economic value. The major system (89 %) of exploiting *Irvingia gabonensis* and *Irvingia wombolu* is from the wild. Other exploitation systems were around homestead (85.7 %), agroforestry (83.5 %) and *Irvingia* plantations (39.6 %). The most important part of *I. gabonensis* to the rural people is its nutritious seeds which have also been found useful in the reduction of cholesterol and body weight in obese patients. In agroforestry practices, rates of growth and reproduction of NTFP, enhancement forest plantings and home gardens may also differ significantly from those in unmanaged forest environments, due to differences in intraspecific competition, light or a combination of factors.
Conclusion

In the present scenario of climate change, agroforestry practices, emerging as a viable option for combating negative impacts of climate change. Convincing people regarding adoption and promotion of agroforestry is a great challenge and can be overcome by capacity building, providing suitable incentives and utilizing public-private partnership. Also, the government incentives and policies are the main task for success of intensive agroforestry system. Nowadays, agroforestry has gained popularity among farmers, researchers, policymakers and others for its ability to contribute significantly in meeting deficits of tree products and socioeconomic and environmental benefits. Therefore, agroforestry system gives diversification, provides societal continuum, creates green cover for carbon sequestration, generates fresh water harvesting potential and ground water recharge and increases the nutrient uptake, and their utilization management practices that lead to improved organic matter status of the soil will lead inevitably to improved nutrient cycling and better soil productivity.

Reference

AICRPAF, 2006. All India Coordinated Research Project on Agroforestry, Report, NRCAF, Jhansi.
INTEGRATED FARMING SYSTEM APPROACH FOR ENHANCED EFFICIENCY OF NATURAL RESOURCES

Santosh Korav and Dharam Bir Yadav

Department of Agronomy, College of Agriculture, CCS HAU, Hisar-125004, Haryana

Corresponding author Email: santoshkorav@gmail.com

Abstract

Farming systems is a set of agro-economic activities that are interrelated and interact among themselves in a particular agrarian setting. In diversified farming, though crop and other enterprises exist, the thrust is mainly to minimize the risk. While in the Integrated Farming Systems (IFS) a judicious mix of one or more enterprises along with cropping has a complimentary effect through effective recycling of wastes and crop residues and encompasses additional source of income to the farmers. IFS activity is focused round a few selected inter-dependent, inter-related and inter-linking production systems, based on crops, animals and related subsidiary professions. It is a rich source of species of diversity with helps in soil building, preserve and improves ecological condition essential to long-term sustainability.

In recent years, food security, livelihood security, water security as well as natural resources conservation and environment protection have emerged as major issues worldwide. Developing countries are struggling to deal with these issues and also have to contend with the dual burden of climate change and globalization. It has been accepted by everyone across the globe that sustainable development is the only way to promote rational utilization of resources and environmental protection without hampering economic growth. Developing countries around the world are promoting sustainable development through sustainable agricultural practices which will help them in addressing socio economic as well as environmental issues simultaneously. Within the road concept of sustainable agriculture “Integrated Farming System” holds special position as in the system nothing is wasted, the by-product of one system becomes the input for other. It is an integrated approach to farming as compared to existing monoculture approaches. It refers the agricultural systems that integrate livestock and crop production. Moreover, the system help poor small farmers, who have very small land holding for crop production and a few heads of livestock to diversify farm production, increase cash income, improve quality and quantity of food produced and exploitation of unutilized resources.

Integrated farming system

Integrated farming system is a resource management strategy to achieve economic and sustained agricultural production to meet diverse requirement of the farm household while preserving the resource base and maintaining high environmental quality. It focused round a few selected, inter-dependent, inter-related and often inter-linking production systems based on few crops, animals and related subsidiary professions.

Why Integrated Farming Systems?

Deteriorating resource Base

During post-green revolution period, attempts to solve food problem through excess use of agrochemicals, frequent irrigations and high cropping intensity had led to food contamination, ground water pollution, soil degradation and suffering of beneficial microorganisms. In many regions, both surface and ground water is becoming unfit for human and animal consumption due to high concentration of pesticides residue. Available estimates revealed that nearly 120.72 million ha. of land
in the country is being degraded. Intensified agriculture, coupled with indiscriminate use of irrigation water and fertilizer, especially in irrigated areas has led to soil abnormalities.

**Adverse effect of Climate Change**
The consecutive increase in green-house gases resulted in global warming. The Intergovernmental Panel for Climate Change (IPCC) projections on temperature predicted an increase of 1.8 to 4.0°C temp by the end of this century. Temperature and sea level changes will affect agriculture through causing direct and indirect effects on crops, soils, livestock, and fisheries along with other bio-pests. The apprehension of Environmental changes in future is expected to be very high due to greater dependence on agriculture, misuse of natural resources, unscientific rearing of livestock population, faulty land use pattern and socio-economic factors that pose a great threat in meeting the food, fibre, fuel and fodder requirements. Recent studies done at the Indian Agricultural Research Institute, New Delhi indicated the possibility of 4-5 million tons wheat loss in future due to every rise of 1°C temperature. The integrated farming system could only be the way to mitigate the effect of climate change.

**Narrowed Biodiversity**
The narrowing of genetic biodiversity occurs as traditional crop varieties and local animal breeds are being replaced by modern ones. These new varieties/breeds will certainly be matched to modern intensive agriculture, but rarely any consideration was given to preserving the bio-diversity of an agricultural ecosystem. In addition, the monoculture farming tends to erode the biodiversity of flora and fauna in present agriculture. For example, extensive adoption of rice-wheat monoculture in Indo-Gangetic Plains has replaced the other traditional crops. Soil micro-flora is also been adversely affected due to heavy use of agrochemicals and lack of crop residues recycling. The IFS with multiple enterprises and round the year farming can be realistic towards increasing biodiversity.

**Multiplicity of Integrated Farming Systems**
Very often, almost all Indian farmers, in pursuit of supplementing their needs of food, fodder, fuel, fiber and finance resort to adopt integrated farming systems. Majority of them revolving around the crops + livestock components. Livelihood of small and marginal farmers, comprising more than 85 per cent of total farmers, depends mainly on crops and livestock, which is often affected by weather aberrations. Under present scenario, in the absence of scientifically designed, economically profitable and socially acceptable integrated farming systems models, farmers were unable to harness the real benefits of integration. An important consequence of this has been that their farming activities remain, by and large, subsistent in nature rather than commercial and many times proved uneconomical.

**Low Rate of Farm Resource Recycling**
In absence of adequate knowledge among farmers about techniques and benefits of recycling, industrial and households’ organic wastes in agriculture, remain unutilized. A vast untapped potential exists to recycle these solid and liquid organic wastes of farm origin. Recycling of crops residue may be a potential organic source to sustain the soil health. Incorporation of crop residues of either rice or wheat increases the yield of rice, nutrient uptake and also improves the physiochemical properties of the soil which ensures better soil environment for crop growth.

**Technology Adoption Gaps**
In order to develop and improve existing technologies, involvement of people in conceptualization and transfer of technologies would appear very important. The farm family had never been the focal point of our investigations. This top down approach had given a poor perception of the problems that they tried to solve. Due to poor extension mechanisms at national as well as state levels, many farmers, especially those who are at lower strata of social structure, remained unaware about many of the developmental schemes, so that the desired impact of such schemes are not obtained. One of the
reasons for poor rate of transfer of agricultural technologies is poor linkages between the different
groups of agriculture. Practically linkages among farmers, service providers, technological and
financial institutions are either weak or nonexistent (NAAS,2009). Continuous production of crops
without external inputs reduces the ability of the soil resource base which often results in declining
productivity. Nevertheless, growing of only few creates risk of crop failure due to range of factors (i.e.
disease, drought) which exposes farmers to a high degree of variability in yield. Commercial farming
systems are threat to the environment through a loss of genetic diversity and the possible negative
impacts of these systems and their associated inputs. No single farm enterprise is likely to be able to
sustain the small and marginal farmers without resorting to integrated farming systems (IFS) for the
generation of adequate income and gainful employment. Under the gradual shrinking of land holding,
it is necessary to integrate land based enterprises like dairy fishery, poultry, duckery, apiary, along
with field and horticultural crops etc. within the bio-physical and socio-economic environment of the
farmers to make farming more profitable and dependable.

Objective of Integrated Farming System

- To identify location specific needs
- To set up priorities for sustainable agricultural development
- To draw plans for production based system activities to be undertaken by farmers
- To facilitate the empowerment of farmers

Goals of Integrated Farming System:

- The four primary goals of IFS are-
  1. Maximization of yield of all component enterprises to provide steady and stable income.
  2. Rejuvenation / amelioration of system's productivity and achieve agro-ecological equilibrium.
  3. Avoid build-up of insect-pests, diseases and weed population through natural cropping system
management and keep them at low level of intensity.
  4. Reducing the use of chemicals (fertilizers and pesticides) to provide chemical free healthy
produce and environment to the society.

Advantages of Integrated Farming System

- Increased productivity through increased economic yield per unit area per time by virtue of
intensification of crop and allied enterprises.
- Improved profitability achieved mainly by way of reduced costs due to recycling of wastes of
one enterprise as energy inputs for other systems.
- Greater sustainability in production on farm due to integration of diverse enterprises of
different economic importance. Recycling of wastes being in built in the system, this helps to
reduce dependence on external high-energy inputs thus conserving natural and scarce
resources.
- Integration of different production systems provides an opportunity to solve malnutrition
problem due to production of variety of food products.
- The recycling of wastes for production helps to avoid piling of wastes and consequent
pollution.
- The farming system provides flow of money to the farmer round the year by way of disposal
of eggs, milk, edible mushroom, honey, silkworm cocoons etc. This will help resource poor
farmer to get out from the clutches of moneylenders/agents.
- Because of the linkage of dairy/mushrooms/sericulture fruit crops/vegetable crops/flower
cultivation etc. cash available round the year could induce small and marginal farmers adopt
new technologies such as fertilizer, pesticides etc.
**Integrated Farming System: The Future of Agriculture**

h) Recycling of organic wastes reduces requirement of chemical fertilizer. Further, biogas production can meet household energy requirement. Thus, IFS, goes a long way in solving energy crises.

i) Fodder/pasture/tree species included in the system help to get more fodder and thus solve fodder crises to some extent.

**Components in IFS**
Agriculture, Horticulture, Forestry, Apiary, Sericulture, Dairy, Poultry, Goat rearing, Sheep rearing, Piggery, Rabbitory, Fish farming, Duck rearing, Pigeon rearing, Mushroom cultivation, Azolla farming, Kitchen gardening, Fodder production, Seed Production, Vermiculture, Value addition.

**Integrated Farming System models**
The following Integrated Farming Systems suitable particularly for hilly regions of the North Eastern Region are explained below in a concise manner.

- Integrated Fish cum Pig farming
- Integrated Fish cum Duck Farming
- Integrated Fish cum Poultry Farming
- Integrated Fish farming cum Cattle farming
- Integrated Fish farming cum Rabbit farming
- Integrated Fish farming cum Agriculture

**Integrated Fish cum Pig farming**
A scientifically sound and economically viable production system integrating pig husbandry with fish culture has been evolved for Indian conditions. The pig sties are constructed on the pond embankment or near the pond and the pig manure (faeces and urine) are directly drained into the pond or lifted from the animal house and applied to pond. The pig dung acts as excellent pond fertilizer and raises the biological productivity of the pond water and consequently increases fish production. Further, the fish also feed directly on the pig excreta which contain 70% digestible food for the fish. No supplementary fish feed or pond fertilizer is required in this system. The expenditure on fish culture is drastically reduced as the pig excreta acts as substitute to fish feed and pond fertilizer which accounts for 60% of the input cost in fish culture.

**The system has obvious advantages**
The pig dung acts as excellent pond fertilizer and raises the biological productivity of the pond and consequently increases fish production. Some of the fishes feed directly on the pig excreta which contains 70 per cent digestible food for the fish. No supplementary feed is required for the fish culture, which normally accounts for 60 per cent of the total input cost in conventional fish culture. The pond dikes provide space for erection of animal housing units. Pond water is used for cleaning the pigsties and for bathing the pigs. The system cannot be adopted in all parts of India due to religious consideration but it has special significance in the North Eastern Region as it can improve the socioeconomic status of weaker rural communities, especially the tribal’s who traditionally raise pigs at their backyards and fond of eating fish. They can take up fish-pig farming easily.

**Pond Management**
In establishing IFS depending on the farmer’s preference, suitable agro-climate, available technology and marketing facilities, natural resources conservation employing available modern concepts of farming systems are essential and vital for sustainable agricultural development and ensuring greater livelihood of the indigenous farming communities of the region. Therefore, natural resources management is an integral part of integrated farming system. North Eastern Hilly (NEH) region of India is characterized by varying topography that is largely affected by high seepage flow and flash
runoff. Dual effect of water in the form of heavy rainfall during monsoon and water scarcity during post monsoon is severe in this region. Existing undulated terrain and dual effects of water are the main limiting constrain in storing/concentration of runoff water. Hence, there has been an increasing interest in low cost Water Harvesting ponds for small scale farming practices as to tackle such problems in NEH Region of India.

**Stocking**
The pond is stocked after the pond water gets properly detoxified. The stocking rates vary from 8000-8500 fingerlings per hectare (100m x100m) and a species ratio of 40% surface feeders, 20% column feeders, 30% bottom feeders and 10% macro vegetation feeders is preferred for high fish yields. Mixed culture of Indian Major Carps can be taken up with species ratio of 40% surface feeders, 30% column feeders and 30% bottom feeders.

i. Culturing of Indian Major carps alone: Catla 3 : Rohu 4 : Mrigal 3
ii. Culturing of Indian Major carps and common carps: Catla 3 : Rohu 4 : Mrigal 1 : Common carp 1
iii. Culturing of mixed species i.e. Indian Major carps and exotic carps : Catla 2 : Rohu 3 : Mrigal 1 : Common carp 2 : Silver carp 1

**Use of pig waste as manure:**
Pig dung, urine and spilled feed from pig sites are channelled into the pond every day. The excreta voided by 30-40 pigs are adequate to fertilize one hectare water area under polyculture of fish.

Table 1. Pig manure contains many nutrients

<table>
<thead>
<tr>
<th>Type of Manure</th>
<th>Dry matter (%)</th>
<th>Crude protein (%)</th>
<th>Non Protein Nitrogen(%)</th>
<th>Ash (%)</th>
<th>Ether extract (%)</th>
<th>Crude Fibre (%)</th>
<th>Acid Digestible Fibre (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle Manure</td>
<td>20.4</td>
<td>16.9</td>
<td>-</td>
<td>14.0</td>
<td>3.1</td>
<td>23.9</td>
<td>40.3</td>
</tr>
<tr>
<td>Swine Manure</td>
<td>25</td>
<td>27.9</td>
<td>0.86</td>
<td>18.0</td>
<td>7.0</td>
<td>15.0</td>
<td>26.5</td>
</tr>
<tr>
<td>Cage layer Manure</td>
<td>30.8</td>
<td>33.9</td>
<td>3.65</td>
<td>22.4</td>
<td>2.1</td>
<td>19.1</td>
<td>17.2</td>
</tr>
<tr>
<td>Manure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broiler Manure</td>
<td>85.7</td>
<td>37.1</td>
<td>0.86</td>
<td>3.53</td>
<td>17.5</td>
<td>3.2</td>
<td>-</td>
</tr>
<tr>
<td>Broiler litter plus manure</td>
<td>88.7</td>
<td>30.8</td>
<td>0.86</td>
<td>2.47</td>
<td>17.2</td>
<td>18.4</td>
<td>-</td>
</tr>
</tbody>
</table>

**Feeding of grass carp**

Aquatic weeds such as Hydrilla/Najas etc. or chopped green cattle fodders such as maize, banana leaves, cow pea, oat, Napier grass, leaves etc. are provided to grass carp.

**Periodical netting**
Trial netting is done once a month to check the growth of fish. It also helps in timely detection of parasitic infection, if any.

**Control of algal bloom**
Plank tonic algae sometimes appear in great abundance in the manure-loaded creating algal bloom condition especially during the summer season. This condition is not desirable for fish culture, and these weeds are kept under control by using herbicides like Diuron or Simazine.

**Pig husbandry practices**
Management of pigs is very much essential for optimum production of pig meat. Good housing with adequate feeding and proper health cover are essential requirement for pigs. The roof of pig house may be GI sheet or asbestos. For healthy growth of pig, a lying space of 1-1.5 sq.m/pig and dung area of 1.5 sq.m/pig is regarded quite adequate.
Selection of pig

The exotic upgraded stock of pigs such as large-white Yorkshire, Hampshire and Landrace are most suitable for raising in comparison to the local Indian variety since they are quick growers and prolific breeders. They attain slaughter maturity size (60-70kg) within 6 months and give 9-12 piglets in every litter. About 30-40 pigs can be raised for a hectare of pond area. Considering easy management and good return, it is advisable to rear only superior grower/fatteners in small scale Integrated Farming System, instead of rearing sows for piglet productions which require better care and management for profit. Large White Yorkshire, Landrace, Hampshire, Ghungroo, or superior upgraded animals are well adapted to the north eastern region and grow well in this climatic condition.

Floor space required for different categories of animals

<table>
<thead>
<tr>
<th>Category of pigs</th>
<th>Roofed/covered Area (Sq m)</th>
<th>Open yard area (Sq m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boar</td>
<td>6.0-7.5</td>
<td>8.8-12.0</td>
</tr>
<tr>
<td>Farrowing sow</td>
<td>7.5-9.0</td>
<td>8.8-12.0</td>
</tr>
<tr>
<td>Weaner pen</td>
<td>0.3-0.5</td>
<td>0.3-0.5</td>
</tr>
<tr>
<td>Fattening pigs</td>
<td>0.9-1.2</td>
<td>0.9-1.2</td>
</tr>
<tr>
<td>Dry sow/gilt</td>
<td>1.0-1.5</td>
<td>1.0-1.5</td>
</tr>
</tbody>
</table>

Feeding

Feed requirement depends upon the types of pig reared i.e. dry or pregnant, boar, lactating sow, grower or finishers. For finishers, adlibitum feeding is practised. Boiled grasses, roots, tubers, kitchen waste can substitute up to 50% of finisher/fattener pig feed without much effect on growth. Fish or poultry waste intestinal parts of the farm or obtained from local market can be boiled before feeding, which will be a very good animal protein source for pigs. Feeding should be done at frequent intervals in small quantities to minimize the residual feed and thereby will reduce digested problems.

Harvesting of Fish

Keeping in view the size attained, prevailing market rate and demand of fish in the local market, partial harvesting of fish is done. After harvesting partially, the stock is replenished with the same number of fingerlings. Final harvesting is done after 12 months of rearing. Fish yields ranging from 6000-7000kg/ha/yr is generally obtained. The pigs attain slaughter size (70-80kg) within 6-7 months.

(Channabasavanna et al., 2010)
Over all Advantages of Integrated Farming System

1) **Productivity:** IFS provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises especially for small and marginal farmers.

2) **Profitability:** Cost of feed for livestock is about 65-75% of total cost of production; however use of waste material and their by product reduces the cost of production, conversely it is same for the crop production as fertilizer requirement for crop is made available from animal excreta no extra fertilizers required to purchase from outside farm as a result the benefit cost ratio increases and purchasing power of farmers improves thereby.

3) **Sustainability:** In IFS, subsystem of one waste material or by product works as an input for the other subsystem and their by product or inputs are organic in nature thus providing an opportunity to sustain the potentiality of production base for much longer periods as compare to monoculture farming system.

4) **Balanced Food:** All the nutrient requirements of human are not exclusively found in single food, to meet such requirement different food staffs have to be consumed by farmers. Such requirement can be fulfilled by adopting IFS at farmer level, enabling different sources of nutrition.

5) **Environmental Safety:** In IFS waste materials are effectively recycled by linking appropriate components, thus minimize environment pollution.

6) **Recycling:** Effective recycling of product, by products and waste material in IFS is the corner stone behind the sustainability of farming system under resource poor condition in rural area.

7) **Income Rounds the year:** Due to interaction of enterprises with crops, eggs, meat and milk, provides flow of money round the year amongst farming community.

8) **Saving Energy:** Cattle are used as a medium of transportation in rural area more over cow dung is used as such a burning material for cooking purpose or utilized to generate biogas thereby reducing the dependency on petrol/diesel and fossil fuel respectively, taping the available source within the farming system, to conserve energy.

9) **Meeting Fodder crisis:** By product and waste material of crop are effectively utilized as a fodder for livestock (Ruminants) and product like grain, maize are used as feed for monogastric animal (pig and poultry).

10) **Employment Generation:** Combining crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problems of under employment to a great extent IFS provide enough scope to employ family labour round the year.

**Constrains related to integrated farming system:**

- Lack of appropriate technology
- Lack of farmers participatory research
- Inadequate Training
- Lack of rural infrastructure
- Policy implication
- Inadvertent avoidance of farm women
- Socio-economic constraints
- Inadequate institutional support
**Integrated Farming System: The Future of Agriculture**

**Conclusion**
Efficient utilization of scarce and costly natural resources is the need of the hour to make crop production a viable proposition in the present day competitive scenario. Following the concept of Integrated farming systems through supplementation of allied agro enterprises by recycling the waste of one enterprise in another is a right step in this direction. A better planning and utilization of the available resources will usher in bright prospects for the farm economy as a whole.

**Reference**


MONOCULTURE: ECOLOGICAL IMPLICATIONS IN INDIAN AGRICULTURE

Sarita Rani¹, Rekha Rantanoo², Mamta Phogat¹, Sunil Beniwal¹ and Sunil Kumar³
¹College of Agriculture, CCS Haryana Agricultural University.
²Department of Agronomy, Punjab Agricultural University.
³Department of Soil Science and Agricultural Chemistry, SKRAU-Bikaner, Rajasthan.
 Corresponding author email: sarita.sherawat92@gmail.com

Abstract

Monoculture is agricultural practice of growing a single crop, plant, or livestock species, variety, or breed in a field or farming system at a time. In polyculture more than one crop is grown in the same space at the same time. In the last half century, agriculture intensification has occurred at a faster rate in terms of dissemination of high yielding varieties, consumption of large amount of energy, more application of external inputs (fertilizers, irrigation, plant protection measures, herbicides etc), purposeful selection of single crop and varieties, which collectively disturbs the natural ecosystem and enhance the willful cultivation of agro-ecosystem (human interfered one). This led ecological implications viz., reduction in diversity of plant species, soil health deterioration, environmental pollution, depletion of available water resources, nutrients imbalances, human health issues etc. Problems associated with monoculture are to be addressed and their improvement strategies should be worked out. This chapter covers the monoculture, its ecological impact with special reference to the most prevalent monoculture of rice-wheat cropping system.

Monoculture is the agricultural practice of producing or growing a single crop, plant, or livestock species, variety, or breed in a field or farming system at a time. Polyculture, where more than one crop is grown in the same space at the same time, is the alternative to monoculture. Monoculture is more preferred as compared to polyculture or oligoculture in both commercial agriculture as well as natural farming practices/organic farming practices as it allows increased ease and efficiency in planting and harvesting. In today’s agriculture scenario, simple monocultures involving two or three cereal crops are more prevailing all over the world and in India, as compared to polyculture. Panigrahi et al conducted a remote sensing survey of Indo-gangetic plains of India and reported that rice was predominant crop covering 65.54% followed by maize covering 11.26% of total agricultural area of India whereas wheat covered 67.18% of area in Rabi. Moreover, rice and/or wheat crops were components of 10 out of 13 cropping patterns identified. This is because agrotechniques developed so far, are in the form of package for intensive cereal based crop sequences. Uniform management practices from field preparation to harvesting of crop, advent of high yielding varieties, broad range of pesticides, easily available and subsidised fertilizers and irrigation gave an edge to to monoculture over polyculture because in such favourable conditions monoculture proved to be more profitable as compared to polyculture.

Agriculture as an applied ecology

Agriculture is also an applied ecology therefore, it can be examined through application of knowledge about organism and their environment. In an ecosystem whether it is natural or managed by humans (i.e. agroecosystem) ecological principles will be implied in a similar fashion. Evolution of a natural ecosystem involves several organisms and environment altogether and core mechanism is continuous interaction and adaptation of organism to the dynamic environment which is also aided by invasion of new organisms and species and finally there is a climax community. In any ecosystem individuals of a species exist in one or more populations and the different species which interact biologically will form an ecological community. (Thomas and Kevan, 1993). The characteristic feature of climax community in a natural ecosystem that it is
diverse as much as possible. Ecological biodiversity can be explained on the basis of principle, namely continuous regulation of of a species in terms of their abundance (how many individuals) and distribution (where they occur) as high diversity ecosystem will have more species occurring more frequently among the habitats than ecosystems of low diversity. Biodiversity confers stability and resilience to certain level of disturbances (various biotic and abiotic factors) to a community. An agroecosystem is also governed by same principles of ecology having same chain of evolution except a small modification that is human intervention in natural ecosystem mechanisms. This human intervention mechanism involves:

1) Suppression of dominant but undesirable organisms insect-pest and weeds, and disease propagules.

2) Selection of desirable plants and animals.

3) Diversion of maximum resources towards the selected desirable species to get maximum output.

Therefore, some ecological events are modified such as a plant species is artificially protected from various biotic and abiotic stresses by using agrochemicals and provided an edge by modifying the growing conditions as required (such as submerged and puddled conditions for rice even in unsuitable soil and water availability conditions) thus adaptation is replaced by false adaptation which simply means organism (plant or livestock) is not or partially confronted with real ambience (including soil moisture, competition by insect-pests and weeds, and abiotic stresses such as drought, heat, cold, frost etc.). Moreover, biotype and succession events are completely absent or checked at a certain level.

**Agriculture as applied ecology**

Agriculture has modified natural ecosystems in a number of different ways. In agricultural systems, biodiversity performs ecosystem services beyond production of food, fiber, fuel, and income. Examples include recycling of nutrients, control of local microclimate, regulation of local hydrological processes, regulation of the abundance of undesirable organisms, and detoxification of noxious chemicals (Alteiri, 1999) but the species richness/biodiversity is purposefully reduced to accommodate the desired cultured species. Due to biological simplification, these natural services of an ecosystem are lost.

Then the need to supply crops with costly external inputs is increased because agroecosystems deprived of basic regulating functional components lack the capacity to sponsor their own soil fertility and pest regulation. Diversion of nutrients, energy, water and other natural resources is towards commercially desirable species occurred into abundance of single crop variety in a field, that is ecologically known as disproportionate and intentionally overabundance of one organism. But economically, this phenomenon serves the purpose of agriculture and this can not be displaced just for the sake of mimicking the natural ecosystem because a better measure of agricultural productivity is the amount that can be harvested and exported to cities, sustainably. Herbivores and decomposers in natural ecosystems consume much of their primary production, leaving little for harvest if selective diversion of resources in not done in favour of desired crop or animal (Altieri, 1999). Agriculture intensification has occurred in last half century in terms of transfer and dissemination of high yielding varieties, use of large amounts of energy, exogenous fertilizers, pesticides, and herbicides per hectare, the association of cultured crop species has been replaced by prevalent monocultures and continuous cropping of the same variety. The existence of such monocultures is maintained by elaborate plant and animal control programs to maximize protection of the monocultured crop. Simultaneously, such monocultures serve as huge opportunities to exploit a vast pool of nutrients and energy not only by humans, but also by competitors (weeds, insects, and pathogens) which are able to resist the artificial eradication
Integ 

rated Farming System: The Future of Agriculture

schemes. Matson et al 1997 has discussed the following biological consequences of agricultural intensification:

Pest complex refers to the community composition of herbivorous insects, their natural enemies (predators and parasites) and microbial community attacking crops. Strong favour towards crop specific herbivorous pest is trend in monoculture whereas low abundance of specific pests due to severe competition from other insects, higher predation rate and higher ratio of natural enemies to herbivores is characteristic of polyculture. Microbial pathogens – crop diversification can either discourage or inhibit pathogen growth according to microclimatic conditions created by crop which can either favour or discourage development of severity of plant diseases. Virus infestation is obviously less in polyculture because insect vector tend to be found at lower incidence. Crop rotations are devised so that cultivation of one crop potentiates the growth of a particular succeeding crop so that a successional sequence is used, artificially, to enhance productivity for human use. Ecological successions have usually been replaced by crop rotations. Intercropping of cereals with shrub or tree crops achieves spatially what rotations achieve temporally in a given area. Lands used for the production of annum crops or animal forage are kept in the early productive stage of a succession so that energy and nutrients are used more for structural plant growth and reproductive structures than for the maintenance of mature plants. Even where fruits of long-lived plants constitute the crop, as in orchard tree fruits and berry crops, succession is held in check and the diversity of associated species is kept low.

Selection Mechanism

Selection of a species is toward achieving maximum commercially desired part of organism body for example in cereals higher grain yield as compared to vegetative parts. Other selection criteria are to enable the species to grow in different environments and resist against different stresses such as drought resistance, insect-pest resistance diseases resistance, cold hardiness and so on. Thus, artificial selection for narrow array of goals characterises an agroecosystem whereas, natural selection, emphasises upon variability and reproductive fitness in a natural ecosystem. Group selection, which is supposedly absent in nature, would be the most appropriate type of selection for improving the productivity and uniformity of agricultural and forestry crops (Thomas and Kevan, 1993).

Recycling of nutrients

Nutrient and organic matter recycling in a natural ecosystem is never complete rather it is a continuous process. Inputs are soil mineralization, nitrogen fixation, and direct importation by migratory animals. Processes such as denitrification, leaching, and export by migratory animals, remove nutrients from the systems. However, this system of nutrient cycling is altered in an agroecosystem owing to its some characteristic features like i) removal of crop residues from the field. ii) Input is aided by heavy application of fertilizers. ii) as already known farms exist to export the agricultural commodities for human consumption and there is little recycling between human settlements and farms. iv) uncoupling of animal production from crop production. V) tillage of soil in cropping area interferes with naturally occurring processes in soil.

Rice-Wheat Cropping System

Most R-W systems are located in South and East Asia within subtropical to warm temperate climates, characterized by cool, dry winters, and warm, wet summer. Indo-gangetic plains constitute 85% of total area RWCS of South Asia i.e. 13 mha in which Indian part of IGP comprises about 10 m ha. About 75% of the total rice area and 63% of the wheat area in the IGP is under RWCS. About ¾ of total cereal production comes from RWCS in Punjab. RWCS which is a long established grain production system of China, is quite new to Indian Subcontinent and started only in late 1960s with the introduction of dwarf wheat from CIMMYT, Mexico, which requires a lower temperature (mean below 23°C) for good germination than that required for
In traditional tall Indian wheat. Thus wheat sowings were shifted from mid-October to mid November which provided a full extra month for the preceding rainy season crop. This provided enough time for rice to mature; high yielding varieties for which were already available. This set in the RWCS in the Indo-Gangetic plains (IGP) of the Indian subcontinent i.e. Punjab, Haryana and western UP (traditionally wheat growing regions) and Bihar and West Bengal (traditionally rice growing regions) were turned into rice-wheat regions. The green revolution technologies led to the emergence of rice-wheat as the major cropping systems in the IGP, which now ranks first among 30 major cropping systems of India.

Fig. 2: Distribution of R-W production areas in South Asia and China

Panigrahi et al carried out a study for carried out to delineate the existing cropping systems in the Indo-Gangetic Plains (IGP) using 10 day composite SPOT VEGETATION (VGT) NDVI data. The analysis of seasonal cropping pattern showed that, during kharif season, in IGP states rice is the major crop covering about 65.5% of the agricultural area of the plain. During rabi season, wheat is the major crop of the IGP except West Bengal. The total area covered by the crop is 67% of the agricultural area of the IGP. The crop rotations and their spatial distribution obtained by combining the kharif, rabi and summer crops of all the states are shown in Fig. 2. Rice and/or wheat is component of 11 out of 12 cropping systems.

Fig. 2: Major Cropping Systems of Indo-Gangetic plain derived from Multi-date SPOT VGT NDVI data
Characteristics of Rice-Wheat cropping system

The dry-wet-dry transition
The traditional technique of rice culture involves puddling the soil to form a saturated root zone for the ready establishment of transplanted seedlings above a compacted subsoil layer that reduces seepage of standing water from the paddy during the crop cycle. Wheat and other crops in the system cannot tolerate the anaerobic conditions to which rice is well adapted, however, so the dominating feature of current R-W systems becomes the annual conversion of soil from aerobic to anaerobic and then back to aerobic conditions. These conversions have significant effects on the physical, chemical, and biological status of soils that determine growing conditions for all crops in the system. Thus, Seasonal wet and dry crop Cycles over a long period have important implications for management practices, including crop establishment and nutrient, water and weed management in RW system.

Increased use of reliance on inorganic fertilizers

Intensification and mechanization of RWS in Punjab, Haryana, and some parts of Uttar Pradesh had reduced cattle population. This is due to lack of demand for animal power and conversion of pastures and other areas under fodder crops into agricultural lands. As a result, use of organic manure for rice and wheat crops has drastically reduced over the period in these states as well as in eastern India. Further, availability of chemical fertilizers at subsidized cost is also a principal factor for the negligence of conventional organic manures under intensive RWS.

Modern rice and wheat varieties are highly responsive to chemical fertilizers. Therefore, use of fertilizers has increased tremendously for rice and wheat in the intensive rice-wheat belts. Use of chemical fertilizers is still low in Bihar as adoption of HYVs is low with less proportion of area under irrigation. In West Bengal, fertilizer use increased after the 1980s as modern varieties started spreading.

Asymmetry of planting schedules

The reasons for late planting of wheat in the rice-wheat system include late harvest of the preceding rice crop; growing of long duration, photosensitive, high quality basmati rice that matures late; a long turn around time between rice harvest and wheat planting; and growing of a short duration third crop after rice. Measures to avoid late planting include practicing zero tillage in wheat and direct sowing of rice.

Greater uniformity in crop varieties cultivated and hence their susceptibility to same pests

Constraints in rice-wheat cropping system

Declining water availability and ground water depletion

A large amount of water is used to maintain flooding in rice field. Rice grown by traditional practice requires approximately 1500 mm of water during a season. In addition, around 50 mm of water is required to grow seedling to the transplanting stage. The actual amount of water applied by farmer is much higher than recommended. Availability of sufficient irrigation water has made the RW system in the NW IGP a typical example of a highly productive system in non-ideal rice soils (porous, coarse and highly permeable). Paddy consumes about 62% and Wheat 20% of total irrigation water requirement of Punjab state. Four decades of RW system have depleted the water resources in this region to a great extent. In Punjab alone there is a water shortage of 1.2 mha meters annually (Hira, 2009). The excess demand for water is being met through overexploitation of groundwater, leading to a decline in the water table. Only 23% of area in Punjab is irrigated by canals and for remaining 77% of area tubewells have become a reliable source. Ground water
depletion in Punjab as well as other parts of NW zone is at the rate of 70 to 100 cm/year. The areas having water table below 9 m increased from 3% in 1973 to about 90% in 2004 and almost 100% in 2010 in RWCS zones of India (Kumar et al 2010).

From Figure it is clear that ground water table depth below 40 m is in Rajasthan and area having GW below 20-40 m are mostly concentrated in Punjab, Haryana and Rajasthan.

Deteriorating soil health

Water Logging, Soil salinity and alkalinity
Water logging is caused by seepage of water from canal system and over irrigation and submergence requirement of rice crop cause waterlogging which delayed planting of wheat in rotation with rice because soil is not in condition for field preparation for wheat sowing immediately after rice harvesting. Further, the farmers in North-west India are facing a situation in which they have to deal with salt volumes that are harmful for the water uptake of crops. Soil salinity may occur due to the two reasons:

i) Source of salt content in surface soil is use of poor quality ground water and heavy irrigation in semi-arid areas which helps to sub-soil salt content to come on surface soil layers.

ii) Puddled soil conditions reduce permeability to water so salt can not be leached down beyond the root zone.

iii) In some irrigate areas, considerable recharge of ground water leads to waterlogging and capillary salinization.

Dutta and Jong (2002) conducted a case study in gohana sub-division of Sonepat district of Haryana and concluded that water logging and salinity problem started around 1970, and it took 4 years until the first 5% of the land was affected, another seven years for the next 5% and until
1995 about 35% of the area was affected from salinity. In area situated on the bank of canal 50% of the land area was affected from salinity in 1995.

**Poor soil fertility**

Rice and wheat are heavy feeder of nutrients. One ton of wheat grains is estimated to remove 24.5, 3.8 and 27.3 kg N, P and K, respectively. Whereas similar production of rice grains removes 20.1 kg N, 4.9 kg P and 25.0 kg K. the rice-wheat system has not only resulted in mining of major nutrients but also caused imbalance of nutrient, leading to deteriorating soil health because nutrient applied by farmer are not in proper ratio, for example, NPK ratio in 2012-13 was very wide i.e. 8.3:2.7:1 and Use of high analysis fertilizer with macronutrients (mostly N and P only) while neglecting micronutrient requirement. Moreover, increasing trend of burning of crop residue also leads to permanent nutrient loss from plant-soil cycle. Particularly K mining is at alarming rates because 80 to 85% of the K absorbed by rice and wheat crop remains in straw. That’s why there is a negative K balance in soil due to crop residue burning. K removal by crop residue represents approximately five times as much as is supplied by fertilizers. (Chander, 2011). A negative K balance can be substantially improved by returning wheat residue to soil which are now being removed mainly for dry fodder. The partial factor productivity of N, P and K for food grain production has dropped from about 81 kg grain per kg N in 1966-67 to 15 kg/kg N in 2006-07. Ladha et al (2003) analyzed the data from 33 LTE of India, Nepal, China and Bangladesh. The annual yield change in rice ranged from -5.1 to 3.6% per year of average yield of respective LTE after 14 and 11 years of rice and wheat cultivation, respectively. Yield of both rice and wheat were stagnant in 75 and 85% of LTE while 22 and 6% of LTE showed a significant decline in yield trend. On the system basis 60% of LTE had a negative yield trend with 18% significant decline. In 90% of LTE the fertilizer K addition were not sufficient to sustain a neutral input-output balance and all the LTE with significant yield decline had negative balance of K. in one of the LTE yield declinre was arrested when Zn was applied along with NPK-micronutrient (Pusa).

**Micronutrient status**

Imbalanced use of macronutrient fertilizers, decreased use of organic manure, reduced recycling of crop residues, and bumper harvests in the past three decades have induced secondary and micronutrient deficiencies in the IGP. In several areas with intensive cropping, zinc (Zn) deficiency appeared initially and subsequently the deficiencies of iron (Fe), manganese (Mn), boron (B), and molybdenum (Mo) were recorded. The severity of these deficiencies depended on the soil conditions and the crop grown. Rice crop removes larger quantities of micronutrients compared to wheat. Increase in fertility levels progressively increases the total removal of micronutrients due to increased dry matter production. The extent of micronutrient deficiency varies not only in different states and districts but also in different blocks within the same district depending upon the soil characteristics and other management conditions. 

**Areas of micronutrient deficiency**

- Zn deficiency first appeared in rice in Uttarakhand in 1965 and then in Punjab in 1970 and now its deficiency is most widespread in India among all micronutrients.
- The extent of iron deficiency is approximately a fifth that of zinc deficiency and is largely influenced by the vast areas under alkaline to calcareous soil tracts.
- Iron deficiency is only second in importance after zinc deficiency in Punjab and Haryana.
- Manganese deficiency is in localized sites where rice-wheat crop rotation is practiced in coarse-textured soils.
- Copper deficiency is not widespread in the IGP, but deficiency based on plant analysis is higher than soil analysis. The critical limits used for soil copper or plant copper need to be re-calibrated.
• The incidence of boron deficiency was highest in the acid soils of West Bengal followed by the calcareous soils of Bihar.

**Table: Extent of Micronutrient deficiency in Indian states**

<table>
<thead>
<tr>
<th>State</th>
<th>No. of soil samples</th>
<th>% soil samples deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Zn</td>
</tr>
<tr>
<td>Bihar</td>
<td>19214</td>
<td>54</td>
</tr>
<tr>
<td>Haryana</td>
<td>21848</td>
<td>60.5</td>
</tr>
<tr>
<td>Punjab</td>
<td>16483</td>
<td>48.1</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>26126</td>
<td>45.7</td>
</tr>
<tr>
<td>West Bengal</td>
<td>6547</td>
<td>36.0</td>
</tr>
<tr>
<td>Total</td>
<td>90218</td>
<td>50.6</td>
</tr>
</tbody>
</table>

Singh, 1999

In all, deterioration of soil health in IGP tract has occurred due to the following reasons:

• Increased water logging in low lying area, canal seepage and over irrigation and increased salinity due to use of poor quality ground water and secondary salinization.

• Reduced levels and frequency of farmyard manure applications to crop fields is attributed to changes in livestock herd size and composition; and increased use of manure for household fuel.

• Fewer crop residues (incorporated into the soil or used as surface mulch) are attributed to their increased use for livestock fodder (due to reduction in grazing/pasture area); and increased burning of crop residues.

• Increased reliance on continuous rice-wheat rotations and a decline in the attractiveness of break crops are attributed to low yields and profits from break crops; and market access problems and associated policy issues.

• Intensive nutrient mining in the surface soil is attributed to restricted root growth associated with the plough pan created during puddle rice culture.

• Low application levels of inorganic fertilizers, insufficient to replace nutrients extracted during crop production.

• Use of inorganic fertilizer sources that do not contain secondary elements or micronutrients.

**Yield Decline**

The Green revolution that made Asia food sufficient was the result of continued research on improvement of germplasm and agronomic practices and government policies that made farmers adopt these new HYVs and new technologies. But Actual Yields (Ya) are far below Potential Yield (YP) in developing countries as compared to developed countries. George (2014) has given poor adoption and practice of the advances in agronomy and opting for low-risk, low-cost practices over high risk investments in labor and other inputs required for high-yield agronomy by the average developing country farmer as most common reason for large yield gaps as indicated by:

a) The PFP of fertilizer drastically declined in India from about 75 kg grain kg fertilizer between 1965 and 1980 to just 17 kg grain kg⁻¹ fertilizer in 2009.

b) While rice is 100% irrigated in the US (Ramsey, 2010), only about 59% was irrigated in India in 2008.
The rice yield growth rate has been low in India; yield increased at a rate of only 46 kg ha⁻¹ yr⁻¹ from a low 1965 Ya of 1.3 Mg ha⁻¹ in India compared to a rate of 74 kg ha⁻¹ yr⁻¹ from a high 1965 Ya of 4.4 Mg ha⁻¹ in the US. Ladha et al (2003) analyzed the data from 33 LTE of India, Nepal, China and Bangladesh. The annual yield change in rice ranged from -5.1 to 3.6% per year of average yield of respective LTE after 14 and 11 years of rice and wheat cultivation, respectively. Yield of both rice and wheat were stagnant in 75 and 85% of LTE while 22 and 6% of LTE showed a significant decline in yield trend. On the system basis 60% of LTE had a negative yield trend with 18% significant decline. In 90% of LTE the fertilizer K addition were not sufficient to sustain a neutral input-output balance and all the LTE with significant yield decline had negative balance of K. In one of the LTE yield decline was arrested when Zn was applied along with NPK. Besides, they reported following causes of yield decline:

<table>
<thead>
<tr>
<th>LTE</th>
<th>Causes of yield decline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhairahva 1, Nepal</td>
<td>Delay in sowing (wheat), decline in soil N, available P,K and Zn</td>
</tr>
<tr>
<td>Bhairahva 2, Nepal</td>
<td>Delay in sowing (wheat), decline in soil C, available P and K</td>
</tr>
<tr>
<td>Karnal (India)</td>
<td>Decline in soil K</td>
</tr>
<tr>
<td>Ludhiana, India</td>
<td>Decrease in solar radiation, increase in minimum soil temperature, decline in soil C, N and K</td>
</tr>
<tr>
<td>Pantnagar, India</td>
<td>Decline in soil and N, and soil available P and K</td>
</tr>
<tr>
<td>Pusa, India</td>
<td>Decline in soil K and Available Zn</td>
</tr>
<tr>
<td>Tarahana, Nepal</td>
<td>Decline in soil available P and K</td>
</tr>
</tbody>
</table>

**Soil C status vs. Yield**

Soil organic matter serves as a soil conditioner, nutrient source and substrate for microbial activity and considered as a most important basis of sustained yield. Several researches and analyses of LTE have demonstrated that although other soil properties do not show acceptable changes in LTE of RW sytem, in irrigated double- and triple cereal crop systems SOM appears to be increased. However, increasing stocks of soil organic C not necessarily increase the yield and yields of rice and wheat decreased in some of the LTE instead of increasing total soil organic carbon (Ladha et al., 2003). Cassman, 1999 has discussed the reason and concluded that the decrease in soil N supply caused by the accumulation of phenol C in the youngest humic fractions in irrigated rice systems, and that phenol enrichment results in a reduced rate of mineralization from these organic matter pools. Bronson et al (1998) observed that only active fraction of SOM is important as it is directly involved on nutrient availability whereas the total SOM stocks is not of such importance.

**Disposal of crop residues**

The Ministry of New and Renewable Energy (MNRE, 2009), Govt. of India has estimated that about 500 Mt of crop residues are generated every year. Among different crops, cereals generate maximum residues (352 Mt), followed by fibres (66 Mt), oilseeds (29 Mt), pulses (13 Mt) and sugarcane (12 Mt). The cereal crops (rice, wheat, maize, millets) contribute 70% while rice crop alone contributes 34% to the crop residues and wheat ranks second with 22% of the crop residues. Generation of crop residues of cereals is also highest in Uttar Pradesh (53 Mt), followed by Punjab (44 Mt) and West Bengal (33 Mt). Traditionally crop residues have numerous
competing uses such as animal feed, fodder, fuel, roof thatching, packaging and composting. The residues of cereal crops are mainly used as cattle feed. Rice straw and husk are used as domestic fuel or in boilers for parboiling rice. The remaining residues are left unused or burnt on-farm. In states like Punjab and Haryana, where crop residues of rice are not used as cattle feed, a large amount is burnt on-farm. The surplus residues i.e., total residues generated minus residues used for various purposes, are typically burnt on-farm. Estimated total amount of crop residues surplus in India is 91-141 Mt. Cereals and fibre crops contribute 58% and 23%, respectively. Out of 82 Mt surplus residues from the cereal crops, 44 Mt is from rice followed by 24.5 Mt from wheat, which is mostly burnt on-farm.

![Fig. 2. Residue generation by different crops in India (MNRE, 2009)](image1)
![Fig. 3. The share of unutilized residues in total residues generated by different crops in India (MNRE, 2009)](image2)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Haryana</td>
<td>27.83</td>
<td>11.22</td>
<td>9.06</td>
</tr>
<tr>
<td>Punjab</td>
<td>50.75</td>
<td>24.83</td>
<td>19.62</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>59.97</td>
<td>13.53</td>
<td>21.92</td>
</tr>
<tr>
<td>All India</td>
<td>501.76</td>
<td>140.84</td>
<td>92.81 (IARI, 2012)</td>
</tr>
</tbody>
</table>

**Reasons of burning crop residues in RWCS**

However, because of increased mechanization, particularly the use of combine harvesters, declining numbers of livestocks, long period required for composting and unavailability of alternative economically viable solutions, farmers are compelled to burn the residues. The number of combine harvesters in the country, particularly in the Indo-Gangetic Plains (IGP) has increased dramatically from nearly 2000 in 1986 to over 10000 in 2010. The north-western part (Punjab, Haryana and Western Uttar Pradesh) of the IGP has about 75% of the cropped area under combine harvesting. Combine harvesters are used extensively in the central and eastern Uttar Pradesh, Uttarakhand, Bihar, Rajasthan, Madhya Pradesh and in the southern states as well.
for harvesting rice and wheat crops. Major reasons for rapid increase in the use of combines are labour shortage, high wages during harvesting season, ease of harvesting and thrashing and uncertainty of weather. On using combine harvesting; about 80% of the residues are left in the field as loose straw that finally ends up being burnt on farm.

**Adverse consequences of on-farm burning of crop residues**

Burning of crop residues leads to release of soot particles and smoke causing human and animal health problems. It also leads to emission of greenhouse gases namely carbon dioxide, methane and nitrous oxide, causing global warming and loss of plant nutrients like N, P, K and S. The burning of crop residues is wastage of valuable resources which could be a source of carbon, bioactive compounds, feed and energy for rural households and small industries. Heat generated from the burning of crop residues elevates soil temperature causing death of active beneficial microbial population, though the effect is temporary, as the microbes regenerate after a few days. Repeated burnings in a field, however, diminishes the microbial population permanently. The burning of crop residues immediately increases the exchangeable NH4 N and bicarbonate-extractable P content, but there is no build up of nutrients in the profile. Long-term burning reduces total N and C, and potentially mineralizable N in the upper soil layer. The burning of agricultural residues leads to significant emissions of chemically and radiatively important trace gases such as methane (CH4), carbon monoxide (CO), nitrous oxide (N2O), oxides of nitrogen (NOX) and sulphur (SOX) and other hydrocarbons to the atmosphere. About 70%, 7% and 0.7% of C present in rice straw is emitted as carbon dioxide, carbon monoxide and methane, respectively, while 2% of N in straw is emitted as nitrous oxide upon burning. It also emits a large amount of particulates that are composed of a wide variety of organic and inorganic species. One ton of rice straw on burning releases about 3 kg particulate matter, 60 kg CO, 1460 kg CO2, 199 kg ash and 2 kg SO2. Besides other light hydrocarbons, volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), SOx and NOx are also emitted. These gases are of major concern for their global impact and may lead to increase in the levels of aerosols, acid deposition, increase in tropospheric ozone and depletion of the stratospheric ozone layer. These may subsequently undergo trans-boundary migration depending upon the wind speed/direction, reactions with oxidants like OH, leading to physico-chemical transformation and eventually wash out by precipitation. Many pollutants found in large quantities in biomass smoke are known or suspected carcinogens and could be a major cause of concern leading to various air-borne/lung diseases.

**Weed flora shifts and herbicide resistance**

In rice, excessive suppression of most dominant weed *Echinochloa* species led to occurrence of several other weeds like *Cynodon dactylon*, *Ischameum rugosum*, *Leptochloa chinensis* and *Paspalum distichum* (grassess), *Ammania baccifera*, *Ludwigia* sp., *Caesalia axillaris*, *Commelina benghalensis* and *Eclipta prostrate* (BLWs) and *Cyperus* *difformis*, *Cyperus iria*, *Cyperus rotundus* and *Fimbristylis milacea* (Sedges) as important and dominant weeds in rice. In wheat, *Phalaris minor*, *Cornopus Didymus*, *Melilotus spp.*, *Vicia sativa*, *Lathyrus aphaca*, *Chenopodium album*, *Anagalis arvensis* and *Polygonum spp.* are the dominant weeds. The most dominant and problematic weed is *P. minor*, which was introduced in India with wheat seed imported from Mexico in the late 1960s and soon became a major weed in wheat in the RW cropping system in the fertile and irrigated conditions of the NW IGP. The presence of this weed has been noticed in other cropping sequences also but at lower intensities. The most affected states in India are Punjab and Haryana, however, *P. minor* infestation is one of the serious causes of concern in Uttar Pradesh, Uttarakhand, Madhya Pradesh and parts of Bihar, and Himachal Pradesh, where it reduces wheat production significantly. The success of *P. minor* in the rice-wheat rotation appears to be related to high surface moisture for seedling emergence, high input levels, and a phenology which is ideally suited to the climatic conditions (Malik and Singh 1995). Yadav and
Malik () has mentioned the following reasons for its survival and spread in this region along with citing reasons given by Dhiman et al (2002); Malik et al. (1998) and Malik (2003):

One reason for its continuous success is cropping pattern itself. With continuous growing of wheat, weed flora did not diversify. Diversification by growing alternate crop will make other weeds to emerge and grow, thus posing the competition to a single weed like *P. minor*. It is susceptible to solarization. Presence of water in rice fields lowers the temperature of soil, and thus helps in its survival in rice-wheat system as compared to other cropping systems.

1. Puddling helps in deep placement of seed in the soil and hence exposure to relatively lower temperature.
2. The increased and prolonged activity of alcohol dehydrogenase in *P. minor* is known to play a detoxifying role in anaerobic respiration, hence retaining viability.
3. Its tolerance to anoxia might be due to inherent ability of seed in using NO₃ as an alternate electron acceptor in Electron Transport System (ETS) with the help of nitrate reductase activity.
4. Spread of littleseed canary grass from farm to farm in contaminated wheat seed and in irrigation water particularly under canal irrigation system, farm machinery and exchange of wheat-seed amongst farmers.
5. It is quite often that most of the farmers use wheat seed for sowing purposes from their own stocks of previous years, because seed replacement with certified seed is hardly 10% each year. The seed used from farmers’ own stores for sowing purpose may also contain large number of *P. minor* seed due to carelessness or ignorance in cleaning before sowing.
6. After the evolution of herbicide resistance (1992-93), this weed has flourished in the absence of serious competition from other weeds. *P. minor* is highly competitive and in most of the instances it does not allow other weeds to pose serious threat in wheat. It is evidenced by the fact that mostly broadleaf weeds appear in wheat when *Phalaris* is effectively controlled.
7. Burning of rice stubbles straw, especially after combine harvesting, appears to have reduced herbicide efficacy possibly due to increased adsorption of isoproturon on ash.
8. Continuous rotation of rice-wheat could have favoured this weed because of adequate moisture availability throughout the year.
9. Growing of short-statured high yielding varieties of wheat and increased fertilizer use will continue to favour this weed.

The herbicide isoproturon introduced to its control in 1970s proved to be a magic herbicide that ruled the wheat field for more than two decades due to its broad spectrum weed control, low cost and post emergence application. However, faulty spraying techniques, the use of lower than recommended rates, the use of less quantity of spray solution and repeated use of the herbicide year after year eventually resulted in the evolution of biotypes of *P. minor* resistant to isoproturon. The threat was further aggravated with time due to multiple resistance to alternate herbicides clodinafop and fenoxaprop and cross resistance to pinoxaden and fenoxaprop. Area under isoproturon resistant *P. minor* varies between 0.8 to 1.0 million hectares in India mainly confined to Haryana (0.5-0.6 m ha) and Punjab (0.3 m ha) (Yadav and Malik, 2005).

**Climate change**

Wetland rice is major source of atmospheric methane (24 %) only followed by enteric fermentation (63%). Alternate wetting and drying conditions lead to nitrous oxide emissions due to denitrification process. About 150 l of diesel is consumed per year per ha in field preparation and pumping water in conventional systems which amounts the emission of 400 kg CO₂ per ha per annum (Chauhan et al, 2012).
Integrated Farming System: The Future of Agriculture

Table: Result of meta analysis to determine GWP associated with GHG emission for major crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield Level (Range) t/ha</th>
<th>Average N rate</th>
<th>GWP (% CO2 eq./ha)</th>
<th>Contribution in GWP kg/ha/season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>6.1 (2.2-10.2)</td>
<td>172</td>
<td>3757</td>
<td>100</td>
</tr>
<tr>
<td>Wheat</td>
<td>4.8 (1.1-10.8)</td>
<td>115</td>
<td>662</td>
<td>Minor</td>
</tr>
<tr>
<td>Maize</td>
<td>8.0 (1.0-17.5)</td>
<td>152</td>
<td>1399</td>
<td>Minor</td>
</tr>
</tbody>
</table>

Transgenic monoculture
The global land area under transgenic crop increased 4.5 fold at one year interval i.e. 2.8 mha in 1996 to 12.8 mha in 1997 (Altieri, 2000) and in 2010 it was 150 mha. India has more than 11 mha area under Bt cotton. Transgenic crops being grown mostly are herbicide resistant maize, rice, canola, soybean and insecticide resistant cotton. Transgenic crops are grown as monoculture due to high level of uniformity in morphology and uniform management practices and ease of application of broad spectrum herbicides.

Implications of Transgenic Monoculture
Altieri (2000) has described the following ecological consequences of Transgenic monoculture:

- Imbalance in composition of community;
- Increased use of broad spectrum herbicides promote herbicide resistance in weed population;
- Residual effect due to more repeated use of herbicides will narrow the choice of crops in rotation;
- HRCs will act as weed in other crop fields;
- Transfer of herbicide resistant gene from HRC to its relative weeds will give rise to "Superweed";
- Increased dominance of non-lepidopteran insects in Bt resistant crops;
- No reduction in insecticide doses as more insecticide will be needed to control other non-lepidopteran insects;
- Continuous release of Bt toxin in field will pose strong selection pressure and cause resistance in lepidopteran insects;
- Natural enemy insect which feed on insects targeted through Bt cotton will extinct due to starvation;
- Reduction in Agroecosystem complexity due to total weed removal will deprive us of certain benefits of acceptable levels of weed diversity such as soil cover reducing erosion, allelopathic effect on other weeds.

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Dutta, K. K. and Jong, C. 2002. Adverse effect of water logging and soil salinity on crop and land productivity in northwest Haryana India. *Agricultural water management* 57: 223-238


AGRO-ECOSYSTEM IMPROVEMENT STRATEGIES IN MONOCULTURE

Sarita Rani¹, Rekha Rantanoo² and Sunil Beniwal¹

¹Department of Agronomy, College of Agriculture, CCS Haryana Agricultural University, Haryana, India
²Department of Agronomy, Punjab Agricultural University, Punjab, India
Corresponding author email: sarita.sherawat92@gmail.com

Abstract
Monoculture is a prevalent practice widely adopted in India. It is a agricultural practice of growing a single crop, plant, or livestock species, variety, or breed in a field or farming system at a time. In multi cropping more than one crop is grown in the same space at the same time. In the last half century, agriculture intensification has occurred at a faster rate in terms of dissemination of high yielding varieties, consumption of large amount of energy, more application of external inputs (fertilizers, irrigation, plant protection measures, herbicides etc), purposeful selection of single crop and varieties, which collectively disturbs the natural ecosystem and enhance the willful cultivation of agro-ecosystem (human interfered one). This led ecological implications viz., reduction in diversity of plant species, soil health deterioration, environmental pollution, depletion of available water resources, nutrients imbalances, human health issues etc. Problems associated with monoculture are needed to be addressed and their improvement strategies should be worked out. This chapter elaborates the different improvement strategies to be taken into action for improving agro-ecosystem of monoculture.

Monoculture is a prevalent trend of crop cultivation and an important feature of Indian agriculture. It is observed from last decades that cultivation of single crop or cropping system year by year leads to ecological concerns and negatively affect the sustainability of Indian agriculture. We all aware about the ecological impacts of countinous cultivation of rice-wheat cropping system in major part of Indo-gangetic plains, which led to many problems viz., reduction in diversity of plant species, soil health deterioration, environmental pollution, depletion of available water resources, nutrients imbalances, human health issues, sustainability issues etc. But at the same time diversification in these prevalent cropping system needs time and suitable options regarding the crop selection, its market value, farmer socio-economic level, mental level satisfaction, etc so, we have to work out some important and simple technological interventions, that can help in improving the agro-ecosystem of existing monocropping trends. This chapter provide options available in literature that can be used for agro-ecosystem improvement. Overall all success of technological interventions is further strengthened by policy and financial support by the government sector.

Agroecosystem improvement in monoculture
Natural ecosystems are considered more stable and sustainable owing to their relative abundance of species, spatial patterns, trophic interactions which are superior to human designed alternatives. Even when natural ecosystems are more sustainable, potential benefits from mimicry will often be limited by incompatibility between agricultural goals and the characteristics which allow natural ecosystems to function as they do. Complete mimicry of natural ecosystem is neither necessary nor possible because: Natural ecosystems persist without synthetic inputs while agricultural productivity can not be maintained just depending upon the indigenous supply and self regulation of insect pest and diseases as proved by several researches. Agricultural constraints (exporting protein and energy to cities, challenges in managing mixtures) that would limit the complete mimicry.
The improvement in any agroecosystem should be based on two principles:

- Maintaining the biodiversity
- Judicious use of resources

In fact, recently developed concepts like Conservation agriculture (CA), Best Management Practices and Resource Conservation Technologies can give an answer to continuously increasing demand for food as well as degradation of natural resources owing to conventional agricultural practices.

Conservation Agriculture

The term conservation agriculture refers to the system of raising crops with minimum tillage of the soil while retaining crop residues on the soils. It aims at reversing the process of degradation inherent to the conventional agricultural practices like intensive agriculture, burning or removal of the crop residues. Thus, conservation agriculture is a management system that maintains a soil cover through surface retention of crop residues, no tillage and reduced tillage. This concept has been found favourable in the states of Punjab, Haryana and Western UP. The key features include:

a) Minimum soil disturbance by adopting no-tillage and reduced tillage for agricultural operations.

b) Leave and manage the crop residues on the soil surface.

c) Adopt spatial and temporal crop sequencing/crop rotation to derive maximum benefits from inputs and safeguard the environmental impacts.

Crop cover

i) The importance of surface residues lies in soil water conservation and reduction in wind and water erosion.

ii) Crop residues of cultivated crops are a significant factor for crop production through their effects on soil physical, chemical and biological functions as well as water and soil quality. They can have both positive and negative effects, and the role of agricultural scientists is to enhance the positive effects.

iii) The energy of raindrops falling on a bare soil result in destruction of soil aggregates, clogging of soil pores and rapid reduction in water infiltration with resulting runoff and soil erosion. Mulch intercepts this energy and protects the surface soil from soil aggregate destruction, enhances the infiltration of water and reduces the loss of soil by erosion.

iv) Surface mulch helps reduce water losses from the soil by evaporation and also helps moderate soil temperature. This promotes biological activity and enhances nitrogen mineralization, especially in the surface layers.

v) A cover crop and the resulting mulch or previous crop residue help reduce weed infestation through competition and not allowing weed seeds the light often needed for germination. There is also evidence of allelopathic properties of cereal residues in respect to inhibiting surface weed seed germination.

Minimum Tillage

i) Tillage takes valuable time that could be used for other useful farming activities or employment. Zero tillage minimizes time for establishing a crop. The time required for tillage can also delay timely planting of crops, with subsequent reductions in yield potential.

ii) Tractors consume large quantities of fossil fuels that add to costs while also emitting greenhouse gases (mostly CO2) and contributing to global warming when used for Ploughing.

iii) Turnaround time in this rice–wheat system from rice to wheat varies from 2 to 45 days, since 2–12 passes of a plough are used by farmers to get a good seedbed. With zero-till wheat this time is reduced to just 1 day.

iv) Tillage and current agricultural practices result in the decline of soil organic matter due to increased oxidation over time, leading to soil degradation, loss of soil biological fertility and
resilience. Zero-tillage, on the other hand, combined with permanent soil cover, has been shown to result in a build-up of organic carbon in the surface layers.

**Rotations**

1. Crop rotation is an agricultural management tool with ancient origins. The rotation of different crops with different rooting patterns combined with minimal soil disturbance in zero-till systems promotes a more extensive network of root channels and macropores in the soil. This helps in water infiltration to deeper depths.

2. Because rotations increase microbial diversity, the risk of pests and disease outbreaks from pathogenic organisms is reduced, since the biological diversity helps keep pathogenic organisms in check.

**Best management Practices**

A practice or combination of practices to be effective and practicable (given technological, economical and institutional considerations) to manage nutrients to protect surface water and ground water. Those practices include: conservation tillage, crop rotation, soil testing, crop diversification, fertilizer splitting, IWM and IPM, water conservation practices, use of biopesticides, biofertilizers and bioherbicides and so on.

**Table 1. Individual and system (annual) crop yield in different treatment scenarios consisting of CA and/or BMP (Laik et al. 2014)**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Wheat (Mg/ha)</th>
<th>Legume (Mg/ha)</th>
<th>Rice (Mg/ha)</th>
<th>System yield (Rice equivalent) Mg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.78 b</td>
<td>-</td>
<td>4.38 a</td>
<td>7.37 c</td>
</tr>
<tr>
<td>2</td>
<td>3.64 a</td>
<td>1.43 a</td>
<td>4.82 a</td>
<td>13.61 a</td>
</tr>
<tr>
<td>3</td>
<td>4.06 a</td>
<td>0.49 b</td>
<td>5.43 a</td>
<td>11.25 b</td>
</tr>
<tr>
<td>2010-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3.07 b</td>
<td>-</td>
<td>6.52 b</td>
<td>9.63 c</td>
</tr>
<tr>
<td>2</td>
<td>3.71 b</td>
<td>1.86 b</td>
<td>6.84 ab</td>
<td>16.62 a</td>
</tr>
<tr>
<td>3</td>
<td>4.72 a</td>
<td>4.18 a</td>
<td>7.17 ab</td>
<td></td>
</tr>
</tbody>
</table>

Scenario 1: wheat-fallow-rice; farmer’s practice
Scenario 2: wheat-mungbean-rice; BMP + partial CA (conservation agricultural practices)
Scenario 3: wheat-cowpea-rice; BMP (Best management practices) + full CA

Resource Conservation Technologies/ Natural resource management

Intensified agriculture coupled with indiscriminate use of irrigation water and heavy application of fertilizers and/or plant protection chemicals to achieve maximum production in irrigated areas has led to various kinds of physical and chemical degradation of the soil. Besides, emergence of multi-nutrient deficiencies, and the problems of soil salinity, alkalinity and water logging also got accentuated. This calls for integration of technologies for conservation and management of resources vis-à-vis input-use efficiencies while safeguarding the soil health and sustaining the productivity. Gupta, 2010 has suggested the Natural Resource management solutions for monoculture based intensive cereal systems (Table 2)
### Integrated Farming System: The Future of Agriculture

<table>
<thead>
<tr>
<th>Production system constraint</th>
<th>Potential solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>High production cost, resource fatigue, and low factor productivity</td>
<td>Conservation agriculture based RCTs</td>
</tr>
<tr>
<td>Impending Ug 99 threat, low seed replacement rate</td>
<td>Farmer participatory seed systems, seed cooperatives and seed quality</td>
</tr>
<tr>
<td>Water scarcity, declining water tables</td>
<td>Laser land leveling, AWD, remove puddling, direct seeded rice, skip furrow irrigation, bunding (rainwater), mulching ZT and raised beds</td>
</tr>
<tr>
<td>Lowland flooding/ excess moisture</td>
<td>DSR before rains, sub-1 rice</td>
</tr>
<tr>
<td>Late planting of cereals and other crops</td>
<td>DSR-ZT, Double ZT, surface seeding, relay seeding, short duration Cultivars</td>
</tr>
<tr>
<td>Imbalanced and inappropriate fertilizer use, multiple nutrient deficiencies and low nitrogen use efficiency</td>
<td>Conjunctive use of organics and fertilizer nutrients (R, W, M), SSN, LCC, Green seeker, customized fertilizer recommends. N application methods/schedule</td>
</tr>
<tr>
<td>Late rice nursery, <em>rabi</em> (rice fallows) and <em>kharif</em> fallows</td>
<td>Some ground water development, Surface seeding, Relay crops, Intercrops</td>
</tr>
<tr>
<td>Weeds complexes and non availability of the chemical molecules</td>
<td>Pre seeding herbicides, stale bed technique, integrated weed management, minimal soil disturbance protected sprays intercrops and cover crops</td>
</tr>
<tr>
<td>Weedy rice</td>
<td>Stale beds/ pre-plant herbicides, new cultivars (Apo)</td>
</tr>
<tr>
<td>Herbicide resistance, and weed escapes</td>
<td>Crop rotations, herbicide rotation, residues mulching, no-till, herbicide resistant crops</td>
</tr>
<tr>
<td>Low profitability of sugarcane-wheat systems</td>
<td>Autumn planting, raised beds for intercropping of wheat and other winter crops in cane</td>
</tr>
<tr>
<td>Residue burning, air quality</td>
<td>New generation planters for residue management (turbo seeder, PCR planter)</td>
</tr>
<tr>
<td>Low diversification of RWCS</td>
<td>Intercrops, raised bed planting, short duration legumes</td>
</tr>
<tr>
<td>Labor and energy shortages</td>
<td>Mechanization (zero tillage, land leveling, DSR)</td>
</tr>
<tr>
<td>Seed viability, post harvest losses</td>
<td>Post harvest solutions (drying, storage, superbags)</td>
</tr>
<tr>
<td>Low productivity, sodicity, acidic soils, Zn,B deficiencies</td>
<td>Cultivar choices, mixed cropping, fertilizer methods/schedules</td>
</tr>
<tr>
<td>Fodder shortages, poor animal health / productivity</td>
<td>Cover/ intercrops for fodder crops, introduction of chaff cutters for wheat, maize, rice straw in Eastern India</td>
</tr>
<tr>
<td>Non availability of the machinery and inputs in Eastern plains</td>
<td>Custom service, cooperatives, create local machinery banks</td>
</tr>
<tr>
<td>Mismatched perceptions among the stakeholders (e.g. rotavator)</td>
<td>Information communication technologies, policy (farmers-researchers-policy interface)</td>
</tr>
<tr>
<td>Less existence of Public-Private Partnerships (ppm) and research-extension linkages and less trained man power for CA</td>
<td>Capacity building, study tours, graduate internships, certified crop advisors, net working, strengthen PPP</td>
</tr>
</tbody>
</table>
In all, inclusion of following management practices adopted according to requirements can help in mitigating the adverse impact of monoculture practice on environment:

- Inclusion of Legumes in intensive cereal based cropping systems.
- Incorporation or surface mulching of crop residues.
- Adoption of IPM and IWM which is based on principle of maintaining the pest population below ETL instead of complete eradication.
- Adoption of Direct seeding of rice in order to reduce pressure on scarce water resources and timely sowing of succeeding wheat crop.
- Laser Land leveling to increase water and nutrient use efficiency.
- Site-specific nutrient management and timely correction of micronutrient deficiency.
- Zero tillage, minimum tillage to save fuel and large costs of field preparation.
- BED planting of wheat and maize in order to increase water use efficiency and ease of mechanical weed control.
- In case of transgenic (insecticide resistant) crop, grow mixture of transgenic and non-transgenic cultivars to delay the development resistance in pests

**Conclusion**

Indian agriculture is facing many challenges and sustainability is major issue. In order to sustain the agro-ecosystem of prevalent monoculture in India various resources conservation technologies plays a vital role. Adoption of various technologies at farmer level is a function economic level and financial need besides its suitability for particular region and place. Proper extension service, method demonstration and government support are key input for their adoption at wider level.

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**Integrated Farming System: The Future of Agriculture**


Abstract

Seed is a basic input in agriculture. Seed may be defined as “Structurally a true seed is a fertilized matured ovule, consisting of an embryonic plant, a store of food and a protective seed coat, a store of food consists of cotyledons and endosperm” Seed may be sexually produced matured ovule consisting of an intact embryo, endosperm and cotyledon with protective covering from seed coat. So seed is propagating materials used for production purpose. Seed is the most vital crucial input for crop production.

Timely availability of certified quality seeds of high yielding varieties is still a major concern. Concerted and coordinated efforts are imperative in ensuring timely availability of seeds as well as increasing the seed replacement rate. The production of pure seeds and seeds are multiplied through different types such as nucleus seed, breeder seed, foundation seed and certified/truthful labeled seed (Trivedi and Gunasekaran, 2013). The process of quality seed production of notified varieties is regulated by the Seed Act, 1966. The bags of different classes of seed are identified with specific coloured tags.

Different classes of seed for varietal improvement

<table>
<thead>
<tr>
<th>Colour of tags used for different classes of seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic or nucleus seed (Stage I and Stage II)</td>
</tr>
<tr>
<td>Breeder seed (Stage I and Stage II)</td>
</tr>
<tr>
<td>Foundation seed (Stage I and Stage II)</td>
</tr>
<tr>
<td>Certified seed(Stage I and Stage II)</td>
</tr>
<tr>
<td>Truthful labeled seed</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The major seed quality characters were describe followed.

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. This quality character could be obtained with seed lots by proper cleaning and grading of seed (processing) after collection and before sowing/ storage.

Genetic purity

It is the true to type nature of the seed. i.e., the propagating material 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.
**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. Difference in seed vigour will be expressed in rate of emergence, uniformity of emergence and loss of seed germination.

**Seed Health**

Health status of seed is nothing but 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.

**Whereas, the good quality seed should have**

- High genetic purity
- High pure seed percentage (physical purity)
- High germinability
- High vigour
- Free from pest and disease
- Good shape, size, colour etc., according to the specification of variety
- High longevity / shelf life.
- Optimum moisture content for storage
- High market value

**Maximum genetic purity:**

- Breeder /Nucleus - 100%
- Foundation seed - 99.5%
- Certified seed - 99.0%

**How Doubling Farmers’ Income**

All the nations facing problems of poverty, hunger and malnutrition will need to accelerate their agricultural growth for achieving sustainable development goals (SDGs), especially while aiming at no poverty, zero hunger and safe environment for all (Paroda, 2017). The Green Revolution not only led to food self-sufficiency but also helped to reduce the poverty and hunger. And yet, despite fivefold increase in food grains production, as against a fourfold increase in population, India still has around 250 million people who live in poverty and about 45 million children below five years of age who are malnourished. Moreover, after 50 years of Green Revolution, India is also facing the second generation challenges like decline in the factor productivity growth, poor soil health, loss of soil organic carbon, ground and surface water pollution, water related stress, increased incidence of pests and diseases, increased cost of inputs, decline in farm profits and the adverse impact of climate change. On the demographic front, India adds annually almost one Australia (about 15-16 million) to its population. Thus, any progress gets nullified by an overall increase in population. Also, around 48% of the population is currently dependent on agriculture and allied fields and the agriculture sector contributes around 17% to national gross domestic product (GDP). Moreover, the public sector capital investment in agriculture and rural development has declined from almost 20% during Green Revolution period to currently less than 10%. In the process, many States have remained deprived of growth and development. As a result, most farmers are not benefitted especially since majority of them are smallholders and find agriculture not profitable any more. The Prime Minister’s vision of doubling farmers income by 2022 is worth serious attention. This laudable objective could not only improve the well being of our farmers but can also be a trigger to boost agri-based manufacturing growth in rural India. But it is also important to have a debate on how best to achieve this objective. First we need to define our target. Doubling farmers’ income implies increasing income form crop cultivation. At the current 3-per-cent growth rate it would take 25 years to double farmers’ income. If a large number of agricultural households are connected to mass consumption markets both domestic
and global the objective of doubling farm income doesn’t seem daunting. The focus must shift from increasing per acre productivity to gainfully employing farm households in other farm-related activities. The explosion of the services sector allowed that to happen in urban India. We need a similar catalyst for the lowest end of the income spectrum among rural households. The goal should be to double incomes of rural, farm owning households in the bottom quartile income. A supplementary goal should be to use this effort to trigger a much needed boost to agriculture and to agric-related manufacturing.

An interesting experiment was taken up by the Gates Foundation in developing small-scale poultry farming around the villages of Itarsi. These poor households generated an annual supplementary income of around 50,000 per household. Solutions for doubling household income must centre around this “Itarsi Model”. There is the need to involve the under-employed adults in rural households in low-skilled non-crop activities that integrate output from these activities into the existing or future markets. Central to this approach is creating a market-place that supports a rural enterprise which is partly agricultural and partly non-agricultural.

The following five activities could be developed across India for booting rural incomes.

**Menstrual hygiene market**

Thirty years ago, the shampoo market in India exploded, mainly driven by a spike in consumption due to a rupee denominated sachet, locally assembled in small units spread across rural areas in Tamil Nadu. Similarly, localising the assembling of sanitary napkins in small units set up by enterprising women in villages can create a rural-based production system that generates employment and creates basic industrial skills. Such enterprises can create supply chains and further employment generating economic activities. If 500,000 households in the poorest rural districts were brought into this production system, and each household produced up to 200 pads a day, realising as conversion cost, that would lead to an incremental annual income of 60,000 per household. Direct employment can be provided to 5 lakh women, and supporting employment from the household for another 2.5 lakh persons. The upstream employment generation potential for producing manual presses, the potential for repairs and maintenance of this equipment, additional employment for producing raw materials, storage and transportation of raw materials/finished goods and incremental income for the PDS network would be net incremental.

**Goat rearing**

On goat rearing, studies by various researchers point to the potential for net annual income of 1,200-1,300 per goat which can increase to 2,000 per goat through value addition to milk and leather processing. An average herd size of 10-15 goats can produce an annual income 12,000-19,000 per household which is also driven by the growing market for meat. Collection of goat milk from above households and distribution through the milk co-operatives will create a large, broad-based collection, processing and storage infrastructure. Importantly goat rearing will integrate the most water-stressed regions into the milk grid. Including goat’s milk into the mid-day meal scheme across India can create a massive market for goat milk and creates opportunities for setting up goat dairying infrastructure. There are opportunities in goat cheese production which is in great demand in overseas markets. Goat hide is another opportunity for creating home-based production systems that engage the womenfolk and young adults. Leather garments, footwear, bags and wallets could be produced and marketed through organized retail both within and outside country.

**Honey production**

The declining bee population is a cause of concern for agricultural scientists in India. Apart from helping in pollination of crops, apiaries can be a low-cost source of income for rural households.
Each hive produces about 40 kg of honey. At ₹75 per kg, it has a revenue potential of 3,000 per hive. Each household can manage 10 to 15 hives to generate an annual income of 30,000-45,000 through this enterprise. A milk collection type system will ensure that the collected honey is processed, packaged and branded to international standards and made available to domestic retail outlets and for exports. Again, the mid-day meal scheme is an excellent outlet for providing this nutritional food to our children.

**Value addition to crops**

Some crops have great potential for value addition. Potato production in India has ranged between 45-48 million tonnes. Prices collapse when production touches the higher end of that range. If 5-7 mt were to be absorbed for use in the mid-day meals as processed potato flake-based products, a massive new food industrial segment would emerge. Additionally, if the government were to mandate that all wheat flour sold in the country carries 5 per cent potato flour, the problem of glut in potato production can be overcome. Kalahandi District, an underdeveloped district, produces excellent quality turmeric. The curcumin content of that turmeric is of pharmaceutical grade. If pharma companies are incentivised to set up solvent-based extraction facilities in this district, it will increase the farm gate price for tribal farmers as they move from selling to spice traders to a value-added use of the turmeric.

**Bio-fuel market**

Biofuel crops like Jatropha should be permitted for genetic modification for increased oil yields. Oil companies should help village entrepreneurs to set up collection and processing units for absorbing every kg of seed produced and the output blended with hydrocarbon fuels as done in Brazil. Turning farm waste into fuel instead of burning is another worthwhile project. These will bring low income rural households into a commercial farming and encourage small enterprises for collection, processing and extraction of bio-fuels. The current MSP driven model to increase farm income is not sustainable and does not increase productivity. The government should leverage the petroleum distribution network, the Army supply chain, the milk grid, and the mid-day meal scheme to re-orient existing subsidies towards developing markets for rural manufactured produce. This creates industrial jobs in rural India and generates employment and non-farm income for rural households. A sudden withdrawal of subsidies will hurt the farmers, but creating industrial units in rural areas will create jobs and wean away the weakest from a debilitating, non-value creating model of dependency.

**Initiatives by the Government for doubling the farmer’s income**

For quite some time now, the distress of small and marginal farmers has been drawing the attention of policy makers. In 2004, the Government had set-up a National Commission on Farmers, headed by Dr. M.S. Swaminathan. The Commission had submitted the reports in 2006 (Govt. of India, 2006) aiming at “faster and more inclusive growth”. It came out with several useful recommendations to revitalize agriculture and protect farmers from vagaries of nature and price volatility. The key recommendations were: i) improving farmers’ income from farm and non-farm sources, ii) enhancing efficiency in the use of resources, iii) minimizing expenditures on non-renewable inputs, and remunerative price to farmers at 50% higher than the minimum support price (MSP). Somehow, the last recommendation, which is directly linked to farmers’ income, has not yet been implemented. On the contrary, the price fluctuations in the market of farmers’ produce and the higher cost of inputs have caused widespread discontentment among farmers, resulting in protests and even suicides, thus drawing an urgent attention of the policy makers to draw a strategy for doubling farmers’ real income. As a first step, the Government changed the name of the Ministry as: Ministry of Agriculture and Farmers’ Welfare. It also initiated the programmes like Attracting Rural Youth in Agriculture ARYA), Mera Gaon Mera Gaurav, National Skill Qualification Framework, Skill Training, Value Addition and Technology
Incubation Centres in Agriculture (VATICA), Knowledge Systems and Homestead Agricultural Management in Tribal Areas, 6 Nutri-sensitive Agricultural Resources and Innovations (NARI), Climate-Smart Villages, Web and Mobile Advisory Services. The potential role of farmer producers organizations (FPOs) in innovation up scaling for increasing overall income has also been given due importance. The present Government has taken many new initiatives for increasing the farmers’ income such as: i) “per drop, more crop”, ii) availability of quality seeds, iii) soil test based nutrient management - distribution of soil health cards, iv) post-harvest crop losses- large investments in warehousing and cold chains, v) value addition by the farmers, vi) creation of a national agricultural market, by removing distortions and having e-markets to link farmers to market, vii) Pradhan Mantri Fasal Bima Yojana, viii) high priority to diversification towards high value activities – horticulture, dairying, food processing, poultry, sericulture, bee keeping and fisheries, etc. Also, the Govt. in its budget of 2014-15 had established National Adaptation Fund for Climate Change, also a long-term Rural Credit Fund, provision of financial assistance of INR 5 lakhs for Bhoomi Heen Kisan though National Bank for Agriculture and Rural Development (NABARD), launching of soil health cards, Pradhan Mantri Krishi Sinchayee Yojana, Agri-Tech Infrastructure Fund. In its budget of 2015-16, the Government had emphasized on rural infrastructure development and created a Long-Term Credit Fund, Short-Term Cooperative Rural Credits Refinance Fund and Paramparagat Krishi Vikas Yojana to promote organic farming. Further, in the budget of 2016-17, a provision for Long-Term Irrigation Fund was made and the Union Budget of 2017-18 made some special provisions: i) allotted INR 10 lakh crores to ensure adequate flow of credit to under-service areas, ii) allotted INR 9,000 crores to increase the coverage under Pradhan Mantri Fasal Bima Yojana, iii) emphasized contract farming for strengthening and linking horticulture sector and agro processing units, iv) allotted INR 2,000 crores for dairy processing and infrastructure development to NABARD for modernizing milk processing 7 units. Besides these, several other measures were taken in the past for promoting agriculture and farmers’ income such as MGNREGA, Rashtriya Krishi Vikas Yojana (RKVY), etc. The resources of NABARD are also being augmented substantially following Parliament’s nod to a six-fold increase in its authorized share capital to INR 30,000 crores. The Development Financial Institution (DFI) is eyeing a balance sheet size of INR 7 lakh crores by 2023 as against INR 3.90 lakh crores as at present. The rural India focused DFI plans to achieve this balance sheet size by stepping up focus on providing support to irrigation projects, dairy farming, improving market infrastructure in rural areas (so that farmers get remunerative prices for their produce), enhancing credit flow to deprived areas such as central and eastern States, and support to rural housing. Despite these initiatives, the agricultural economists have differing views. Some have even expressed doubts and consider the goal unrealistic and unachievable since there is negligible information available on farmer’s income and also there is no clarity as to how to double the income (Gulati and Saimi, 2016). This is because the real income in the past has increased only by 5.2% per annum between 2002-03 and 2012-13. At this rate, it may take at least more than a decade to double the real income of farmers, unless a new and dynamic strategy is put in place and implemented in a Mission Mode (as suggested later) to achieve higher than 10% income per annum, which appears to be a gigantic task. NITI Aayog has indicated that doubling the farmers’ income may take a little longer than the target year of 2022, unless needed reforms are expedited (Chand, 2017). Also, the combined effect of growth was found to be 75.1% in seven years and 107.5% in 10 years. According to him, if the farmers’ income growth is considered to rise at the same rate as experienced between 2001 and 2014 (except price factor), the income will rise by 66% by 2022-23 and will possibly double in 10 years i.e., by 2025-26.

Doubling of farmers’ income must be attempted by creating a framework where all related agencies come together and work in harmony, with a maestro conducting that orchestra. In its initial years of reforms started by China between 1978 and 1986, witnessed growth of 14% per annum in farm income. This led to a reduction in poverty by half by generating demand for
industrial products in rural areas. Doubling rural income in nominal terms is possible by increasing agriculture output & minimum support prices (while keeping inflation below 5%), doubling rural income in real terms would be a daunting task considering increasing agriculture output by 12% every year with no additional land likely to be utilized for agricultural activity. However, a long term solution remains faster execution of policies that could develop infrastructure to support irrigation system and reduce the dependency on rains. There is every possibility not only to double the income of farmers through enhancement in productivity, changes in cropping pattern, inspire additional income through many supplementary activities but also provide stability in farmer’s income.

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DOUBLING FARMERS’ INCOMES: APPROACHES

Sneha Singh¹, Satyendra Kumar Singh¹ and Niraj Kumar Mishra²

¹Department of Extension Education Institute of Agricultural Sciences, Banaras Hindu University, Varanasi- 221005
²Department of Extension Education, N.D.U.A.T, Kumarganj, Faizabad.(UP)
Corresponding author email: sarita.sherawat92@gmail.com

Abstract

Agriculture development in India has been viewed by and large in the background of increasing the output rather than welfare of the farmers. In the recent past, the sector has been facing ordinary distress and crisis posing a severe threat to peasants in practicing agriculture as a main source of livelihood. Under this perception, the Government of India in 2016 announced to double the farmers income (DFI) by 2022 by shifting the focus from agricultural output and food security to income security. Farm household income comprise revenue from sources viz., wage, crop production, livestock rearing and non-farm activities (non-farm income includes earnings from non-agricultural economic activities like manufacturing, handicrafts, repairs, construction, mining and quarrying, transport, trade, communication, community and personal services in the rural areas etc).

The Government of India in its annual budget of 2016-17 set a policy target of doubling farmer’s income by 2022. Agriculture sustains livelihood for more than half of the country’s population. Doubling farmers’ income in such a short period is a daunting task. Literature reveals that between 2004-05 and 2011-12 the real per caput farm income (from agriculture and allied activities) of cultivators increased by 64%. Data of NSSO and CSO of 2002-03 and 2012-13 revealed only a 34% increase in farmers’ real per caput income. In India, the farmers maintain different enterprises for their gracious and complementary nature and for ensuring sustainable livelihood from time immemorial. After the beginning of green revolution in late-1960s and economic liberalization in early-1990s, the farmers progressively started focusing on a few enterprises due to several imposing factors including shrinking farm sizes, unpredictable commodity prices, livelihood diversification and shortage of labor during peak agriculture season. It had a severe impact on food and nutritional security of millions of poor farm households. The anguish of farmers is often expressed in terms of their agitation in one or the other part of the country, unwillingness to continue farming and increasing demands of compensating their economic loss. Although suggestions are pouring in from experts and leaders of organisation for strengthening the income base of farmers, the government cannot implement them entirely due to compulsions from socio-economic and political considerations. However, the Government of India has made an announcement about Doubling Farmers’ Income by 2022. Experts are judging the options and strategies for achieving this enviable target. One of the options is to estimate the potential of age-old integrated farming system (IFS) in enhancing income of farm families within the seasonable time period. This paper deals with dairy-based project combinations for their contribution to sustainable livelihood of farm families with income enhancement as a major plank. The intention of the Government of India is to double the income including farm and non-farm activities in a span of six years since the announcement requires a compound annual growth rate of 12.25% from the base year 2016. Given the sources of income, the article discusses the pathway and strategies for doubling the income of wheat producers by 2022, a major food security crop accounting for about 35% of total food grains produced and being cultivated in 30.6 million ha by around 25 million farmers. Doubling farmers’ income with
dairy as a major component of the farming system based on the identified parameters from the study and the existing literature.

**Approaches**

The role and factors associated with integrated farming system have been studied as a potential option to improve farmers’ income and ensure their sustainable livelihood in India. The contribution of different combinations of enterprises such as poultry, fishery, sheep and goat and horticulture; with crop and dairy as base enterprises have been analysed for their impact on farmers’ total income. The financial benefit of adopting different enterprise combinations analysed through partial budgeting has been found ranging from ₹ 7880/ha to ₹ 57530/ha. A demand and profit oriented shift in preferences of farmers towards keeping farm forestry, mushroom culture, fishery, goat and poultry rearing from 1994 to 2014 in India (Haryana) was noticed by the trend analysis. The heavy investment in the initial years and non-availability of labour were observed as the major constraints in adopting integrated farming system. The farmers can realize the doubling of their income within a contemplated period of five years by adding livestock in the farming system and reap the consequent social and ecological benefits. The incomes from each combination are computed from the yield of the component enterprises and price realised by the sample respondents. Income variations from enterprise are combined with other socio-economic parameters. Further, case study approach was followed for calculating the total income contribution through partial budgeting method in 2017. An estimate of income that could be realized from the manure and urine of different animal components in the IFS was made.

**Agriculture policy and relief to farmers**

A highly potent strategy to augment farmers’ income relates to their differential access to information. There has been significant penetration of mobile phones in rural areas, but this means of communication has remained grossly under exploited for dissemination of information on agricultural technologies, practices, weather advisories, programmes and policies. The modern communication technologies can be a cost-effective and efficient means of information dissemination. The need is to bundle all types of information that farmers need, and link it with the modern communication networks for its dissemination. In the long run, boost to farmers’ income must come from technological breakthroughs as per niches of markets, enhance resource-use efficiency, reduce cost of production and improve resilience of agriculture to extreme changes in climate. The role of non-farm sector (including labour market, salaried employment, and businesses) would be an important pathway for enhancing farmers’ income, especially small- and marginal-farmers. The government agenda for doubling farmer's income by 2022 is a daunting task since around 70% of the farmers have annual per caput income less than ₹ 15,000. Only 10% of them earn more than ₹ 30,000. Only 7% of the marginal farmers fall in the high-income class (> ₹ 30000). To achieve doubling farmer's income might require novel strategies and some change in the policy stance. The income enhancement of farmer would come mainly from seven sources like increase in productivity of crops, increase in production of livestock, improvement in efficiency of input use that would save cost, increase in cropping intensity at farmers’ field, diversification towards high value commodities, better remunerative price realized by farmers, and shifting way surplus labour (unproductive) from agriculture to non-farm activities. This could only be possible through government development initiatives, technology generation and dissemination besides policies and reforms in agriculture sector.
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**Implication**

The MSP regime in India in centivizes farmers to grow crops more intensively. The domestic price of agri produce is more influenced by international (future) price rather than cost of production and other production risks. The general trend of international future price of agri-produce is lower than domestic price or MSP. This arrest the commensurate rise in domestic MSP/market price compared to cost of production. There is no check on rise in cost of inputs used in agricultural production. Here some points are discussed:

- System mode of production incorporating crop, livestock, fish, horticulture and agro-forestry is a potential option for doubling farmer’s income.
- The severity of constraints experienced in the adoption of IFS could be reduced through market intelligence along with risk management, processing and value addition.
- The productivity and total production could been hanced through supply of quality inputs including seeds, fingerlings, birds for back yard poultry and saplings.
- Empowering farmers with real time access to information and ICT tools and knowledge networks like effectively contribute to higher income realization.

**Conclusion**

In conclusion, doubling farmers’ income in a short period could be possible, if the stakeholders follow a comprehensive, multi-pronged and targeted approach encompassing income opportunities and their enabling conditions including investment in agricultural R&D and infrastructure, and development of institutions and human resources. The ambition of the Government of India has to be met comprehensibly through productivity improvement coupled with cost reduction, price realization and policy support. Income from a single crop or commodity will not fulfill the target of doubling farmers’ income but it has to emulate from farm and non-farm sources. Diversification of activities which yields better reward (region specific) should be the ideal strategy. Clearly, in the case of wheat, the whole value chain has to be strengthened to be on the track of doubling the income for all classes of farmers.
INFLUENCE THE ENZYME ACTIVITIES IN SOILS CONTAMINATED TO HAZARDOUS ELEMENTS PARTICULAR HEAVY METAL IN VARYING DEGREE

Surendra Singh Jatav¹ and Munnesh Kumar²

¹Department of Soil Science and Agriculture Chemistry, ²Department of Genetic and Plant Breeding, Institute of Agricultural sciences, Banaras Hindu University, Varanasi 221005-U.P. India
Corresponding Author Email: surendra.jatav1@bhu.ac.in

Abstract

Soil Enzymes and Their Role in Soil The biological activity of the soil, the enzyme activity, is an important component indicating the regularity of soil processes. Soil enzymes catalyze processes related to the breakdown of organic matter mineralization into the soil during plant growth. They also stimulate the processes connected with the formation, decomposition of soil humus, and a distribution and release of mineral substances.

Moreover, enzymes are responsible for making those substances available to plants and for binding of molecular nitrogen, detoxification of xenobiotic, as well as nitrification and denitrification processes (Das and Varma 2011). Soil enzyme activity results from the activity of the enzymes accumulated in soil (extracellular enzymes) and from the enzyme activity of reproducing microorganisms (intracellular enzymes). Cells of microorganisms, as well as remains of plants and animals, are sources of enzymes in the soil (Mukhopadhyay and Maiti 2010). The enzyme activity of the soil is most often assessed on the basis of the effect of five enzymes: dehydrogenase, phosphatase, urease, invertase, and protease. The activity of soil enzymes is also known as a sensitive indicator of natural and anthropogenic changes in ecosystems, which is used to assess the impact of various pollutants including heavy metals in the soil, both in a long and short period of time (Gulser and Erdogan 2008; Januszek 1999; Kuziemska 2012).

Characterization of Selected Soil Enzymes

Dehydrogenases catalyze redox processes. Under aerobic conditions, they are transferred by a series of intermediaries on to the components of the respiratory chain, and ultimately onto oxygen, while in anaerobic conditions, oxidized inorganic forms such as NO₃, Mn (IV), Fe (III), SO₄²⁻ and CO₂ serve as acceptors of organic compounds, in the fermentation process. Thus, dehydrogenases are indicators of the respiratory metabolism of soil microorganisms mainly of bacteria and actinomycetes they constitute an integral part of living cells and do not accumulate extracellular in the soil. They belong to constitutive enzymes, that is, those which are present in almost constant amounts in the cell, independently of the amount of substrate (Das and Varma 2011). It has been stated that the optimal soil pH value for the activity of dehydrogenases is 6.6–7.2. Dehydrogenase activity depends on the total population of microorganisms living in the soil, and that is why they are considered to be an indicator of overall soil microbial activity (Mukhopadhyay and Maiti 2010). Phosphatases belong to a large group of enzymes that catalyze the hydrolysis of organic phosphorus compounds and are used to assess a potential rate of mineralization of these compounds in the soil (Gulser and Erdogan 2008). These are the following types of phosphatases: acidic, neutral, and alkaline ones. Acid reaction, which corresponds to pH value ranging from 4 to 6, is optimal for acid phosphatase, whereas alkaline pH (pH 8–10) is accurate for alkaline phosphatase. The neutral phosphatase shows optimal activity at a pH value of 6.5–7.0. Microorganisms are the main source of phosphatases in the soil, but they are also produced by roots of plants and soil fauna. Phosphatase activity in soil reflects the activity of enzymes associated with soil colloids and humic substances (Das and Varma...
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2011). Urease catalyzes the hydrolysis of urea in the soil to carbon dioxide and ammonia, which is one of the sources of nitrogen for plants. The activity of this enzyme reflects the ability to transform organic nitrogen to effective nitrogen and the ability to provide inorganic nitrogen (Ianelli et al. 2012). This enzyme is present in the cells of plants and many microorganisms, especially bacteria as both intra- and extracellular enzyme. Proteases catalyze the hydrolysis of proteins in the soil environment, breaking down the peptide bonds (CO-NH) to amino acids. They are produced mainly by aerobic and anaerobic bacteria, fungi, and actinomycetes. Most proteases produced by bacteria are most active at pH 7–8. These enzymes are bound by the mineral and organic colloids (Das and Varma 2011) is an enzyme which is widely distributed in soils. It plays a significant role in increasing the content of soluble nutrients in the soil and carbon transformations. The activity of this enzyme reflects the ability of the soil to break down sucrose and release simple sugars, which are the main energy sources of soil microorganisms.

Natural Environmental Factors Influencing the Activity of Soil Enzymes

The variability of enzyme activity in soils indicate the impact of many environmental factors such as soil type, soil profile depth, composition and diversity of soil microorganisms, soil pH, organic matter content, and temperature on the enzyme activity. Many studies have shown that the activity of enzymes, such as dehydrogenases, urease, protease, phosphatase, and invertase, is proportional to the content of organic matter (organic content of C and total N) and is much higher in the rhizosphere than in the deeper horizons of the soil profile (Chodak and Niklinska 2010; Januszek 1999; Mocek-Płociniak 2011). According to many authors Wolinska and Stepniewska 2012), the factors which have a significant positive effect on the activity of dehydrogenases are the water content and cations, Ca, Mg, K, and Fe, whereas a negative impact is exerted by the oxidizing-reducing potential. Under conditions of the humid temperate climate, it is observed that in most cases, enzymes are most active in summer. Enzymes released from litter, living and dead microorganisms, as well as plant roots, are washed down to lower horizons. Their further fate, stability, and activity in the soil depend on the soil texture, mineral composition, as well as physical and chemical properties of soils. Extracellular enzymes secreted by living or dying cells can be present on the surface of cell walls and cell membranes, as well as fragments of cell organelles or plasma. They can also be accumulated in the soil, where they form labile enzyme-substrate compounds, are adsorbed onto the surface of mineral particles, or enter into complex compounds with colloids of humic substances. They can even remain partially, and on a short-term basis, in the soil solution. Free enzymes are very active but short lived, and they quickly undergo proteolysis. There are not only enzymes bound to organic colloids as a result of copolymerization during the process of the formation of humus and accumulated in humic complexes which may survive for long periods in the soil but also, to a smaller extent, enzymes bound to mineral colloids (Januszek 1999). In comparison with free enzymes, bound enzymes usually display lower levels of activities. It is because the complexation blocks the access to the substrate by occluding the active centers. Therefore, bound enzymes constitute a potential reservoir of enzymes. They can also be the source of enzymes in case of substrate deficiency or stressful conditions. One theory states that the enzyme spread increases as the enzyme-substrate availability decreases, which allows the producer of enzyme to access more distant substrate. The level of enzyme activity in the soil can also depend on vegetation and its succession, as extracellular enzymes are often released by plant roots. The urease activity varies depending on the species of a plant or a combination of plants. Mechanisms connected with the Influence of Heavy Metals on Soil Properties. The increasing interest in the environmental pollution caused by heavy metals results from their toxic effect on plants, animals, and humans. They suppress the activity of enzymes, damage nucleic acid chains, and tend to bioaccumulate in tissues of living organisms. The consequences of their occurrence in the environment are mutagenic and carcinogenic changes in the metabolism or limitation of photosynthesis (Mocek-Płociniak
The effect of heavy metals on soil enzyme activity may be direct or indirect. The direct impact refers to the extracellular free enzymes, while the indirect one is manifested through the influence on the biosynthesis of enzymes performed by microorganisms. The indirect impact is also manifested by the effect of heavy metals on the composition of the population of microorganisms in the soil, as well as root exudates production and the release of enzymes from dead cells. Possible influence on the growth and metabolism of soil microorganisms by disturbing the integrity of cell membranes or adversely affecting their functioning. Heavy metals also reduce soil enzyme activities by interacting with the complex enzyme-substrate and masking catalytically active groups, which produces the effect of denaturation toward active proteins of enzymes. Heavy metals affect the number, diversity, and activity of microorganisms. In the soil polluted with heavy metals, there prevail less diverse, slowly growing microorganisms which are more resistant to metals, but are characterized by a lower biological activity. Lock and Janssen (2005) claim that the zinc contamination of soil causes microorganisms sensitive to this metal to die out. This can increase the number of resistant microorganisms. The activity of intracellular soil enzymes produced by soil microorganisms is inhibited to a greater extent than the extracellular soil enzyme activity. The influence of the heavy metal pollution of the soil on the activity of enzymes depends on the degree of contamination, the type of metal, time of exposure, and environmental factors, including mainly the soil reaction, which plays the key role in the solubility and the activity of metals in the soil. Neutral or alkaline soil reaction contributes to the formation of metal compounds which are hardly soluble and therefore unavailable to plants. The enzyme activity inhibited by heavy metals can also be associated with decreased contents of C, N, and P, which results in a lack of balance in the nutrient content and the soil degradation. However, heavy metals which are present in small quantities in soils may stimulate the activity of enzymes. Not until they exceed the threshold content do they play a role in the reduction of microorganism activity and the production of extracellular enzymes.

### Effects of the Short-Term Influence of Heavy Metals on the Activity of Soil Enzymes Observed During the Incubation

Incubation laboratory experiments enable us to trace the relationship between the content of heavy metals in soil and the level of activity of soil enzymes. The results of several studies show that as more time passes since the start of incubation and as the concentration of metals in the soil grows bigger, the enzyme activity gets lower. The extent of inhibition and the time after which the greatest reduction of enzyme activity is observed depend on the enzyme, the type of metal, their combination, and doses.

### Cadmium and Lead

Khan et al. (2007) and Pang and Yu (2011) incubated the soil with the additional amounts of lead and cadmium salts. The researchers were progressively increasing amounts of those metals treating them both separately and as a combination. They observed that while they were increasing the doses of metals, the activity of urease, acid phosphatase, and dehydrogenase was getting lower proportionally to the dose of introduced metal. The enzyme activity was at its lowest after the scientists applied a combination of salts and the highest dose of metals. In the Pang and Yu (2011) experiment, the addition of 100 mg of Cd + 500 mg Pb kg\(^{-1}\) of soil resulted, after 10 weeks, in 50% reduction of urease and dehydrogenase activity, whereas the acid phosphatase activity was reduced by 30% after 2 weeks. The impact of Cd on the enzyme activity is more toxic than Pb due to the greater mobility of the former element and a lower affinity with soil colloids. The implemented dose of lead did not alter the activity of dehydrogenases and acid phosphatase and even resulted in an increase in the activity of alkaline phosphatase. The increased activity of alkaline phosphatase was explained by the increase in the
soil pH value which had been caused by the introduction of alkalizing lead compounds. A small amount of cadmium (2.25 mg kg$^{-1}$) incorporated into the silty soil stimulated enzyme activity in the range of 2.1–23.4%. Such an impact of a small cadmium dose (1.5 mg kg$^{-1}$) on a sandy soil was observed only in the soil with pH 7. Cadmium contamination of soil at a medium level (addition of 4.5 mg Cd to the light soil and 6.75 mg Cd kg$^{-1}$ to the medium soil) had generally a clear toxic effect in both soils and at each level of pH value, except for the soil with silty texture and pH 5.5, in which a slight increase in the activity of dehydrogenases was recorded.

Zinc

The results of incubation experiments, in which different doses of zinc had been introduced into the soil, showed that this metal was a stronger inhibitor of the activity of enzymes than lead and cadmium. In the experiment of Ciarkowska (2010), the introduction of an increased amount of zinc into the soil strongly suppressed the activity of dehydrogenases from the very beginning. In the sandy soil, a negative effect of additional amounts of zinc was clearly seen since the first day after the introduction of the metal. The introduction of zinc played a role in reducing the dehydrogenase activity in the range of 5.8–46.1% in relation to the control soil. The amounts added were the following: 200 mg Zn kg$^{-1}$ into the light soil and 300 mg Zn kg$^{-1}$ into the medium soil. The enzyme activity decreased to the range of 34.5–74.5% when 600 mg Zn kg$^{-1}$ was introduced into the light soil and 750 mg Zn kg$^{-1}$ was added into the medium soil. Showed a similar inhibiting effect of zinc on enzyme activity in the incubation experiment, in which they added increasing doses of zinc into the soil to test their effect on the activity of dehydrogenases, urease, as well as acid and alkaline phosphatases. The dose of 5 g Zn kg decreased dehydrogenase by 3.5%, and a dose of Zn, which was 400 times higher, brought the dehydrogenase activity down by 89%. Excessive doses of zinc led to the decline of urease activity, but the influence was much weaker than in the case of dehydrogenases. The highest dose of zinc made the activity of the discussed enzyme 4.3 times smaller. Phosphatase activities were even less affected by the increased zinc content.

Combination of Zinc, Lead, and Cadmium

Studied the effect that the increasing amounts of Zn, Pb, and Cd, individually or as a whole, had on catalase, urease, alkaline phosphatase, and invertase activities. They found out that, in case of all objects of experiment, lead, either as a single agent or in combination with the other two metals, stimulated the activity of catalase. The authors explain the fact by a reaction of Pb with the functional groups of catalase. The influence of heavy metal contamination of soil on the activity of urease was always inhibitory and proportional to the dose of introduced metals. It was stronger when they were applying the combination of metals rather than each one individually. A particularly strong synergistic interaction was observed for Zn and Cd. The activity of alkaline phosphatase was inhibited the most by the addition of Cd, while the effect of lead was not significant. Invertase was most strongly inhibited by a combination of three metals. Each of the enzymes responded differently to the single metal contamination and a combination of three metals. Various effects of individual metals on the enzyme activity resulted from different reactions into which enzyme functional groups and metals entered. In the experiment of cadmium was a strong inhibitor of all analyzed enzyme activity. Whereas zinc inhibited urease and catalase activities, lead proved to have the least inhibitory effect on enzymes and even a stimulating effect on catalase activity. The inhibitory effect of Cd on catalase and urease was strongly intensified by the addition of Zn. As far as the studied enzymes are concerned, urease has proven to be the most sensitive to the combinations of heavy metals.
Chromium

It was also observed that chromium (Cr (III) and Cr (VI)) was another element which had a negative influence on the activity of dehydrogenases in various types of soils. The results of the incubation experiment showed a rapid and significant decrease in the activity of dehydrogenases in each of the soils after the addition of higher doses of chromium, whereas small doses of chromium (2 mg kg$^{-1}$) increased the enzyme activity. The authors explained that the small additional amounts of Cr compensated for deficiencies of this element in the soils. The inhibitory effect of chromium on the activity of dehydrogenases depends on the type of soil, especially on the content of the organic substance. The activity of dehydrogenases was more sensitive to the effects of chromium in Haplic Luvisol and Eutric Cambisol than in Mollic Gleysol (Stepniewska and Wolinska 2005).

Nickel

The purpose of the pot experiment of Kuziemska (2012) was to determine the effect which the increased amounts of nickel introduced into the soil after bean cultivation had on the dehydrogenase activity. The results showed a significant change in the enzyme activity in each year of the experiment. After nickel was introduced at the lowest dose of 50 mg Ni kg$^{-1}$, the scientists observed, during the three following years a significantly increased activity of dehydrogenases, whereas higher doses of the metal (100 and 150 mg Ni kg$^{-1}$) strongly decreased their activity. In the fourth year of the experiment, only the highest dose of nickel (150 mg kg$^{-1}$) lowered the activity of these enzymes. Liming of the acid soils reduced the negative impact of nickel.

Summary

The results of research connected with the impact of heavy metals on the enzyme activity in the soils contaminated with heavy metals for a short period of time are very ambiguous. This fact implies that various soil microbial populations have different sensitivities to heavy metals, even if the soils have similar physical and chemical properties. They are also caused by the chemical and exchangeable sorption of heavy metals by the organic substance, clay minerals, metal oxides and hydroxides, as well as free amorphous aluminosilicates. The above mentioned results of experiments can be summarized by stating that, the heavy metals discussed above, such as zinc, lead, cadmium, nickel, and chromium, tend to have a negative effect on enzyme activities in the soils which have not been contaminated for a long time. – The inhibitory effect of metals on the activity of enzyme depends on the type of enzyme, soil properties, and the dose of metal. The inhibitory effect of zinc, lead, and cadmium can be arranged in the following order: Cd > Zn > Pb or Zn > Cd > Pb.

Effects of the Long-Term Influence of Heavy Metals on the Activity of Soil Enzymes

Effects of long-term heavy metal pollution on the soil enzyme activity were studied in soil samples taken from the mining areas and/or metallurgy areas connected with nonferrous metals (copper, zinc, lead). Mostly observed a decrease in the activity of enzymes such as alkaline and acid phosphatases, urease, and dehydrogenase in soils which were in the direct vicinity of the emitter (Bielinska and Mocek-Plociniak 2010; Castaldi et al. 2004; Januszek 1999). The negative effect of heavy metals on enzyme activity is also confirmed by the results of the research analyzing the activity of urease and alkaline phosphatase in soils which are located at different distances from roads with heavy traffic. The indicated that the enzyme activity was higher as the distance from a road was growing. It also showed a significant negative correlation between the activity of enzymes (urease and alkaline phosphatase) and the content of Mn, Cr, and Pb. This
heavy metal contamination of the soils located along roads inhibited the activity of the enzymes discussed above (Gulser and Erdogan 2008). Showed a high inactivation of dehydrogenases in soils under conditions of long-term industrial emissions when she carried out the study of the enzyme activity of soils contaminated with emissions of lead industry, which had been functioning since the eighteenth century. The activity of dehydrogenases significantly decreased when the pollution increased, whereas changes in the urease activity were rather ambiguous and correlated with the content of nitrogen. This can be explained by the fact that microbial populations which are exposed to long-term impact of toxic metals are increasingly tolerant to metals. The extracellular enzyme activity, as compared with the activity of dehydrogenases, can be more useful to evaluate changes in the soil. Mocek-Plociniak (2011) also described the activity of phosphatase as a good indicator of heavy metal pollution of the soil, but the results of her study did not demonstrate the negative impact of a high content of heavy metals (Cu and Pb) on urease activity. Studies of Castaldi et al. (2004) confirm that the urease activity is not significantly correlated with the content of heavy metals in the soil. The only limiting factor is the availability of urea because urease, as an extracellular enzyme, is synthesized only in its presence. Results of analyses of urease and invertase activities which were conducted by Ciarkowska et al. (2004) on the land that had been subjected to the long-term effects of strong pollution by zinc, lead, and cadmium showed that long-term and significant accumulation of metals in the soils had no reducing effect on the activity of enzymes and the invertase activity was even higher in polluted soils than in unpolluted forest soil. The authors explained that fact by arguing that the growth of metal-resistant microbial population and/or organic matter accumulation, as well as neutral reaction of the soil, caused heavy metals to occur mainly in biologically inactive forms. Also Finkenbein et al. (2013), the increased activity of enzymes in soils suffering from long-term stress, which resulted from heavy metal contamination, was the effect of changes in the composition of the microbial population. However, the decrease in the enzymatic activity may be the result of the consumption of energy in the process of the physiological adaptation of the microorganisms by which they develop the tolerance of heavy metals. This adaptation consists of the following processes: synthesis of intracellular and extracellular proteins which sequester metals as well as biochemical reactions of metal precipitation or capture which occur on the surfaces of microbial cells explain also that the lack of relationship between the enzymatic activity of certain enzymes (dehydrogenases, urease, and phosphatases) and the content of heavy metals in soils characterized by various degrees of heavy metal contamination, including those located near metallurgical plants of nonferrous metals, results from a high content of organic matter and a low concentration of soluble forms of heavy metals. Drawing conclusions from the above-presented research results, we can observe that a variety of enzyme reactions to long periods of heavy metal pollution may result from the various levels of sensitivity of microorganisms to metal toxicity, as well as from the development of mechanisms of resistance to metals and changes in the structure of microbial population, which can compensate for losses in more sensitive populations. Therefore, it seems that a reliable assessment of the quality of the soil environment can be achieved only by studying a series of soil enzymes.

Determining the Level of Degradation

The determination of enzyme activity is used as an indicator of both the rate of degradation of ecosystems and the improvement in the quality of mining areas as a result of rehabilitation procedures. The reclaimed soil has to be microbiologically active, so it is very important to study the activity of microorganisms by, for example, testing the enzyme activity (Finkenbein et al. 2013). Habitats created after the opencast mining of nonferrous metals, apart from strong contamination by heavy metals, are often characterized by very unfavorable soil conditions such as extreme pH values, as well as scarcity of organic matter and nutrients for plants. The activity
of many enzymes, both intra and extracellular, is determined by the organic matter content or composition of the vegetation growing on degraded lands. Soil texture and pH value are other important properties, which determine the enzyme activity, of the soil forming on degraded areas. In strongly acid soils, the presence of organic carbon and total nitrogen may not stimulate microbial activity (Chodak and Niklinska 2010; Finkenbein et al. 2013). An important and difficult issue is to determine the point at which the soil can be considered completely reclaimed. For this reason, indicators which reflect the state of the soil and its functions, such as the activity of enzymes which provide information about the soil microbiology as well as its physical and chemical parameters, are very useful (Antunes et al. 2011). According to the activity of urease and invertase can be such an indicator. It has been noted that the activity of these enzymes in the soils of zinc and lead ores mining areas which have been restored in recent years is significantly lower than in the soils of the same area but reclaimed decades ago. However, is not yet completed, and microbial communities are still under the influence of mining activities. Who were examining the activity of dehydrogenases in reclaimed soils which were degraded after opencast mining of metal ores, found out that the activity of these enzymes in reclaimed soils was lower than in referential soils. The results support the opinion that enzymatic activity is reduced immediately after the introduction of metals into the soil, but usually, as time passes, it returns to its original level (Ciarkowska and Gambus´ 2004). The use of a biological parameter allows us to specify the ecologically negative effects of mining and metal ore processing as well as destabilization of the soil ecosystem.

**Reference**


MANAGEMENT OF POOR QUALITY IRRIGATION WATER IN AGRICULTURE

Gawade Nagesh Vithu¹, Varu D. K.¹, Khunt Jaydeep A.¹ and Bhosale Neha Arun²
Department of Horticulture, Junagadh Agricultural University, Junagadh-362001
²Mahatma Phule Krishi Vidyapeeth, Rahuri-413722
Corresponding Author Email: nageshgawade777@gmail.com

Abstract

Supplies of good quality irrigation water are expected to decrease in the future because the development of new water supplies will not keep pace with the increasing water needs of industries and irrigation water. With increasing demand and decreasing availability of good quality waters, there is growing tendency among the farmers to use these poor quality waters for crop production. Indiscriminate use of poor quality waters in the absence of proper soil-water-crop management practices pose grave risks to soil health and environment by deteriorates the productivity of soils through salinity, sodicity and toxic effects of heavy metals and some ions.

Water is a transparent and nearly colourless chemical substance that is the main constituent of earth's streams, lakes, and oceans, and the fluids of most living organisms. It covers about 71% of the earth's surface and exists in three forms on the Earth viz., solid (ice, hail, snow or frost), liquid (in lakes, oceans, rain, dew, fog or mist) and gas (steam or water vapour). About 97.3% of the water on the earth's surface is in the world's oceans. This is where you can find most of the other 2.7%.

![Fig.1: Availability of unused water resources in India](image)

Source: World Bank Agriculture and Rural Development Unit, South Asia Region, 2005

The Fig. 1 shows that the availability of unused water resources i.e. ground water and surface water in India in cubic kilometers per annum. From the above figure, the per year availability of unused water resources get decreasing with higher rate. In the year 2050, it will decrease up to below 100 km³/yr.
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All the sectors in India increase their water demand day by day. The projected water demand in the year 2050 in all sectors is so high which will not fulfil by the present status of water. From the Fig. 1 and Fig. 2 it can be conclude that the availability of water get decreasing with increasing water demand year by year. The efficient use of available water is more important for the future prospects. By the managing poor quality water it can be used for the different purposes like washing, cleaning, flushing etc. In agriculture, using different purifying methods, poor quality water can be used for the irrigation water. Central Water Commission (2010) predict the irrigation water demand by the year 2050 is 1072 BCM which is quite difficult to fulfil by the available water. Therefore management of poor quality water for irrigation in agriculture having more importance. In this chapter we will discuss mitigation strategies for poor quality water.

Types of Water

- **Pure water:** Contains essentials chemical elements and minerals at very low levels and do not pose a significant risk to health.
- **Polluted water:** Occur when waste products or other substances change the biological and chemical characteristics of the water and degrade the water quality

1. **Effluent water:** Effluent water containing toxic chemicals including heavy metals
2. **Sewage water:** Sewage water are basically very rich in organic matter and their fertility is very high. It is quietly suitable for irrigation.
3. **Saline water:** Saline water is that water which is usually contains high amount of soluble salts. Saline water generally having soluble salts of cations like Ca$^{2+}$, Mg$^{2+}$, Na+, K+ and anions like Cl$^-$, CO$_3^{2-}$, HCO$_3^-$ and SO$_4^{2-}$.
4. **Sodic water or alkali water:** Sodic water is high in sodium (Na+) concentration relative to concentrations of calcium (Ca$^{2+}$) and magnesium (Mg$^{2+}$). The sodicity of water is expressed as the sodium adsorption ratio (SAR), SAR = Na / V [(Ca + Mg) / 2] (These values are in meq/L). Sodic water is defined as having a SAR greater than 13.

Different sources of poor quality water

- Sodic water
- Natural occurring minerals
- Saline water Effluent water
- Fuel and chemical leakage
- Industrial wastes water
- Sewage water
- Animal waste

Measuring the quality parameters for suitability of irrigation water:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical conductivity (EC)</td>
<td>RSC (Residual Sodium Carbonate)</td>
</tr>
<tr>
<td>Boron concentration</td>
<td>Chloride concentration</td>
</tr>
<tr>
<td>pH</td>
<td>Heavy metal concentration</td>
</tr>
<tr>
<td>Sodium adsorption ratio or sodium hazard (SAR)</td>
<td></td>
</tr>
</tbody>
</table>
Management of poor quality irrigation water

Waste water

It is estimated that more than 15000 million liters of sewage water is produced every day in India, which approximately contributes 3.2 million t of N, 1.4 million t of P and 1.9 million t of potassium (K) per annum, with an economic value of about Indian Rs. 2600 million (US $ 52 million). However, some of the elements present in sewage water and untreated industrial effluents could be toxic to plants and pose health hazards to animals and humans. (Khurana and Aulakh, 2010).

Methods used in wastewater treatment:

(1) Physical processes
   (a) Sedimentation (Clarification)
   (b) Filtration

(2) Chemical process
   (a) Coagulation
   (b) Neutralization
   (c) Chemical oxidation

(3) Biological process
   (a) Aerobic
   (b) Anaerobic
   (c) Oxidation ponds or lagoons

(1) Physical processes
(a) Sedimentation (Clarification)
In the process of sedimentation, physical phenomena relating to the settling of solids by gravity are allowed to operate. Usually this consists of simply holding a wastewater for a short period of time in a tank under quiescent conditions, allowing the heavier solids to settle, and removing the "clarified" effluent.

(b) Filtration
Use of sand filters to further remove entrained solids from a treated wastewater. Wastewater is passed through a filter medium to separate solids.

(2) Chemical process
   (a) Chemical oxidation
   Probably the most commonly used chemical process is chlorination. Chlorine, a strong oxidizing chemical, is used to kill bacteria and to slow down the rate of decomposition of the wastewater. Bacterial kill is achieved when vital biological processes are affected by the chlorine. Another strong oxidizing agent that has also been used as an oxidizing disinfectant is ozone.
   (b) Neutralization
   Neutralization consists of the addition of acid or base to adjust pH levels back to neutrality. Since lime is a base it is sometimes used in the neutralization of acid wastes.
   (c) Coagulation
   Coagulation consists of the addition of a chemical that, through a chemical reaction, forms an insoluble end product that serves to remove substances from the wastewater. Polyvalent metals are commonly used as coagulating chemicals in wastewater treatment and typical coagulants would include lime (that can also be used in neutralization), certain iron containing compounds (such as ferric chloride or ferric sulfate) and alum (aluminum sulfate).

(3) Biological process
   (a) Aerobic process
   In this process, bacteria degrade or eat the organic matter and convert it into carbon dioxide which can be used by plants for their growth. Oxygen is used during aerobic process.
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(b) Anaerobic process
In this process, fermentation process is used to ferment the sludge or waste at a specific temperature. Oxygen is not used in this process.

The management practices for efficient use of saline water
More frequent irrigation
The adverse effects of the high salinity of irrigation water on the crops can be minimized by irrigating them frequently. More frequent irrigations maintain higher soil water contents in the upper parts of the root zone while reducing the concentration of soluble salts. The sprinkler method of irrigation is generally more amenable to increased frequency of water applications.

Irrigation
It is given by the dilution and cyclic use of good and saline water. When good quality water is limited, it can be used as follows:

(i) Pre sowing and first irrigation should be with good quality water. Later saline water can be used.
(ii) Poor quality water can be mixed with good water.
(iii) Drip or pitcher irrigation is found suitable.

Mulching
- Use of mulches to reduce the requirement of water for evaporation.
- Use of mulches and intercultural operations reduce water requirement of crops, thus with saline water salinity develops at a relatively lesser intensity

Conjunctive use of fresh and saline waters
There are situations where good quality water is available for irrigation but not in adequate quantities to meet the evapotranspirational needs of crops. Under these conditions, the strategies for obtaining maximum crop production could include mixing of high salinity water with good quality water to obtain irrigation water of medium salinity for use throughout the cropping season. Alternatively, good quality water could be used for irrigation at the more critical stages of growth, e.g. germination, and the saline water at the stages where the crop has relatively more tolerance.

Selection of crops
On the basis of tolerance level all the crops can be divided into high tolerant, moderate tolerant, moderate sensitive and sensitive.

<table>
<thead>
<tr>
<th>Sensitive 1.5 – 3 dS/m</th>
<th>Moderately sensitive 3– 5 dS/m</th>
<th>Moderately tolerant 5 – 7 dS/m</th>
<th>Tolerant 7– 10 dS/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>Cabbage</td>
<td>Safflower</td>
<td>Barley</td>
</tr>
<tr>
<td>Carrot</td>
<td>Corn</td>
<td>Soybean</td>
<td>Cotton</td>
</tr>
<tr>
<td>Lemon</td>
<td>Rice</td>
<td>Wheat</td>
<td>Sugar beet</td>
</tr>
<tr>
<td>Onion</td>
<td>Grape</td>
<td>Oat</td>
<td>Date palm</td>
</tr>
<tr>
<td>Pulses</td>
<td>Groundnut</td>
<td>Dhaincha</td>
<td>Cluster bean</td>
</tr>
<tr>
<td>Beans</td>
<td>Potato</td>
<td></td>
<td>Pearl millet</td>
</tr>
</tbody>
</table>

Seed rate
- Poor germination, high mortality of young seedlings is common problems when the crop is grown with poor quality water. So, higher seed rate and close spacing is advisable.
- An additional seed rate of 25% should be adopted.

Organic and inorganic fertilizer
- Dhaincha as a green manuring crop improves physical properties of the soil.
- Addition of organic manures to some extent mitigates the adverse effect of poor quality water.
- Fertilizers should be applied 1.25 - 1.5 times the normal rate of their application.
Application of Zn @ 20 kg ZnSO4 ha\(^{-1}\) counteracts the negative effect of higher salinity and sodicity.

**Appropriate uses of ridges or beds for planting**

- The impact of salinity may be minimized by appropriately placing the seeds (or plants) on ridges. Where exactly the seeds should be planted on the ridge or bed will depend on the irrigation design.
- If the crop planted on ridges would be irrigated via furrows on both sides of the ridge, it is better to place plants on the ridge shoulders rather than the ridge top because water evaporation will concentrate more salts on the ridge top or centre of the bed.
- If the crop is irrigated via alternate furrows, then it is better to plant only on one shoulder of the ridge closer to the furrow that will have water.

![Fig.3: Microtopography of ridge and furrow systems designed to avoid salinity damage to crops](image)

(a) Paired crop rows on broadly sloping ridges (b) Single crop rows on asymmetric ridges

![Fig.4. Pattern of salt build-up as a function of seed placement, bed shape and irrigation water quality](image)

**Management practices for efficient use of water with sodicity hazard**

**Application of amendments**

Irrigation water having a sodicity hazard could be improved by increasing the soluble calcium status of the water, thereby decreasing the proportion of sodium to the divalent cations and therefore its adsorption on the soil exchange complex. Applied soluble calcium salts will also neutralize the bicarbonate and carbonate ions thereby reducing the sodicity hazard of the water. Gypsum can be either incorporated in the soil or lumps of gypsum can be suitably placed in the water channel to dissolve gradually. Sulphuric acid has also been used to amend water quality and can be applied directly to the soil or in the irrigation water. It rapidly neutralizes the sodic
constituents of water or reacts with lime in the soil to produce soluble calcium. On an equivalent basis, however, the effect is nearly the same as that of gypsum.

**Mixing with an alternate source of water:**
- If an alternate source of irrigation water is available, mixing the two sources may be helpful in obtaining water which is acceptable for irrigation considering its sodicity hazard.
- Detailed chemical analysis and the quantities in which the water is available from the two sources can help in deciding the proportions in which they need to be mixed.

**Irrigating more frequently:**
- Irrigating frequently with small quantities of water is an effective way to manage water with a sodicity hazard.
- Using sprinkler irrigation with the ability to supply controlled amounts of water at a time should be considered where feasible.

**Growing crops with low water requirements** then the high water tends to create a sodicity problem, it is advisable to use small quantities of water, waters with significant quantities of residual sodium carbonate (RSC) will cause a continuous increase in the exchangeable sodium status of soils and therefore the need to limit water use.

**Why need to Management of poor quality irrigation water**
Supplies of good quality irrigation water are expected to decrease in the future because the development of new water supplies will not keep pace with the increasing water needs of industries and irrigation water. With increasing demand and decreasing availability of good quality waters, there is growing tendency among the farmers to use these poor quality waters for crop production. Indiscriminate use of poor quality water in agriculture in the absence of proper soil-water-crop management practices pose grave risks to soil health and environment.

**Problems may occur with use poor quality irrigation water in agriculture**
- Crop faces difficulty in extracting enough water due to excessive quantities of soluble salts (high OP) in root zone.
- Soil permeability is reduced due to the deflocculation effect of sodium.
- Toxicity problems of boron, chloride, sodium, sulphate and bicarbonate in plants when excessive amounts are taken up.
- Vegetative growth decreases with the increased osmotic pressure of the soil solution.
- Excessive nitrogen in the water causes excessive vegetative growth, lodging, delayed crop maturity.
- Use of poor quality irrigation water through sprinkler may cause leaf burn problem.

**Waste water**
- Range of heavy metals and persistent chemicals are typically present in waste water.
- Another set of problems associated with sewage-fed farming is the potential for contamination of soils and groundwater, particularly when over-applied.
- The degree of contamination depends on both the type of soil and the composition of the wastewater; the risk is not uniformly high in all situations and cooperation from government agencies would be required to monitor areas deemed at higher risk.
- Severe problems include soil clogging, increase in salinity and phytotoxicity (plant poisoning) that may necessitate abandonment of cultivation in the absence of remediation. Proliferation of weeds due to excess nutrients is another frequent problem often leading to increased use of herbicides.

**The presence of saline water can affect plant growth in three ways**
(1) It can increase the osmotic potential and hence decrease water availability;
(2) It can induce specific-ion effects by increasing the concentration of ions with an inhibitory effect on biological metabolism;
(3) It can diminish soil-water permeability and soil aeration by adversely affecting soil structure. The adverse effects of soil salinity on plant growth and productivity vary with the type of plant being grown.

**Salinity**

Salt stress induces the synthesis of abscisic acid which closes stomata when transported to guard cells. Therefore, photosynthesis declines and photo inhibition and oxidative stress occur. Some physiological damages also occur due to salt stress that are water deficiency, osmotic stress. The accumulation of Na⁺ and Cl⁻ ions in the cells is very toxic in terms that these ions can influence the enzymatic action. Excess salt in the soil, reduces the water potential of the soil and making the soil solution unavailable to the plants (physiological drought).

**References**


COWPATHY: AN ORGANIC SOLUTION FOR ENHANCING GREEN AGRICULTURE PRODUCE

Surya Prakash Reddy¹, Vibha², Balkishan Chaudhary ³ and Rajasekhar⁴

¹&³Department of Plant Pathology, ²Department of Plant Physiology, College of Agriculture, JNKVV- Jabalpur-482004, and ⁴Department of Genetics and Plant Breeding Central Agriculture University Umiam-793130

Corresponding author E-mail: suryapath017@gmail.com

Abstract

Panchagavya (cowpathy) - an organic formulation, which is prepared out of unique combination of five products of cow viz., cow milk, curd, ghee, urine and fresh dung at appropriate quantities collected from a lactating desi cow. It is act as one of organic weapon to play the role of promoting growth and providing immunity in plant system thereby confers resistance against pest and diseases.

Organic farming (OF) can be defined as ‘an ecologically, economically and socially responsible way of farming, providing an enduring supply of safe and healthy food and fibers, with the least possible losses of nutrients and energy, and the least negative impacts on the environment, as regulated by certification agencies’ (Finckh and van Bruggen 2015; van Bruggen AHC and Finckh 2015). Therefore, it is a comprehensive production management system which promotes and enhances health of agro-ecosystem including bio-diversity, soil biological activity and biological cycles. It gives importance to the use of management practices particularly the use of off-farm inputs, taking into account that regional conditions require locally adapted systems.

Worldwide, importance of organic farming has increased tremendously over the past 20 years, including in developing countries as the demand for global organic products had reached a value of almost $US 72 billion in 2013 (Willer H and Lernoud J 2015). This farming system is governed by the idea that all natural processes within an agro ecosystem are mutually dependent on each other and that management should aim at achieving and supporting self-regulation through natural processes (Birkhofer K et al., 2008). This has been laid down in detail, in the OF standards, formulated by the International Federation of Organic Agricultural Movements (IFOAM), Thus, solutions to problems are primarily sought within the ecological possibilities of the farming system.

History behind about importance of Panchagavya

In 1950, James F. Martin of USA made a liquid catalyst (living water) from milking cow, using dung, sea water and yeast and it was claimed that it was capable of greening degraded land (Vivekanandan P et al., 1998). Use of cow ghee for managing seedling health had already been described in ancient and medieval times (Kautilya 321-296 BC and Someshwara Deve 1126 AD). Panchagavya has got reference in the scripts of Vedas (divine scripts of Indian wisdom) and Vrkshayurveda (Vrksha means plant and ayurveda means health system). The texts on Vrkshayurveda as systematization of the practices that the farmers followed at field level, placed in a theoretical frame work and it defined certain plant growth stimulants, among them Panchagavya was an important one that enhanced the biological efficiency of crop plants and quality of fruits and vegetables. (Van Bruggen and Finckh, 2015). The positive effect of Panchagavya on growth and productivity of crops has been reviewed and documented by (Somasundaram, 2007).
Panchagavya (Cow pathy) Preparation and Its Importance:
Panchagavya it is nothing but a bio-fertilizer or organic growth stimulant made from natural ingredients to promote plant growth and safeguard the soil micro-organisms. The Sanskrit word *Panchagavya* means "mixture of five cow products" and is also called as Cowpathy. In some areas of India, it is also termed as “Panchakavya”. The ghee contains vitamin A, vitamin B, calcium, fat and also glycosides, which protects cut wounds from infection. Cows curd is rich in microbes (Lactobacillus) that are responsible for fermentation (Chandha, 1996). It is used as solution in farming, it preserves the reproductive and regenerative capacity of the soil, holds plant nutrition that support sound soil management system which ultimately produces nutritious food rich in vitality which has resistance to post harvest diseases. It also plays an important role in supporting animal health and human health. Indiscriminate use of chemicals and pesticides has deviated the choice of consumers from food to organic food so the current agriculture sector has changed its preference from grow more food to grow organic food to satisfy its consumers. Moreover, the market for naturally made organic and bio fertilizers like Panchagavya is boosting therefore farmers has started making their own Panchagavya at their farm to use as bio-fertilizer or pest repellent on their commercial crops or orchards. Looking into the great future of it, some people have taken up the production of Panchagavya as entrepreneurs for making profits. It is also used as organic growth stimulant in milch animals like goat, sheep, poultry, fish and pet animal.

**Over all uses and benefits of Panchagavya on crops**
- It acts as an organic growth-promoter and immunity booster plants. This also cures infested plants and other living organisms.
- It increases the yield (in most cases, yield increased by 20 to 25%, in few cases like cucumber yield has been doubled) and quality of produce.
- It increases the shelf life of vegetables, fruits and other agriculture produce.
- It produces lager leaves and denser canopy.
- It enhances the sugar content and aroma of fruits.
- It application promotes crops to mature early (i.e. advance harvesting by 2 weeks).
- It reduces the water requirement by 25 to 30% thus sustains drought conditions.
- It promotes profuse and dense roots that can penetrate into deep layers of water stress soil.
- This can reduce cost of cultivation compared to chemical based farming.
- Its application is found to be more profitable than recommended fertilizer application and chemical spray in commercial agriculture.
- Growing organic farming sector is reclying on its produce (as bio-fertilizer or bio-pesticide) for farming.
- Panchagavya has very positive effect in animal health and human health owing to organic in nature.

**Problems, Constraints, Barriers and Difficulties in Adopting Panchagavya**
- Lack of awareness about its uses.
- Sometimes during fermentation contamination occurs.
- Slow action.
- Limited availability of its products in markets.
- It encourages weed growth also as it is non selective.
- Less utilization by farmers.
- It may not give expected enhancement in quality of the produce sometimes.

**Traditional Preparation of Panchagavya at home**
To make 20 litres of Panchagavya solution, the following inputs / ingredients are required.
Ingredients of Panchagavya.

Inputs or Ingredients:
Cow dung mixed with water: 5 kg.
Cow urine: 3 litres.
Cow milk: 2 litres.
Cow curd: 2 litres.
Cow ghee: 1 kg.
Well-ripened yellow banana: 1 dozen (12 pieces).
Tender coconut water: 3 litres.
Sugarcane juice: 3 liters (or ½ (half) kg of Jaggery should be mixed with 3 litres of water).

- Wide mouthed mud pots or concrete tank or plastic should be used for preparation of Panchagavya solution.
- The above said and measured amount of cow dung and ghee should be added first into the selected container.
- It should be kept for about 3 to 4 days for fermentation. After fourth or fifth day the remaining ingredients should be added to the container and kept for 7 to 8 more days. The ingredients in the container should be well mixed by stirring for 20 to 30 minutes.
- This stirring should be carried out both in the morning and evening to facilitate aerobic microbial activity.
- After 10 to 11 days of incubation, different concentrations should be prepared and used as foliar spray for plants or crops.

Physico-Chemical Properties
The solution contains a pH value of 3.7 to 3.8, Nitrogen of 1.28%, Phosphorus of 0.72%, Potassium of 2.23% and Organic Carbon of 17.45%.

Cost and preparation of Panchagavya
Production cost of Panchagavya depends on current labour charges and cost of ingredients used in the process. Generally preparation cost varies from Rs 40 to 50 for preparing 1 liter of Panchagavya. If you are planning buying online, it may cost from Rs 150 to 400 based on brand and quality. As making this at home is very simple, it is better to prepare on your own for commercial crops.

Dosage of Panchagavya recommended for field application
Storage of seeds: For storing the seeds, 3% of Panchagavya solution should be used to dip the seeds before drying and storing them for long shelf life, vigour and more percentage of germination.

Seed and Seedling treatment
In this method, seed or Seedling treatment before sowing in the field is an important task to prevent from any seed borne or soil borne pests and diseases. The 3% of Panchagavya solution should be used to soak the seeds for 20 to 25 minutes or in case of seedling treatment dip the seedlings for 20 to 25 minutes before planting in the field or nursery bed. Rhizomes of Ginger, Turmeric and sets of Sugarcane should be soaked for 30 to 35 minutes before planting in the field.

Spray system:
In this method, 3% of Panchagavya solution is found to be most effective. Generally 3 litres of Panchagavya 100 litres of water is suitable for all agriculture crops. The power sprayers of 10 liter capacity may need 300 to 325 ml/tank. When sprayed with power sprayer, sediments should be filtered. However, when sprayed with hand operated sprayers, the nozzle with higher pore size should be used.

Flow system:
In this method, the Panchagavya solution should be mixed with irrigation water @ 50 litres/ha either through flow irrigation or drip irrigation system.

**Properties of panchagavya**

Panchagavya contains several nutrients i.e. macronutrients like nitrogen, phosphorus, potassium and micronutrients which are required for the growth and development of plants and also contains various amino acids, vitamins, growth regulators like Auxins, Gibberellins and also beneficial microorganisms like pseudomonas, azatobacter and phosphorous bacteria etc.

**Panchagavya boon growth of plant**

Panchagavya is a foliar nutrition prepared by organic growers of Tamil Nadu and used widely for various agricultural and horticultural crops. In Sanskrit, Panchagavya means a combination of five products obtained from cow. When suitably mixed and used, these have miraculous effects.

Panchagavya is used in different means such as foliar spray, soil application along with irrigation water, seed or seedling treatment etc. For foliar spray 3% concentration is being adopted by organic farmers using hand-operated sprayers with high pore sized nozzle (Natarajan K 2002).

The biofertilizer potential of Panchagavya prepared in the traditional way and a modified preparation amended with seaweed extract have been evaluated for their fertilizer potential using the pulses viz., *Vigna radiata*, *Vigna mungo*, *Arachis hypogea*, *Cyanopsis tetragonoloba*, *Lablab purpureus*, *Cicer arietinum* and the cereal *Oryza sativa var. ponni* as the experimental plants (Thenavathan R.). Some farmers in the southern parts of India use a modified Panchagavya that contains many other plant products to boost fermentation and to support the growth of beneficial microorganisms. Similarly, soils amended with Panchagavya (both traditional and seaweed based) promoted the production of lateral roots, leaves, leaflets and the growth of lamina in all the experimental plants, as compared to control. The seedlings produced leaves which had 93% more surface area than that of their respective controls. Percent increase over control in the leaf area of the seedlings of *Vigna radiata*, *Vigna mungo*, *Arachis hypogea*, *Cyanopsis tetragonoloba* and *Cicer arietinum* grown in soil amended with seaweed based Panchagavya at a ratio of 1:100 (v/v) was 27%, 35%, 46%, 140% and 37% respectively. Increased production of lateral roots would provide more surface area for absorption of water and minerals by the experimental seedlings than their controls. Similarly, large number of leaves or leaflets with greater surface area could be construed as an indication of enhanced photosynthetic efficiency in plants grown in soil amended with Panchagavya. The effect was marked in the seedlings grown in soil amended with low levels of seaweed based Panchagavya (Panchagavya: soil; 1:100). The effect was more pronounced in *Arachis hypogea*. Even the use of traditional Panchagavya as manure was able to increase nodule formation by nearly 18% to 62% (Subramanian, A. 2005).

**Effect of Panchagavya spray on growth parameters**

Mohanalakshmi M and Vadivel 2008 revealed that ashwagandha plant sprayed with Panchagavya (3%) produced higher number of leaves per plant. (Vennila C and Jayanthi C 2008) revealed that application of 100% recommended dose of fertilizer along with Panchagavya spray (2%) significantly increased the okra plant height (131.7 cm) and dry matter production (5.90 g plant).

**Biogas slurry** with Panchagavya combination is adjudged as the best organic nutrition practice for sustainability of maize-sunflower-green gram system by its overall performance on growth, productivity, quality of crops, soil health and economics (Somasundaram E 2007).
Panchagavya was tested for different crops such as turmeric, paddy, onion, gingely, sugarcane, banana, vegetables and curry leaf and it was found that it enhanced the growth, vigour of crops, resistance to pest and diseases and improvement of keeping quality of vegetables and fruits. (Xu HL. 2001) reported that Effective Micro Organism (EMO) cultures could synthesize phytohormones. The auxins and other growth regulators that stimulated maize plant growth and they contained proactive substances that could significantly affect leaf stomatal response in maize. Leaf stomata of the EMO treated maize opened more rapidly than water treated control plants and when leaves were subjected to dehydration, the stomata closed more slowly (i.e., remained open longer) thus showed that, EMO contained bioactive substances that could have significantly affected leaf stomata response and led to increased LAI. The Panchagavya is rich in such EMOs.

Molecular characterization of a proteolytic bacterium in Panchagavya: An organic fertilizer mixture

These contain macro- and micro-nutrients, amino acids, and growth promoting substances, like indole acetic acid, gibberellins and beneficial micro-organisms. Panchagavya has been reported to possess pro-agricultural activity (biocontrol, biofertilizer, growth enhancer etc.), pharmacological value, growth stimulating activity, probiotic and antimicrobial potential. Beneficial effects of their biodynamic preparations on various crops have been reported. Biodynamic sprays of these preparations have increased the yield of cereals and vegetables significantly (Somasundaram E et al 2007). In Ayurveda, Panchagavya is used for purification of many herbal drugs and also as an important medicine. It is used in the treatment of different types of cancers and immune suppressive diseases. Deepika et al (2006) reported the antimicrobial activity of Panchagavya against different microbial pathogens.

Isolation and identification of proteolytic bacteria from Panchagavya

Commercially available Panchagavya preparation was procured from Green valley agency, Bangalore, and proteolytic bacteria were isolated and identified. Panchagavya sample was streaked on Skim Milk Agar (SMA) plates. The plates were incubated at room temperature for 24 h. A clear zone of inhibition on the SMA, indicated the presence of protease producing bacteria. Based on the zone of clearance, the bacterial colonies were further streaked on a fresh SMA plate to obtain pure culture. Genomic DNA was isolated from overnight grown cultures in Minimal Salt Broth medium, by cetyltrimethyl ammonium bromide (CTAB) method (Ausubel FM et al., 1999). PCR was performed using 16s rDNA universal primers (8F: 50 - AGA GTT TGA TCM TGG CTC AG -30 and 519B2 R 50 - ACG GCT ACC TTG TTA CGA CTT -30 ), following standard procedures (Lane DJ et al 1985). The amplified PCR products were sequenced using DNA Analyzer 3730 (Applied Biosystems, CA, USA). The resulting partial 16s rRNA gene sequences were searched in BLAST (Basic Local Alignment Search Tool) and closely related sequences were retrieved from the NCBI (National Center for Biotechnology Information) database. The unknown SNCK-3 sequence and retrieved sequences were aligned using Clustal W alignment tool in MEGA5 software. The evolutionary distance was inferred using the Neighbor-Joining method in MEGA5 (Tamura K et al., 2011).

Nutrient analysis of Kunapa jala and Pancha gavya and their evaluation on germination of Ashwagandha and Kalamegha seeds: A comparative study

Germination studies are essential to predict the growth and development of plants. The successful cultivation of plants depends on the quality and germination behavior of the seeds. Among the
stages of plant life cycles, seed germination is one of the most key processes in plant growth and survival (Zahra K 2012). The present study was planned to validate KJ and PG on Ashwagandha and Kalamegha as these medicinal plants are mentioned in several Ayurvedic literatures for their wider utility (Pandey G et al., 2005). Besides, both these plants have been identified by the National Medicinal Plant Board (NMPB) of India in the thirty two selected priority medicinal plants, which are in great demand in domestic and international markets. Hence, the present study was aimed to validate the Vrikshayurveda practices viz. KJ and PG by nutrient analysis and evaluated on the germination parameters in comparison with other treatment group viz., control, farmyard manure, humic acid and NPK. Vrikshayurveda has clearly outlined a systematized agricultural practice that insisted of use of KJ and PG to enhance the yield and quality of plants. Though, both the practices have been elaborated in Vrikshayurveda, there are very few studies conducted to evaluate their efficacy on medicinal plants. Previously, no systematic research was undertaken to develop comprehensive standard operative procedure for the preparation of KJ and PG, due to the variation in ingredients and their quantity involved in preparation. Though preparation of KJ and PG seem to be expensive due to type of ingredients used, however these age old preparations are used for application to soil or plants in their diluted forms and hence are cost-effective. The pH of PG is acidic in nature, and was similar to the reports of Gore NS and Sreenivasa MN 2011. and Shailaja et al. 2014 the acidic nature might be due to presence of Lactobacillus bacteria [Shailaja B et al2014]. The results of nutrient content of the present study are in accordance with the results obtained by Jeng et al., where, meat bone meals contain substantial amounts of organic matter and nutritive elements such as N, P and Ca [Jeng A et al 2006]. Similarly, KJ derived from animal products containing one or more nutrients like N, P and K are necessary for plant growth which is in accordance with Shaikh et al., 2013 and Gupta 2007. PG contained appropriate amount of nutrients; the results are in compliance with the study made by Geetha et al. (2013) and as mentioned by Shubha et al. 2014, the nutrient values of KJ and PG may vary according to the quantity, quality of ingredients used and duration of fermentation. There are no specific references on KJ and PG as germination enhancers. A study conducted by Khanna et al 2013. on effect of physical and chemical treatments on germination behavior revealed that seeds treated with 150 mg/mL gibberellic acid took 4 days for onset of germination and the germination percentage was 98%. In another study conducted by Afsan et al., germination percentage of GA3 (500 mg/L) applied seeds of Ashwagandha was 86 ± 0.34% (Afshan N and Nabi SE 2014), where in present study KJ and PG treated Ashwagandha seeds onset to germinate on 4th day and germination percentage of both the groups was 82.66 ± 0.94% and 76.73 ± 1.77% respectively.

**Effect of Panchagavya spray on yield and yield attributes**

(Mohanalakshmi 2008) revealed that application of poultry manure (5 t ha-1) + Panchgavya (3%) in aswagandha exhibited significantly superior performance by registering the highest root yield of 1354.50 kg ha-1. Vennila C and Jayanthi C 2008 revealed that application of 100 per cent recommended dose of fertilizer along with panchagavya spray (2%) significantly increased the number of fruits per plant, fruit weight g fruit-1 and fruit yield q ha-1 of okra. Swaminathan et al.2007 concluded that application of Panchagavya at 3% as foliar spray on 15, 25 and 40 days after sowing (DAS) on black gram recorded the highest grain yield of 1195 kg ha-1. Kanimozhi (2003) revealed that application of Panchagavya at 4 per cent spray was found to be superior in respect of root yield (2.5 times kg/plot) when compared to control in Coleus forskohili. Foliar spray of Panchagavya at 3 percent on 15, 25, 40 and 50 DAS with no fertilizers was the most effective low cost technology in terms of grain yield of green gram (Somasundaram E 2007). Panchagavya and vermicompost combination has given the highest pod yield of French bean variety Ooty 2 which was 36 percent higher than the conventional method (Selvaraj N 2003).
Treatment combinations of poultry manure + neem cake + Panchagavya increased the stick yield of moringa (Beaulah A 2002). Balasubramanian et al. (2001) in Panchagavya, Effective Micro Organisms (EMO) were the mixed culture of naturally occurring, beneficial microbes mostly lactic acid bacteria (Lactobacillus), yeast (Saccharomyces), actinomycyes (Streptomycyes), photosynthetic bacteria (Rhodopsuedomonas) and certain fungi (Aspergillus) and that improved the soil quality, growth and yield of sweet corn, which was equal to or higher than what was obtained from reported that dipping of rice seedlings in Panchagavya before transplanting enhanced the growth and yield chemical fertilizers (Somasundaram E, 2007). In Jasmine, spraying two rounds of Panchagavya, one before the flower initiation and another during bud setting phase ensured continuous flowering and in annual moringa, spraying doubled the stick yield besides giving resistance to pests and diseases. Panchagavya sprayed on 25 and 40 DAS advanced the paddy harvest by 10 days (Vivekanandan P. 1998).

**Effect of Panchagavya spray on nutrient uptake**

Presence of macro (N, P, K and Ca) and micro (Zn, Fe, Cu, Mn) nutrients besides total reducing sugars (glucose) were observed in Panchagavya. Chemolithotrops and autotropic nitrifiers (ammonifiers and nitrifers) present in panchagavya which colonize in the leaves increase the ammonia uptake and enhance the total N supply (Papen, H. 2002). Beaulah 2002. reported that the secondary and micronutrients (Ca, S and Fe), macronutrients (NPK) contents of leaves and pods of annual moringa were superior under poultry manure + neem cake + Panchagavya treatments. Higher nutrient uptake and nutrient use efficiency in both main and ratoon crops of annual moringa were also observed. Similarly, the quality parameters viz., crude fibers, protein, ascorbic acid, carotene content and shelf life were also higher under organic manure applied with Panchagavya spray.

**Influence of Panchagavya spray on soil fertility.**

Microbial flora of soil plays an important role in soil health. The microorganisms present in the rhizospheres environment around the roots influence the plant growth and crop yield. The beneficial microorganisms from Panchagavya and their establishment in the soil improved the sustainability of agriculture.

**Panchagavya makes enhancing of bioagents in soils**

Meena et al. (2000) reported that during the entire course of two years of investigation, no pest and diseases were found in crops sprayed with panchagavya. Panchagavya contained Pseudomonas (45 x 103cfu ml-1) and saprophytic yeasts (35 x 104 cfu ml-1) which might have contributed to plant protection because Pseudomonas on plant surfaces have been found to induce pathogenesis related protein, siderophores, antibiotics and HCN in groundnut and rice, thus, enabled its use as a bio-controlling agent. Jahagirdar et al. (2000) conducted a field experiment and investigated ecofriendly integrated management of pepper foot rot caused by Phytophthora capsici Leonian and observed that combined application of Trichoderma viride and modified panchagavya mixture (mixture of cow milk, curd, ghee, dung and urine supplemented with yeast and common salts) reduced the disease incidence and increased the yield above 50% as compared to control. Ravi Kumar et al. (2011) reported that in groundnut, quality parameters like protein content (22.4) and protein yield (363.2 kg ha-1) were significantly higher with the application of FYM (7.5 t ha-1) + Rhizobium + PSB + panchagavya (3% at 30, 60 and 75 DAS) as compared to other treatments.

**Management aspects of Panchagavya in in vitro and in vivo conditions.**
Evaluation of antifungal activity

Disc diffusion method revealed that panchagavya inhibited vegetative growth of all the three fungal pathogens. Maximum inhibition was recorded with *Sclerotium rolfsii* (10mm) followed by *Fusarium oxysporum* (9mm). Different concentrations (5, 10, 15 %) of panchagavya exhibited significant inhibition in the fungal growth of the pathogens. The increase in concentration of the panchagavya there was corresponding increase in the inhibition of vegetative growth of the fungal pathogens. It is evident from the results that all the concentrations of Panchagavya proved to be significant in improving seed germination as compared to control. Seeds dipped in 5% concentration of Panchagavya showed maximum of 70% seed germination after 48 hours whereas 100% germination was recorded with 15% concentration. Applications of Panchagavya to capsicum plants adversely influenced their growth pattern. Significant variation in seedling length was observed due to spray with different concentrations of panchagavya. (Savita Jandaik and Vishakha Sharma 2016). Sugha (2004) evaluated antifungal potential of panchagavya against *R. solani* causing damping off of cauliflower seedling. It inhibited 40-100 per cent mycelial growth and suppressed the disease by 78-82 per cent in nursery beds. Panchagavya - an organic formulation was evaluated under in vitro for its antifungal activity against *Curvularia lunata* which was found to be the dominant pathogen in causing grain discoloration. Panchagavya resulted in 86.30 per cent inhibition of mycelial growth and 95.9 per cent of spore germination of *C. lunata*. Seed treatment with panchagavya further enhanced the seed germination with 90.7 per cent (Sumangala and Patil, 2007). Yadav and Lourduraj (2006) studied the effect of organic manures and panchagavya spray on rice (*Oryza sativa L.*) quality. Foliar spray of panchagavya recorded significantly higher physical characteristics like grain size, 1000-grain weight and milling quality as well as cooking quality.

Effect of Panchagavya on pest management

Jahagirdar et al. (2003) reported that modified panchagavya mixture (mixture of cow milk, curd, ghee, dung and urine supplemented with yeast and common salts) found most effective for the management of panama disease of banana. Boomiraj et al. (2004) reported that panchagavya was effective against leaf hopper (*Amrasca biguttula*) and white fly (*Bemisia tabacci*) in okra. Mudigora and Balikai (2009) reported that panchagavya + cow urine in combination with NSKE proved next best over spinosad in controlling shootfly in sorghum.

Economics

Gopakkalii and Sharanappa (2014) reported that in chilli, application of enriched biodigested liquid manure at 125 kg N equivalent ha-1 + 3 sprays of panchagavya (3%) recorded significantly higher gross return (1,51,668), net returns (96,281) and B:C ratio (2.74) as compared to control. Yadav and Tripathi (2013) observed that panchagavya + neem leaf extracts and panchagavya alone in greengram increased gross and net returns as well as B:C ratio as compared to control, being significantly the highest gross return and net return and B:C ratio recorded with the panchagavya + neem leaf extracts. Similarly, application of foliar sources at branching + pre-flowering + pod setting (3 foliar sprays) being at par with 4 foliar sprays (branching + preflowering + pod setting + pod maturation) resulted in significantly higher gross and net returns over application at two foliar sprays (branching + preflowering) or single foliar spray at either of irrespective stages.

Conclusion
The increasing concern for environmental safety and global demand for pesticide residue free food has evoked keen interest in crop production using eco-friendly products which are easily biodegradable and do not leave any harmful toxic residues besides conserving nature. So it is necessary to use natural products like Panchagavya to produce chemical residue free food crops and hence Panchagavya can play a major role in organic farming.

Reference


Integrated Farming System: The Future of Agriculture


DRIP IRRIGATION SYSTEM: AN APPROACH

Bhagwat Saran¹, Anil Kumar¹, Shreya Nivesh¹, Sachin Kumar¹ and Soupayan Saha²

¹Department of Soil and Water Conservation Engineering, College of Technology, G. B. Pant University of Agriculture and Technology, Pantnagar-263145, India.

²Department of Agro-Meteorology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar-263145, India.

Corresponding author email: saran.bhagwat007@gmail.com

Abstract

Drip irrigation system is a most regular technique used of water to the root zone of the plants. It is mostly used to the developing of horticultural products, support of scenes, and re-vegetation of exasperates soils in dry regions and amid times of lacking precipitation. Moreover, water system additionally has a couple of different uses in yield generation, which incorporate securing plants against frost suppressing weed growing in grain fields and helping in preventing soil consolidation. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed or dry land farming. Irrigation systems are also used for dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the natural or artificial removal of surface and sub-surface water from a given area.

Drip irrigation, also known as trickle irrigation or micro irrigation, is an irrigation method which saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. In drip system, the losses by deep percolation and evaporation are minimized. Drip irrigation is of recent origin, and, in India, is being used on a limited scale in Tamil Nadu, Karnataka, Kerala and Maharashtra States, mainly for coconut, coffee, grape and vegetable production. Drip irrigation system is more effective in semi-arid, arid and drought prone areas. Progressive farmers started using this method of irrigation in the late-1970s without the benefit of any subsidies or support from central or state governments. In the states like Maharashtra, Karnataka, Rajasthan and Tamil Nadu is mostly used for irrigation of vegetable and other commercial crops. In India, there has been a tremendous growth in the area under drip irrigation during the last 15 years.

At present, approximate 3.51akh ha area is under drip irrigation with the efforts of the Government of India, while it was only 40 ha in 1960. Maharashtra (94,000 ha), Karnataka (66,000 ha) and Tamil Nadu (55,000 ha) are some of the states where large areas comes under drip irrigation system. Many crops are irrigated by the drip method in India with the tree crops occupying the maximum percentage of the total area under drip irrigation, followed by vine crops, vegetables, field crops, flowers and other crops. Sah et, al.(2010) published an article, Design, construction and evaluation of low pressure and low cost drip irrigation system.

It was originally developed in Israel by Simca Biass, a hydraulic engineer in 1959. Field research on drip irrigation began in Israel in early 1960s with sub surface techniques. During the summer months, the plant was irrigated by a hanging pitcher containing water and a minute hole at its bottom to allow the trickling of water on to the plant. The tribal farmers of Arunachal Pradesh practiced a primitive form of drip irrigation system using a slender bamboo as the conduit for water flow. The history of drip irrigation is very old; use of drippers in sub surface irrigation
system was first experimented in Germany 1869. The conspicuous growth of the petrochemical industry during and after the 1950s facilitated manufacturing of plastic pipes at a cost much cheaper than the cost of metallic or cement concrete pipes. Due to reliability and cost, plastic pipes are most commonly used for water conveyance on every corner of the field under pressure and also the plastic materials are easily formed into the desired configurations. These are the important features of plastic according to the field-scale use of drip irrigation. The area under drip irrigation system in the USA is about 1 M ha, followed by India, Spain and Israel. Drip irrigation has been used since ancient times when buried clay pots were filled with water, which would gradually seep into the grass.

Modern drip irrigation began its development in Afghanistan in 1866 when researchers began experimenting with irrigation using clay pipe to create combination irrigation and drainage systems. E.B. House (1913) applying water to the root zone of plants without raising the water table. Perforated pipe was introduced in Germany in the 1920s and in 1939 O.E. Plastic microtubing and various types of emitters began to be used in the greenhouses of Europe and the United States. Usage of plastic emitter in drip irrigation was introduced in Israel by Simca Blass and his son Yeshayahu. Rather than discharging water through small openings, blocked effectively by modest particles, water was discharged through bigger and longer paths by utilizing speed to moderate water inside a plastic producer. The principal test arrangement of this sort was set up in 1959 when Blass collaborated with Kibbutz Hatzerim to make a water system organization called Netafim. Starting in 1989, Jain water system helped pioneer successful water-the-board through dribble water system in India. Jain irrigation also introduced some drip irrigation marketing approaches to Indian agriculture such as 'Integrated System Approach', One-Stop-Shop for Farmers, and 'Infrastructure Status to Drip Irrigation & Farm as Industry'. The latest developments in the field involve even further reduction in drip rates being delivered and fewer tendencies to clog.

Drip Irrigation for Landscape and Garden

Hundreds of thousands of acres of money-producing crops are now being irrigated exclusively with drip irrigation. Agriculture dribble water system frameworks currently have near a multi-year history since the early trials started in Israel. Presently with the experience increased through horticultural use, it is currently feasible for mortgage holders to all the more likely water trees, bushes, bloom and vegetable greenhouses, ground cover, pruned and hanging plants. The utilization of trickle water system has significantly expanded as the general population has been looked with rising water expenses and shortage of water. Drip irrigation now provides homeowners with an exciting plant watering concept that not only conserves water, but also accelerates plant growth. Drip irrigation is very successfully used in a different of climates, soil, plants, crops and growing methods. It involves the installation of a permanent plant watering system that to provide water where it is wanted, and in the fix amount that is necessary for optimum plant growth. Drip irrigation is the most efficient because in the sprinklers system water into the air, where much of the water is lost through evaporation and never reaches to the plants. Flood irrigation transports the water in open trenches to the soil where the planting gets about half of the water supplied. With the water supply getting lower and lower throughout the country and the world, the conservation of this precious commodity by drip irrigation may eventually be the difference between adequate food and famine, or green yards and dirt. In short, drip irrigation is the slow and precise delivery of water to chosen plantings. This is achieved by the use of flexible polyethylene tubing or PVC pipe with devices for dripping water (emitters) and low-volume sprays, drip tape, Laser Soaker Line, or Porous Pipe systems. The frameworks are anything but difficult to introduce, requiring no trenching and shears for cutting polyethylene hose or tubing, and PVC pipe cutters for cutting PVC pipe. A whole punch is required for
installing an emitter into the polyethylene hose. Drip irrigation system can maintain moisture near to the root zone of the plants, avoiding dewatering and dry in the root of plants. Drip irrigation systems can be controlled manually or by the use of an automatic timer in conjunction with a tension meter, and can be used to apply fertilizers directly to the roots of plants. If the entire area being irrigated to set up in one system, multiple or higher output emitters can be placed by the plants which require more water. An ideal arrangement is to set-up numerous frameworks, with plants that have comparable watering needs being set on a similar framework. This permits expansive plants, for example, trees, to get the profound watering they require, while permitting the regular shallow watering that little ornamentals incline toward. Emitters should not be buried, but can be brought to the surface by either bringing the main polyethylene hose to the surface wherever the emitters are attached to the hose, or by attaching a small adaptor and tubing to the main line, and inserting the emitter, leaving only the emitter above ground. Small “Mini-Sprays,” are also useful in mixed landscape areas.

Fig. 1 Component of drip irrigation system

Component of Drip irrigation system: A typical drip irrigation system consists of the following components:

A. Pump unit
B. Control Head
C. Main and sub main lines
D. Laterals
E. Emitters and drippers

Pump unit: It consist a pump to lift water and to produce desire pressure (about 2.5 atmospheres pressure) from the source to distribute the water through the nozzles.

Control head: As drip irrigation used to obtain high irrigation efficiency, flow and control devices are an integral part of the system. Flow and pressure are to the control during each phase of irrigation. The flow control valve and pressure regulator valve are used for control flow and pressure.

Mains and sub-mains: These are normally of flexible material such as PVC or plastic. The diameter of the mains sub-mains should be sufficient to carry the design discharge in the system. There should be a balance between the diameters of mains and Sub-mains and friction losses. The size of mains and sub-mains is ranges from 4 cm to 11 cm in diameter.
Laterals or drip line: Use 25mm PVC or polyethylene irrigation pipe for mainlines and laterals. The aggregate length of the mainline and the sidelong together ought not to be in excess of 120 meters. Keep in mind mainline is the pipe before the control valve, parallel is pipe after the control valve. Many drip systems won’t need mainlines or laterals. There are small diameter flexible lines (usually 1 to 1.25 cm diameter) taking off from mains or sub-mains. The laterals are normally kept parallel to each other; usually one lateral line is use for each crop row. A pressure drop about 10% is permitted between the two ends of laterals. The laterals are usually made of low density polyethylene. The size of laterals ranges from 10mm to 20mm inside diameter.

Drip nozzles or emitter: An emitter is also called a dripper and is used to transfer water from a pipe or tube to the area that is to be irrigated. Typical emitter flow rates are from 2 to 10 liters per hour. In market different type of emitters available, flow will vary with pressure, some emitters are pressure compensating.

Fig.-2 Emitter

Application of chemicals and fertilization in drip irrigation system

Water soluble fertilizer can be effectively and efficiently through the drip irrigation system (fertigation) it reduces labour equipment and energy cost and higher fertilizer use efficiency are the major benefits of fertilization compare to the water application the plant protection can be applied effectively same facility. The fertilizer tank is used for mixing the fertilizers. The fertilizers tank should have a sufficiently large capacity to contain the entire fertilizer solution required for the cropped area for any application.

Installation the Drip Emitters:

At the other end of the section of 1/4" hose, attach the drip emitter by pushing or wiggling it on. Then place the emitter at the base of the plant, by the roots. Continue like that, down the row, bringing the drip emitters to each plant. Once you have all of lines in place, turn on the system. Test it and make adjustments. This may be where your goof plugs will come in handy.

Design criteria of Drip Irrigation System: Design of drip irrigation system broadly involves the estimation of water requirement of the crops to be irrigated, number of emitter and laterals, diameter of the main, sub-main and laterals pipe and the size of the pumping unit. Under the normal condition in widely spaced crops, a minimum of 30% of the area irrigated when the drip system is adopted. For mature trees about 70% of the area may have to be irrigated. The following procedure is adopted in designing of drip irrigation system.

For a pump of a given horse power, the following relationship is possible, assuming that the efficiency remains same in both the cases:

\[ Q_1H_1 = Q_2H_2 \]  

In which, \( Q_1 \) = Discharge of the existing pump, lit/sec, \( H_1 \) = Total head of existing pump (m), \( Q_2 \) = Discharge planned for the drip irrigation system, lit/sec and \( H_2 \) = total head required while using the drip irrigation (m)

The design discharge that can be considered for the drip system to be operated by existing pump can be written as:
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\[ Q_2 = \frac{H_0 Q_1}{H_d + H_1} \] ---- (2)

Hd= Additional head required for the operating the drip irrigation system (m).

The concept of a uniformity coefficient is applied to measure the moisture distribution pattern of a drip irrigation system full set of drip laterals in a main or sub-main may be laid on ground according to design spacing of laterals and drip nozzles. The uniformity coefficient may be calculated by relationship given below.

\[ \text{Uniformity coefficient (Cu)} = 100 \times \frac{1-x}{mn} \] ---- (3)

Where, \( m = \) average application rate mm/hr, \( n = \) total number of observation points , \( x = \) deviation of individual observation from the average application rate (m), mm/hrs and \( mn = \) total of all observation. A Cu of 100% is an indicative of absolutely uniform application rate.

Irrigation efficiency

Water application efficiency is the ratio between the water used by a crop and the total amount of water delivered to that crop, indicating how well an irrigation system performs in transporting water to the plant roots. A strong contrast is apparent when comparing furrows with sprinkler and drip systems, with the former having an efficiency of around 55 %, sprinklers 75 % and drip systems 90 %. To enhance water use productivity, need to think about different variables, and the significance of each will rely upon the activity's specific conditions. Smaller than normal Sprays:

There are wide assortments of low volume showers that can be utilized in a dribble water system framework. This shower enables you to communicate dry composts and foundational, and to have them drained into the dirt with the fine, low profile splash. Smaller scale splashes are a little fan type shower.

Watering Times

Times and interims for watering contrast as indicated by the kind of plant. The most essential factor to recollect is the profundity of the root zone and soil organization. The deeper the roots and the finer the soil, the longer the watering time must be, but frequency of watering will be reduced. A better soil, for example, mud, with which the vast majority of us are honored, can't ingest water rapidly, however will hold the dampness for a more drawn out timeframe. Shallow root zones and sandy soil types will require visit watering of a shorter span. Watch plant and soil dampness conditions and modify watering times and interims to boost plant development and limit water use. The primary water system cycle ought to be an any longer one than typical water system. You will need to totally build up the wet zone in each plant's root zone. This cycle could be from as short as 15 minutes, as far as possible up to conceivably 6 hours, contingent upon the plant material that you're watering and the kind of soil.

Maintenance

Occasional upkeep ought to be completed on all trickle water system frameworks. To do this, you have to assess the producers, flush the lines by opening the end top, and clean the channel. Contingent upon water quality, the recurrence of channel cleaning may differ. The advancement of dribble water system items has prompted effective and inconvenience free frameworks for both the business cultivator and the property holder. On the off chance that you are experiencing difficulty with your framework, direct the standard support methodology first. Should the issue be a solitary producer, supplant it. On the off chance that it is progressively across the board, search for a break in the lines. In the event that the issue can't be dictated by perception, it might
be the aftereffect of a deficient water supply or defective framework plan. Essentially removed the harmed area of line and introduce another piece utilizing the couplings to associate the two sorts out. Furthermore, recall, each time you roll out an improvement or fix to our framework; the lines should be flushed to expel any flotsam and jetsam that may have gotten into them as you worked. "Goof” fittings and couplings ought to end up a piece of any fix pack.

Operating of drip irrigation system: Applying water 5 to 7 days each week is preferable to maintain optimum soil moisture levels for most plant varieties. This will lead to deeper moisture penetration and promote a corresponding root profile.

Effect of drip irrigation on Crop: Yield of crops cultivated under Drip irrigation system is substantially higher than the crops cultivated in the same agro climatic Conditions by Flow Method of Irrigation (FMI). Under Drip irrigation system the availability of water and nutrients is very close to the root zone and at required time interval in just adequate quantity. Using drip irrigation system in a field, the yield increase up to 40 - 100% has been increase. There are two main reasons for higher yield for crops under Drip irrigation system. Firstly, unlike Flow Method of Irrigation (FMI), Drip irrigation system supplies water at regular intervals at the root zone of the crops which does not create moisture stress for crops. In Flow Method of Irrigation (FMI), too much of water is applied on the first day and moisture keeps on reducing subsequently. In the case of overwatering, saturation more than field capacity. In this situation increasing leaching of water or deep percolation beyond the root zone of the crop.

Advantages of drip irrigation system:

i. Minimized fertilizer/nutrient loss due to localized application and reduced leaching.

ii. High water application efficiency.

iii. Leveling of is field not necessary.

iv. Ability to irrigate irregular shaped fields.

v. Allows safe use of recycled water.

vi. Moisture within the root zone can be maintained at field capacity.

vii. Soil type plays less important role in frequency of irrigation.

viii. Minimized soil erosion.

Specific Benefits of Drip Irrigation:

i. Water savings, since only those areas directly around the plants root zone are irrigated.

ii. Plants undergo less stress from variations in soil moisture, therefore plant appearance is enhanced.

iii. Constant moisture improves plant growth.

iv. Slow application rate prevents excess surface water build-up and reduces evaporation.

v. The low application rate and the use of automatic timers’ results in precise water control.

vi. Weed growth is reduced because areas between plants are not irrigated.
vii. System can be designed for use in all types of terrain and soil conditions.

14. Disadvantages of drip irrigation:

i. Expense: Initial cost can be more than overhead systems.

ii. Waste: The sun can affect the tubes used for drip irrigation, shortening their usable life. Longevity is variable.

iii. Clogging: If the water is not properly filtered and the equipment not properly maintained, it can result in clogging.

iv. Drip irrigation might be unsatisfactory if herbicides or top dressed fertilizers need sprinkler irrigation for activation.

v. Drip tape causes extra cleanup costs after harvest. You'll need to plan for drip tape winding, disposal, recycling or reuse.

vi. Waste of water, time & harvest, if not installed properly. These systems require careful study of all the relevant factors like land topography, soil, water, crop and agro-climatic conditions, and suitability of drip irrigation system and its components.

vii. Germination Problems: In lighter soils subsurface drip may be unable to wet the soil surface for germination.

viii. Requires careful consideration of the installation depth.

References


*Integrated Farming System: The Future of Agriculture*


IMPORTANT DISEASES OF FENUGREEK AND THEIR MANAGEMENT

Krishna Kumar¹* Sandeep Kumar¹ and Akshay Kumar²

Department of Plant Pathology¹/ Department of Entomology², Narendra Deva University of Agriculture and Technology Narendra Nagar, Kumarganj, Faizabad, (U.P.) 224229, India.

Department of Plant Pathology¹, Sardar Vallabh bhai Patel University of Agriculture and Technology Modipuram, Meerut (U.P.) 250110.

Corresponding Author E-mail: krishvalia1828@gmail.com

Fenugreek (Trigonella foenum-graecum L.) locally known as methi belongs to the family Fabaceae is widely used as seed spice and also cultivated for leafy vegetable. Its fresh and tender leaves are rich in iron, calcium, protein, vitamins and essential amino acids. Besides, it has medicinal values as it prevents constipation, removes indigestion, and stimulates digestive process and metabolism. Seeds are used for the treatment of diabetes, dysentery, diarrhea and rickets. Diosgenin extracted from the seeds is used in synthesis of sex hormones. The seeds also contain a large amount of saponins and fibers that account for many health benefits. Fenugreek has neuroprotective, antimigraine, memory improving, antibacterial, antiviral and antitumor activities, because it contains a large amount of saponins, phenol, flavonoids and fibers that cause for many health fits. Cercospora Leaf Spot is a destructive and widespread disease of fenugreek (Trigonella foenum-graecum L.). Cercospora Leaf Spot disease was reported from Eastern Europe countries, South America, Canada, Australia and India. Among these diseases Cercospora leaf spot (Cercospora traversiana) is reported as the most destructive disease which under suitable environmental conditions for pathogen can cause 80 per cent reduction in yield. The powdery mildew caused by Erysiphe polygoni DC and Laveillula taurica (Lev) Arm. Erysiphe tryphi is also reported. The powdery mildew disease was observed on fenugreek leaves. The disease becomes serious at temperature between 15-25°C and at a relatively humidity range of 60-70%. This disease is caused by Peronospora trigonellae Gaum. In initial stage of disease a whitish growth on the lower surface of leaves appear. This disease is caused by Rhizoctonia solani which is soil-borne. The initial symptoms of the plants show yellowing and drying of leaves and later on whole plant may dry. Symptoms include varying degrees of rotting of the root leading to foliage yellowing in 30-45 day-old-plants. The affected plants wither and dry up.

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1. CERCOSPORA LEAF SPOT

Cercospora Leaf Spot is a destructive and widespread disease of fenugreek (Trigonella foenum-graecum L.) Cercospora Leaf Spot disease was reported from Eastern Europe countries, South America, Canada, Australia and India. Among these diseases Cercospora leaf spot (Cercospora
Cercospora traversiana is reported as the most destructive disease which under suitable environmental conditions for pathogen can cause 80 per cent reduction in yield (Singh, et al., 2011. Cercospora traversiana is only species of the Cercospora that can infect fenugreek (Ryley, 1989, Cook, 1978. The disease is uniformly distributed throughout the field grown for seed production. In severely infected plants only a few upper leaves remained survive. The sign of disease symptoms were surrounded by yellowish halo on older leaves, stem and pods (Mishra, and pandey, 2015.

Symptoms

The disease appears on older leaves as lesion surrounded by a yellowish halo. On individual plants only the upper few leaves remained, giving the appearance of tuffs of green scattered throughout the plot. Stem and pod infection also are severe. The infected areas of the pod are discoloured and severely infected areas are shrunken or twisted. It is the infection of some plants leaf is so severe that even the youngest leaves wilted and died.

Causal Organism

The Cercospora Leaf Spot is caused by Cercospora traversiana disease of fenugreek (Trigonella foenum-graecum L.) Cercospora traversiana Sacc. is a members of Deuteromycetes and is seed borne in nature (Elwakie and Ghneem, 2002. The conidiophores of Cercospora traversiana are dark, paler towards the tip, unbranched and rarely geniculate or septate. The conidiophores develop in groups of 3-12 conidiophores per fascicle, with a length ranging from 17.6-28.8µm and a width ranging from 1.78-3.16µm. the conidia are hyaline, acicular, straight or slightly curved, with a rounded apex, a truncate base and indistinctly multiseptate, with a length ranging from 2.3-2.8µm and a width ranging from 1.2-1.9µm. Cercospora traversiana colonies are seen as cottony white and slightly raised on the upper side of the colony, and the underside of the colonies is olivaceous black with narrow sectors of pale olivaceous grey. The colonies are circular, 46±4 mm in diameter, with irregular margins.

Disease Cycle

Cercospora traversiana is seed borne in nature. The main source of overwintering in plant debris, where stroma can form. Conidia are germinated best at a high temperature. They disperse mainly by the rains-splash and some extend by wind.

Management: Remove infected plant debris from the soil. Select the healthy seed. Follow crop rotation with non-host crops. Use Bavistin (1000ppm) as seed dressing to control the disease.

2. POWDERY MILDEW

The powdery mildew caused by Erysiphe polygoni DC and Laveillula taurica (Lev) Arm. Erysiphe trypi is also reported. The powdery mildew disease was observed on fenugreek leaves. The disease becomes serious at temperature between 15-25°C and at a relatively humidity range of 60-70%.

Symptoms

It usually appears late in the season. White, powdery spots on leaves which expand over time. Yellow spots may be visible on leaf underside. Powdery white growth can be seen on both the surfaces of the leaves. It also appears on above ground plants.

Causal Organism
The powdery mildew caused by *Erysiphe polygoni* DC and *Laveillula taurica* (Lev. The pathogens are obligate parasites. The conidiophores of the fungus are simple and erect, varying in size from 32.5-65.6×9.7-13.6µm and corresponding conidia unicellular, hyaline in colour, ellipsoidal to cylindrical in shape, with size 22.6-48.4×12.4-20.8µm.

**Disease Cycle**

Disease is seed borne and pathogen also survives on plant debris in form of mycelium and cleistothecia of wall of the asci. The Ascospores first infect the lower and older leaves in the next season. The spores are carried by the wind to new hosts.

**Management:** The remove infected plants debris in soil. Select healthy seed for sowing. Treat the seed with Benlate fungicide (0.1% a.i.). The disease is managed by giving two spraying of 0.2% sulphur or 0.05% Karathene. Varieties like- Prabha, Rajendra Kranti, RMT 1 and Lam selection 1 are tolerant.

3. **DOWNY MILDEW**

This disease is caused by *Peronospora trigonellae* Gaum. In initial stage of disease a whitish growth on the lower surface of leaves appear. With the advancement of infection, the leaves start turning yellow and shedding and the plant growth is checked. Symptoms include the presence of yellow patches on the upper surface and a cottony- white mycelium at the surface in the corresponding areas.

**Management:** The disease is managed by employing sprays of any copper-based fungicides. Spray 0.2% solution of Indofil M-45 or Fylotan and repeat it after 15 days if necessary.

4. **ROOT ROT**

This disease is caused by *Rhizoctonia solani* which is soil-borne. The initial symptoms of the plants show yellowing and drying of leaves and lateron whole plant may dry. Symptoms include varying degrees of rotting of the root leading to foliage yellowing in 30-45 day-old-plants. The affected plants wither and dry up.

**Management:** Follow crop rotation for 2 to 3 years. Deep ploughing in summer months may be followed. Use of soil amendments like neem cake @one tonne per hectare and farmyard manure @10-25 tonnes per hectare is beneficial. The antagonistic fungi *Trichoderma viride* is recommended along with neem cake. The disease is checked by a seed dressing with 0.1% Carbendazim or two soil drenching with 0.1% Carbendazim. Captan as a soil drench is also effective.

5. **DAMPING OFF**

The disease is caused by the fungi *Pythium aphanidermatum*. The infected seeds and seedling appear water-soaked, discoloured and soft emitting a bad odour. The seedling topples down and withers of.

**Management:** Use disease free seed. Do deep ploughing of field in summer months. The disease is managed by a drenching of Carbendazim or Brassicol.

**Reference**


