

INTENSIVE AGRICULTURE

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EDITORIAL

The resolution initiated by Government of India to mark year 2023 as the 'International Year of Millets' has been unanimously adopted by the United Nations General Assembly and declared year 2023 as the 'International Year of Millets'. The 'International Year of Millets' stands to provide a unique opportunity to increase global production, ensure efficient processing and consumption, promote a better utilization of crop rotations and encourage better connectivity throughout food systems to promote millets as a key component of the food basket. The International Year will (i) elevate awareness of the contribution of millets for food security and nutrition, (ii) inspire stakeholders on improving sustainable production and quality of millets; and (iii) draw focus for enhanced investment in research and development and extension services to achieve the aims.

Millets are collective group of small seeded annual grasses that are grown as grain crops, primarily on marginal land in dry areas of temperate, subtropical and tropical regions. These crops are adapted to wide range of temperatures, moisture-regimes and input conditions which supply food to millions of dryland farmers and fodder to animals, particularly in the developing world. Millets are among the first plants to be domesticated and are considered nutri-cereals due to their high nutritional content. They have served as a traditional staple for hundreds of millions of people in Sub-Saharan Africa and Asia for thousands of years and are now cultivated across the world.

In India, millets are mainly cultivated in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Odisha, Madhya Pradesh, Rajasthan and Uttarakhand states. India produces more than 170 lakh tones of millets with an average yield of 1239 kg/ha. The productivity of millets has increased by adoption of High Yielding Varieties / Hybrids by farmers.

India has celebrated 2018 as National Year of Millets. The initiative of Government of India to promote millet cultivation through revamped National Food Security Mission Operational Guidelines (NFSM) has focused on 212 millet districts in 14 states to provide incentives to farmers for quality seed production/distribution, field-level demonstrations, trainings, primary processing clusters and research support. Further, the 'One District One Product' initiative, which identifies agro-climatically suited crops with niche demand, has identified 27 districts as focused millet districts.

In the present scenario, when India supports more than 15% of the world's population but has only 4% of its water resources, promotion of millets would have significant role in nutritional security of growing population. Hence, increasing the production as well as popularity of millets as super food is the need of hour. Besides, in the rainfed farming conditions of Indian Agriculture, millets are best suited for cultivation in such conditions having capacity to grow under drought conditions and withstand high temperatures. It is hoped that the 'International Year of Millets - 2023' would certainly popularize the millets as super food at global level and India would emerge as a global leader in millet cultivation, processing, marketing and exports.

Dr. Sanjay Kumar Joshi



Vermicomposting: Recycling Solid Waste into Organic Fertilizer

Roop Singh, Rakesh Kumar Bairwa and Mahendra Singh



Widespread use of chemical fertilizers significantly contributes to environmental degradation through depleting fossil fuels, increasing CO₂ production and contaminating water supplies. There is a growing recognition that adoption of ecological and sustainable farming practices is the only way to reverse the global carbon concentrations and environmental degradation trends. Population growth, urbanization, industrialization and agricultural production have all resulted in massive accumulations of solid waste which has resulted in major environmental issues. Transformation and safer disposal of this solid waste is need of hour for maintaining soil health and pollution free environment. In this journey, vermicomposting is becoming more widely recognized as an eco-friendly procedure for converting a wide range of wastes into valuable organic fertilizer and it also promotes pollution free soil environment.

Vermicomposting is globally becoming a popular solid waste management technique. It is a simplistic microbiological composting method in which certain earthworm species are employed to enhance the waste conversion process and produce a better end product. Earthworms consume organic matter (straw, agri-residues, waste) and generate a product called

Nutrient Composition of Vermicompost

Nutrient element	Availability in Vermicompost (%)
Organic carbon	9.8–13.4
Nitrogen	0.51–1.61
Phosphorus	0.19–1.02
Potassium	0.15–0.73
Calcium	1.18–7.61
Magnesium	0.093–0.568
Sodium	0.058–0.158
Zinc	0.0042–0.110
Copper	0.0026–0.0048
Iron	0.2050–1.3313
Manganese	0.0105–0.2038

vermicompost. Vermicompost contains finely divided peat-like components that have a lot of porosity, aeration, drainage and water-holding capacity. It has a large surface area which allows

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for good nutrient absorption, retention and provides platform for microbial activities. Vermicompost contains nutrients such as nitrates, soluble phosphorus, exchangeable potassium, calcium, magnesium and other micronutrients such as zinc, copper, iron, manganese etc. in these forms which are readily available to the plants.

Earthworms

Earthworms are invertebrates which belong to Annelida phylum and *Oligochaeta* class that comprises more than 1300 species; most of the species belong to *Lumbricidae* family and genera: *Allophora*, *Aporrectodea*, *Bimastos*, *Dendrobaena*, *Eisenia*, *Lumbricus* etc. On the basis of its feeding habits, the worm is classified into two types: (1) burrowing and (2) non-burrowing. The burrowing type lives deep in



vertical burrows, 20-30 cm long and lives for 15 years; e.g. *Lumbricus terrestris*. On the other hand, non burrowing lives in the upper soil surface, 10-15 cm long, lives up to 28 months and feeds on organic matter and detritus; e.g. *Eisenia fetida*, *E. andrei*, *Perionyx excavatus*, *P. sansibaricus*, and *Eudrilus eugenie*. Importance has been given to *Eisenia fetida* and *Eudrilus eugenie* which are potential agent in vermicomposting of different types of agricultural wastes and can grow at wide range of tempera-

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tures varying from 0-40°C. However, the optimum temperature ranges are 20-30°C.

Preparation of Vermicompost

A cost - effective model of vermicomposting adopted by KVK, Kota consists of two chambers (10 ft length X 6 ft width X 1.5 ft height) having partition walls with small holes to facilitate easy movement of earthworms from one chamber to another. This facilitates harvesting of vermicompost, saves labor for harvesting and introducing earthworms.



Favourable conditions for earthworms in the composting material

- ◆ pH: Range between 6.5 and 7.5
- ◆ Moisture: 60-70%
- ◆ Aeration: 40-50% from the total pore space
- ◆ Temperature: Between 18 to 35 °C

Vermicomposting involves the following steps

- ◆ It is commonly prepared in either pit or heap method. The range of agricultural residues include all dry wastes, soybean residues, sorghum



straw and wheat straw, dry leaves of crops and trees, pigeon pea stalks, groundnut husk, vegetable wastes, weed (Parthenium) plants before flowering. In addition, animal manures, dairy and poultry wastes, food industry wastes, municipal solid wastes also serve as good raw materials for vermicomposting.

- ◆ Spread 15–20 cm layer of organic waste material then sprinkle cow dung slurry. Fill the ring completely in layers.
- ◆ Cover the ring/heap with gunny bag. Sprinkle water every three days to maintain adequate moisture and body temperature of the earthworms.
- ◆ When the vermicompost is ready, it has characteristics like black in colour, light in weight and free from bad odor.
- ◆ The vermicompost is ready in 45-60 days depending upon moisture, temperature and used raw materials.
- ◆ Do not sprinkle water for one week to make compost easy for sifting.
- ◆ Prepare another pile about 20 days before removing the compost and repeat the process by following the same procedure.

Precautions

The following precautions should be taken during vermicomposting:

- ◆ Do not cover vermicompost beds/heaps with plastic sheets because it may trap heat and gases.
- ◆ Do not overload the vermicompost heap to avoid high temperature that adversely affects earthworm activity and population.
- ◆ Only plant-based materials such as grass, leaves or vegetable peelings should be used as raw material for vermicompost.
- ◆ The earthworms should be protected from direct sunlight, birds, termites, ants and rats.
- ◆ Adequate moisture should be maintained during the process. Excess or deficit moisture may reduce the activity or it may kill the earthworms. There is provision of drainage channel

around the heap to avoid stagnation of water particularly in high rainfall areas during rainy season.

- ◆ Organic materials used for composting should be free from non-degradable materials such as stones, glass pieces, plastics, ceramic tubes/bulbs etc.
- ◆ Worms are shade and dark loving so cover the bed/heap with gunny bags to make darkness as well as reducing moisture level in beds.
- ◆ Cow-dung should at least be 15-20 days old to avoid excess heat.

How to use Vermicompost?

Vermicompost can be used for all crops: agricultural, horticultural, ornamental and vegetables at any stage of the crop.

- ◆ For general field crops: Around 4–5 ton per hectare vermicompost is used for broadcasting application before sowing or even may be used in standing crop if required.
- ◆ For fruit trees: 5 to 10 kg per tree depending on the age of the plant.
- ◆ For vegetables: For raising seedlings to be transplanted, vermicompost at 1 ton per hectare is applied in the nursery bed. This results in healthy and vigorous seedlings.

Advantages of Vermicompost

- ◆ Vermicompost is a rich source of all essential nutrients, vitamins, enzymes and growth hormones. So, it gives healthy plant growth hence boosts defense mechanism in plants.
- ◆ Vermicompost enhances the microbial activities through providing carbon and energy, therefore, increases the availability of nutrients through N fixation and P solubilization. Its application enhances nodulation in legumes and symbiotic mycorrhizal associations with the roots.

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Intensive Agriculture



Fall Armyworm Infestation in Maize and its Management

Parkash Verma, Rajesh Kumar Meena and Nutan Chauhan



Maize (queen of cereals) is a very important cereal crop of India and being a day-neutral crop, it can be grown round the year in the country. Maize is grown approximately on 9.2 million hectares area in India. Maize production in India is around 30.24mt. Many insect pests infest this crop, major are: maize shoot bug, maize aphid, pink stem borer and shoot fly. Recently there has been an insurgence of a new insect-pest in maize crop in a wide acreage. This insect species has been originated in the USA and later spreaded to many other countries, especially African countries, China and India. This insect pest was first reported in June 2018 in Karnataka state of India. It arrived in India through human aided transport after slippage through the regulatory system. This pest is so destructive that in the year 2018 alone, it has damaged 20-25% crop yield worth about 3.5-5 billion dollars in about 40 African countries. This pest is known as fall armyworm because this insect attacks in a group gregariously like an army and are very destructive to the crop. This insect damages many crops other than maize such as cotton, tobacco, rice, peanut, apple, oranges, and many more.

The scientific description of Fall Armyworm :

Order-Lepidoptera

Family- Noctuidae

Scientific name- *Spodoptera Frugiperda*

Life cycle

The life cycle of this insect completes in four stages, egg, larva, pupa and adult.

Egg- The armyworm's egg is dome-shaped and measures around 0.4 mm in diameter and 0.3 mm in height. Females prefer to lay eggs on the underside of leaves but they will lay them just about anywhere in high populations. The eggs will hatch into larvae within a few days in warm weather. The moths lay around 80-100 eggs in an egg mass and around 1000 eggs in their whole life.

Larva - Larvae of this insect are the only damaging stage and this stage lasts from 14-30 days and goes through 6 different instars. The size of mature larva is about 1.5-2 inches. The colour of the



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Crop damage by fall armyworm larva

larva is light brownish with two black coloured parallel lines on the dorsal side running from head to tail end. In addition, the dorsal side is dotted with black coloured dots. Fall armyworm caterpillars range in colour from shades of brown to grey, green or yellow-green. Four black dots on the posterior part of the body is the unique identification mark for this larva and the other most distinguishing characteristic is a whitish inverted Y between the eyes. The mouth of the larva is black coloured and the biting type of mouth part is present.

Pupa -The larvae pupate underground for 7 to 37 days in a cocoon made of soil and silk.

Adult moth - Adult moths are brown in colour

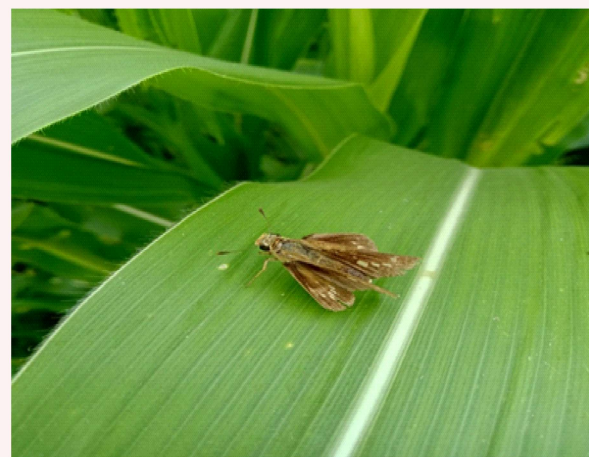
and nocturnal in habit. Adult life span is 10 days.

Damaging symptoms

There is no visible symptom in the early stage of its infestation. However, when larvae grow in size, their feeding capacity increases rapidly and they eat around 50 times their body weight. In the initial stage, the infected leaves can be easily identified by the brown or light yellow coloured excreta on the upper surface of the leaves. In the advanced stage, the plants denote leaves and there is complete arresting of further plant growth. The larvae feed gregariously and also eat even midribs of the leaves. Larvae can be easily found in the central whorl of the plant and it is found inactive



Damaged crop



Adult stage of Fall Armyworm



during day time. During the initial stage of tassel formation, if larvae are present, the whole tassel can be found damaged by the larvae.

Management and control

- ◆ Growing insect-resistant varieties.
- ◆ Avoid staggered planting and growing short-duration varieties. Follow the optimum time of sowing because warmer temperature increases this pest's metabolism and reproduction rate.
- ◆ Intercropping with push-pull technique in which desmodium is grown along with Napier grass to protect maize crop. Due to the repellent odour of the desmodium, which is intercropped with maize crop, insects avoid feeding on maize crop. Then these insects are attracted towards the border crop, i.e. Napier grass. Later on, the insecticide can be sprayed on Napier grass to kill these insects.
- ◆ Organic approaches- Green chilli solution, charcoal powder, salty water, lime, wood ash are some organic methods for fall armyworm control. Directly apply these organic materials



Direct spray of the solution on top of the plants

in the central whorl of the plant, either singly or in combination and then spray little water, it results in killing of larvae within 2-3 days.

- ◆ Biological control- *Bacillus thuringiensis*, *Numuraeareleyi*, *Trichogramma*, neem oil and pyrethrin can selectively control the larvae.
- ◆ Chemical control- Insecticides such as Emamectin benzoate 5% SG @ 100gm/ha, Cartap hydrochloride 50% SP, Thiomethoxam 25% WG, Chlorantraniliprole (Coragen 20 SC) may be applied for controlling the pest. For effective control, the spraying should be directed towards the growing central whorl of the plant where larvae reside.

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- ◆ Vermicompost has high porosity, aeration, drainage and water-holding capacity.
- ◆ Nutrient content of vermicompost is higher than traditional composts.
- ◆ It increases the 'Soil Organic Matter' (SOM), soil structure and prevent soil erosion.
- ◆ It reduces bulk density of soil, prevents soil compaction and erosion.
- ◆ It has immobilized enzymes like protease, lipase, amylase, cellulase and chitinase which continue their function of biodegradation of agricultural residues in the soil so that further microbial attack is speeded up.
- ◆ It does not have foul odor which is associated with manures and decaying organic wastes.



System of Rice Intensification

Pooja, Janardan Singh, Shilpa and Raveena



Rice intensification (SRI) is a system developed in the last two decades to find sustainable agricultural practices that can lead to higher productivity, better use of capital labour, lower input costs and less water use. SRI brings the elements of soil, water, light and plant together in a way that allows plants to reach their full potential. Rice broadcasting on the farm consumes 100 kg seed per hectare, whereas transplanting necessitates 30-60 kg seeds per hectare. Only 7-8 kg of seed is needed per hectare in SRI. Farmers are more likely to accept (and participate in) recommended practices because they are profitable, compatible with current farming practices, simple to implement and relevant to their labour use, farm inputs, credit, community values and crop situation. SRI has been discovered to be an agro-ecologically sound integrated approach to irrigated rice. It's also a well-designed innovation that makes efficient use of scarce resources, protects groundwater from chemical pollution and makes poor farmers more reliant on them.

The Rice Intensification System entails cultivating rice with as much organic manure as possible, beginning with young seedlings planted singly at wider spacing in a square pattern; intermittent irrigation that keeps the soil moist but not in-

undated; and frequent inter cultivation with a weeder that actively aerates the soil. SRI defies all established wet rice cultivation rules. To begin, instead of waiting a month, seedlings are transplanted at the two-leaf stage (between 8 and 12 days old). Rather than planting single seedlings in bunches, the single seedlings are planted with a spacing of around 25 cm. Seedlings develop stronger roots and more tillers as a result of this method, as they are not competing for nutrients, space or sunlight. Rather than continuously flooding fields to prevent weed growth, plants are given the appropriate amount of water only and the soil is kept dry for a short period of time. This encourages microbial growth in the soil and reduces methane emissions. The soil is well aerated because weeds are controlled manually with a mechanical hand tool, it results in better plant growth. Fertilization is done with organic manure and compost. SRI is not a pre-packaged, pre-programmed technological solution, rather it is more of a set of ideas, a methodology for holistically managing and conserving resources by altering how land, seeds, water, nutrients and human labour are used to boost productivity from a small but well-tended number of seeds. SRI, as Father de Laulanié pointed out, is a collection of various beneficial practices.

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System of rice intensification

SRI Principles

There are six principles guiding system of rice intensification (SRI). These are:

- i. Seedlings are transplanted at a younger age;
- ii. Instead of a handful of seedlings, only one seedling is planted in each hole;
- iii. Increased use of organic fertiliser to improve soil fertility;
- iv. Instead of continuous flood irrigation, intermittent watering is used to increase wet and dry soil conditions;
- v. Plants are spaced wider apart instead of close, dense planting, with seed rates of 50-100 kg/ha. Plants were set out carefully and gently in a square pattern with distancing of 25x25cm or wider if the soil is very good. The seed rate is reduced by 80-90 percent and yield is as much as 90-95 kg of rice per hectare; and
- vi. Rotary weeding to control weeds and promote soil aeration.

Farmers can adapt recommended SRI practices to their agro ecological and socio-economic conditions using these principles. Adaptations are frequently made to accommodate changing weather patterns, soil conditions, labour availability, water management, access to organic inputs and whether or not to practice fully organic agriculture.

Critical steps in SRI

1. Nursery area and seed rate

For a 1 ha field, only 7-8 kg of seed is required. The nursery area per hectare has been reduced to 100 m². For 1 hectare, 20 raised beds measuring 1 x 5 m are required. Spread polythene sheets evenly over the rice seed beds for better germination. Fill the soil to a depth of 4 cm on the Polythene sheets. After that, evenly distribute



Nursery area of rice

375 g of seeds in each nursery bed of 5 sq.m. It is recommended that water be provided via a rose can. Use locally available mulching materials like coir pith/straw to cover the seed bed.

2. Seedling age

Seedlings of 8-12 days old age are recommended for transplanting (3 leaves stage). The seedling growth will be manageable if the nursery bed is properly prepared with enough organic manure.



Transplanting of rice seedlings



3. Water Management

One of the most important steps in SRI is water management and providing an aerobic environment in rice fields is the core point. Plants with truncated roots are unable to access the residual soil moisture in lower horizons that plants with large and functional root systems can access in order to maintain their growth and productivity. As a result, alternate wetting and drying is recommended. Irrigation is used to moisten the soil during the first 10 days only. After the development of hairline cracks in the soil, restore irrigation to a maximum depth of 2.5cm until panicle initiation. After panicle initiation one day after ponded water disappears, increase irrigation depth to 5.0 cm.



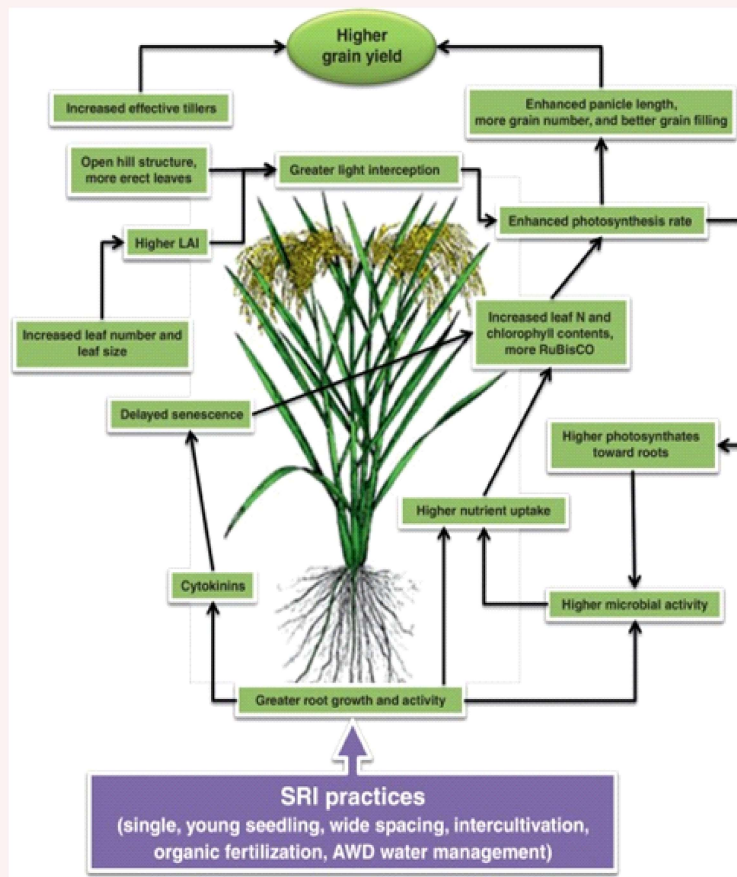
4. Mechanical (Cono) weeder usage

Square planting makes it easier to use a cono/ rotary weeder in two directions, allowing for more efficient weed control. Weeders should be used in SRI at 10 days interval after transplanting. One acre can be weeded in three hours of work. Weeds are trampled and the nutrients are ploughed back into the soil as they decay. Soil is disturbed frequently which has beneficial physico-chemical and biological effects. Tillering, which results in the bursting out of tillers, is triggered by root pruning. The water level should be carefully monitored while using a weeder. It is critical to remove any remaining weeds by hand. As a result, weeding costs are reduced by 52.5 percent.

- ◆ Grain weight increased without change in grain size
- ◆ Higher head rice recovery
- ◆ Withstand cyclonic gales
- ◆ Cold tolerance
- ◆ Soil health improves through biological activity

Advantages of SRI

- ◆ Higher yields – Both grain and straw
- ◆ Reduced duration (by 10 days)
- ◆ Lesser chemical inputs
- ◆ Less water requirement
- ◆ Less chaffy grain percentage



Schematic model showing factors that explain the increased grain yield of rice plants grown under SRI management practices



SRI practices and their effects:

Practices	Effects
Transplanting of young seedlings	<ul style="list-style-type: none"> • No or reduced transplanting shock • Early and increased tillering and root growth • Earlier transplanting date into the main field extends the time for rooting and tillering
Single seedling per hill & transplanted at shallow depth	<ul style="list-style-type: none"> • Seed requirements are greatly reduced • Reduced competition for nutrients, water, sunlight and space within a hill • Open canopy structure gives greater light interception by leaves and less shading of lower leaves, enhancing the supply of photosynthate, especially to the roots • Early root growth enhanced, leading to increased cytokinin flux toward the shoots, delayed senescence of leaves and roots, and increased photosynthesis
Wider spacing	<ul style="list-style-type: none"> • More space (below and above ground) for roots and shoots to access nutrients, water and light • Promotes more profused growth of roots and tillers
Moist and non-flooded water management regime	<ul style="list-style-type: none"> • Aerobic (nonhypoxic) conditions of the soil favor root health and functioning and also support more abundant and diverse communities of beneficial aerobic soil organisms • No degeneration of roots, which under flooded soil conditions become degraded by as much as 75% by the phase of flowering • Water savings up to 40% • Energy savings for pumped water • Reduced Green House Gas emissions
Intercultivation to control weeds	<ul style="list-style-type: none"> • Churning up and aerating the surface soil • Activates beneficial microbial, physical and chemical soil dynamics • Weed biomass is incorporated into soil as green manure • Weeding costs can be reduced
Increased use of organic manures	<ul style="list-style-type: none"> • Improves soil structure and porosity • Promotes root growth and root activity • Sustained nutrient supply over longer period • Favors growth and activity of soil biota

Disadvantages of SRI

- ◆ Higher labour costs in the initial years
- ◆ Difficulties in acquiring the necessary skills
- ◆ Not suitable when no irrigation source available

Conclusion

SRI is a promising option for rice growers than most other available methods of rice

cultivation, given the constraints of growing water scarcity and concomitant pressure to produce more grain to achieve more crop per drop. SRI provides an agroecological and climate-smart form of agriculture that integrates the economic, social, and environmental dimensions of sustainable development as well as addresses food security and climate constraints simultaneously.



Organic Cultivation of Traditional Paddy Variety Karuppu Kavuni

Dr. P. Shanthi, M. Umadevi and V. M. Indumathi



Food quality and safety are the two important factors which have drawn constant attention of consumers. Incidence of new diseases, environmental hazards and reduced immunity of the masses have substantially decreased the consumer's trust towards quality of available food in the last decade. Intensive application of inorganic fertilizers, weedicides and pesticides to increase the production has added contamination in the food chain. Due to this, consumers prefer to food that is produced through ecofriendly cultivation. The food which is cultivated through organic practices, fetch more market value and consumers believe that the food cultivated by organic approach may reduce the toxicity and improve their health by improving immune system.

Rice, wheat and maize are three leading food crops which supply more than 50 percent of the calories to the entire human population in the world. In India, majority of the people consume rice as staple food. It is cultivated around 45 million hectare area with the production of 121.46 million tones. India is the hotspot for biodiversity of paddy crop. In ancient days there were lakhs of traditional paddy varieties suitable for cultivation throughout the year. Jagannath temple in Odisha is a good example where the Pooja for Jagannath is done with freshly harvested grains every day. Tamil

Nadu has also been recognized as a centre with high biodiversity of rice crop. More than thousands of traditional paddy varieties are maintained by volunteers. Mostly all the varieties are highly suitable for organic cultivation.

Among the traditional varieties, only few are under cultivation in large area. Among the varieties, Karuppu Kavuni is very popular due to its taste and medicinal value. Pudukkottai district of Tamil Nadu is the main area for its cultivation because people prefer the food prepared using this traditional variety. They honor their guests with the



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dishes prepared using Karuppu Kavuni. Mostly in all the places this variety is cultivated under organic cultivation.

Karuppu Kavuni is suitable for the areas with red soils and black cotton soils. Duration of this variety is 145-150 days and grain weight is 32-35 gram (1000 grains). It can be cultivated either as direct sown or as transplanted crop. Based on farmer's feedback (Mr. Kalaiselvan from Kovil Veerakudi Village) in Pudukkottai District lodging is less observed in direct sown crop whereas more lodging was observed in transplanted crop. Two kg seeds are needed for cultivation in one acre area. The seeds are soaked overnight and kept as such in a gunny bag with tight covers after draining the water for one day then the seeds are used for sowing. The tillering capacity is 5-6 nos/plant (moderate tillering).

Organic farming is the best method to cultivate this variety. The sunhemp was sown (8 kg/acre) before cultivating paddy and ploughed *in situ* before flowering. Then if the fertility status is low, one tonne of vermicompost or 5 tonnes of Farm Yard Manure is required for basal application. Otherwise the organic fertilizers can be reduced based on the fertility status. The organic farmers can produce vermicompost in their backyard by utilizing farm waste and cowdung slurry. *Azospirillum* one packet (200 g) is required for seed treatment.

The farmers are preparing fish meal solution, Panchagavya, leaf extracts etc. and applying at

appropriate time as growth regulator as well as to control pests and diseases. Papaya leaf, Notchi leaf, Calotropis leaf, Oduvan leaf were soaked with cow urine for 15 days and used for spraying to control pests especially leaf folder and leaf minor. To control stem borer incidence the Panchagavya is used. At the time of flower initiation, cowdung slurry was sprayed to control bacterial leaf blight disease and other bacterial diseases.

Papaya fruits at young stage are cut into pieces and kept around the bunds to control rats. Average grain yield of this variety is around 1800 kgs per acre and 800 kgs of straw is also produced as cattle feed. The grains are milled in specific mills due to its grain size and shape. In the process of value addition, the grains are converted into parboiled/raw rice by milling in specific mills. The farmers cultivating this variety sell it as raw rice and get the price of Rs. 150 to 200 per kg. They are getting around 1000 - 1120 kgs of milled parboiled/raw rice from one acre area and net return per acre is around Rs. 150000 – 200000.

Uses of Karuppu Kavuni

The milling grains are used for preparation of Pongal, Halwa and Paniyaram preparation. Due to its taste and medicinal value, it is most preferred food in Sivaganga and Pudukkottai district. The dishes prepared using this Karuppu Kavuni is treated as prestigious food in Chettinadu area and people include dishes of this rice to honor their guests in all the family functions.

Medicinal uses

- ◆ It protects from colon cancer, heart diseases and obesity.
- ◆ It is having more antioxidants so helps in delaying the aging symptoms.
- ◆ Improves immunity due to its high iron content.
- ◆ It also contains more fiber hence easy for digestion.



User Friendly Tools Suitable for Efficient Nitrogen Management in Field Crops

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and R. L. Choudhary



Nitrogen is the most yield limiting nutrient for crop growth worldwide and its efficient management is important for economic sustainability. About 50% of the applied nitrogen to the soil remains unavailable to crop because of combination of various losses like leaching, volatilization and de-nitrification. Recovery of nitrogen under irrigated and submerged condition is hardly 35% because effectiveness of nitrogen supply to the crop is poor, due to the lack of synchrony between nitrogen supply and demand. Both excess and insufficient nitrogen applications may cause either yield reduction or some physiological disorders like hollow stem and pathological problems. Hence, effective management strategies for nitrogen fertilizer are important to ensure optimum seed yield and seed quality of field crops. Optimal nitrogen management strategies aim at matching nitrogen requirement with actual crop demand, thus maximizing plant nitrogen uptake and reducing its losses to the surroundings. The timing of nitrogen application is used to match the nitrogen demand by crop plants with supply. Leaf nitrogen content of crops is directly associated with photosynthetic rate and dry matter production, greenness of first fully opened leaf from the top which gives an indication of nitrogen demand and has, therefore, used

as guide for application of nitrogen at different crop growth stages. Now a day, many non-invasive tools are available to quantitatively measure leaf chlorophyll content by using leaves greenness, absorbance/reflectance of light by intact leaf. Among these diagnostic tools LCC, Soil Plant Analysis Development (SPAD) meter, and hand-held Green Seeker optical sensor are used widely in cereals to enhance nitrogen use efficiency in South Asia and elsewhere, when crop is already growing in the field to assess real-time nitrogen requirements. The details of these fertilizer saving tools with their using procedures are described.

1. Leaf Colour Chart (LCC)

First LCC was developed in Japan. An improved version of six panel LCC (IRRI-LCC, Six panel) was developed with collaboration of International Rice Research Institute (IRRI) with agricultural research system of several Asian countries. Recently, IRRI developed four panel of IRRI-LCC (Four green colour shades from number 2 to 5) to best match the spectral reflectance of plant leaves. Now a days, use of LCC for nitrogen application in many crops like rice, maize, wheat, sugarcane, potato, cotton, cassava and vegetables is a common practice. Leaf nitrogen status of crop is closely related to photosynthetic

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rate and biomass production, and it is a sensitive indicator of changes in crop nitrogen demand within a growing season. A tool to rapidly assess leaf nitrogen status and thereby guide the application of fertilizer nitrogen to maintain optimal leaf nitrogen content can consequently be vital for achieving high crop yield with effective nitrogen management.

The leaf color chart is an easy-to-use and inexpensive diagnostic tool for monitoring the relative greenness of a leaf as an indicator of the plant nitrogen status. It's a high quality plastic, ruler-shaped strip with different shades of green colour ranging from light yellowish green to dark green. The LCC is used to monitor leaf nitrogen status from tillering to panicle initiation or later (in rice) by either of two equally effective options. The decision on which option to be used can be based on farmers' preferences and location specific factors, such as frequency of visits by farmers to their fields and their knowledge of critical growth stages for nitrogen application. The fixed-time/adjustable-dose option saves time, and is thus preferred by farmers who have gainful alternative activities. The real-time option is generally preferred when farmers lack sufficient understanding of the critical stages for optimal timing of nitrogen fertilizer.

Real-Time Nitrogen Management Option

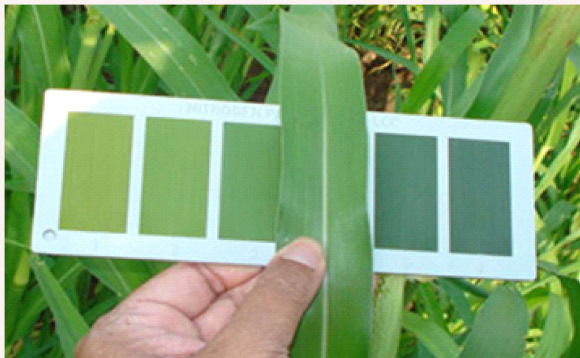
Farmers monitor the leaf color at 7 to 10 days interval from tillering to about 5-10 days after panicle initiation. Farmers apply nitrogen whenever the leaves become more yellowish-green than

a critical threshold value indicated on the LCC.

How to use LCC

LCC determines greenness of the leaf which indicates its nitrogen content. For this purpose, randomly select at least 10 disease-free plants in a field with uniform plant population. Always select the topmost fully expanded leaf from each plant. Place middle part of the leaf on a chart and compare leaf color with color panels of the LCC. Do not detach or destroy the leaf. Measure leaf color under the shade of your body, because of direct sunlight affects leaf color readings. If possible, the same person should take LCC readings at the same time of day every time. Determine average LCC reading for the selected leaves. If the color of a leaf (e.g. rice) is in between two shades, take the average of the two values of the reading. For example, if the color is in between 3 and 4, the reading should be 3.5. Take reading of 10 leaves and determine the average. If the color is more or less than 3, top dressing of nitrogen is needed. Use the LCC once every 7-10 days starting from the beginning of tillering (14 DAT). Continue this process up to 5-10 days after panicle initiation.

Plants deficient in nitrogen are yellowish in colour. Nitrogen deficiency is confirmed when the LCC reading is between panels 2 and 3. At lower nitrogen application rates, plants look better, but low LCC reading still indicates N deficiency. At higher nitrogen application rates, the plants look well developed and the canopy is closed. The LCC reading between panels 3 and 4 is critical range



LCC use in maize and rice



for most of the transplanted rice. In plants with high nitrogen application rate, leaves are dark green. Leaf color darker than the LCC panel no. 4 indicates a surplus of nitrogen fertilizer.

Advantages of Using LCC

- ◆ It is cost effective, cheaper and easy to use as it does not require any technical skills to assess the foliar nitrogen status. It saves excess use of nitrogen besides synchronizing nutrient supply and crop demand those results into higher nitrogen use efficiency.
- ◆ Larger area can be easily managed by using this practice.
- ◆ Using LCC reduces the nitrogen losses occurred during conventional methods (broadcasting/split application of nitrogen fertilizers).
- ◆ Studies reported that about 26-29% saving of applied nitrogen over recommended practices besides increasing partial factor productivity, agronomic efficiency and yield.

2. Soil Plant Analysis Development (SPAD) Meter

The SPAD meter is a hand-held device that is widely used for rapid, accurate and non-destructive measurement of leaf chlorophyll concentrations. It has been employed extensively in both research and agricultural applications for wide range of plant species. The SPAD chlorophyll meter instantly measures chlorophyll content or greenness of plants to reduce the risk of yield-limiting deficiencies or costly over fertilization. The SPAD quantifies subtle changes or trends in plant health long before they are visible to the human eye. Non-invasive measurement includes simply clamping the meter over leafy tissue and an indexed chlorophyll content reading (-9.9 to 199.9) is received in less than 2 seconds. It assesses nitrogen needs by comparing in-field SPAD readings to university guidelines or to adequately fertil-

ized reference strips. Research shows a strong correlation between SPAD measurements and leaf nitrogen content.

How to measure SPAD readings

- ◆ The fully expanded leaf of youngest plant is used for the purpose. Readings are taken from the midrib of the leaf blade.



- ◆ Average of 10-15 readings per plot/field to be taken. If the average value of SPAD falls below a critical value, then immediate nitrogen to be applied to circumvent the yield losses.
- ◆ The practice to assess the leaf nitrogen status should be repeated regularly at 10-15 days' time interval up to pre-flowering stage or initial 10% flowering.

Advantages

- ◆ Instantly measures chlorophyll content or greenness of plants on a scale of -9.9 to 199.9.
- ◆ Non-invasive, non-destructive measurement, waterproof design.
- ◆ Trend graph stores and displays up to 30 measurements.
- ◆ Compares in-field SPAD readings to university guidelines.
- ◆ Available with or without a built-in data logger.
- ◆ Use of SPAD does not require any technical skills, anyone can use it at any time.



3. Green Seeker (Optical sensor)

Green Seeker handheld crop sensor is an affordable, easy-to-use measurement device to assess the health or vigor of a plant in order to make better nutrient management decisions in the field. It is an integrated optical sensing, variable rate application and mapping system that measures crop nitrogen requirement. The device instantly



takes a reading of crop's health and these readings can be used to make non-subjective decisions regarding amount of fertilizer to be applied to crop, resulting in more efficient use of fertilizer that benefit to bottom line and the environment.

How to Use Green Seeker

- ◆ The device gives NDVI (Normalized Difference Vegetation Index) value on pulling the trigger based on density of greenness on a patch of land.
- ◆ The sensor emits brief bursts of red and infra-red light and then measures the amount of each type of light that is reflected back from the plant.
- ◆ The sensor continues to sample the scanned area as long as the trigger remains engaged.
- ◆ The sensor displays the measured value in terms of an NDVI reading (ranging from 0.00 to 0.99) on its LCD display screen.
- ◆ The strength of the detected light is a direct in-

dicator of the health of the crop; the higher the reading, the healthier the plant.

Green plants absorb most of the red light and reflect most of the infra-red light. The denser and more vigorous plants, greater is the difference in between the reflected light signals. The sensor should be held about 24-48" above the crop canopy and continue pulling the trigger. For taking reading from a larger area, walk with sensor while keeping trigger engaged, maintaining a consistent height above the crop surface. The display accumulates multiple readings continuously and gives average value after releasing trigger. Clear the display by pulling trigger for measuring new readings.

Benefits

- ◆ Save money by only applying the fertilizer needed for ideal crop health *i.e.* reduction in the cost of production due to avoid of excess fertilization application and increased net saving.
- ◆ Reduce environmental impacts with reduced chemical applications.
- ◆ Efficient nitrogen management by reducing nitrogen losses due to various means.
- ◆ Affordable data collection allows any operation to benefit from objective decision making.
- ◆ No additional equipment required – use free apps and mobile devices already own to connect via Bluetooth.

Conclusion

Precise dosage and timing of nitrogen application is crucial in modern crop production system for enhancing sustainability in long run apart from yield and nitrogen use efficiency increase including environmental safety. Various site specific nitrogen management techniques have been recommended that optimum nitrogen use resulted from congruence between nitrogen supply and crop demand and that fertilizer nitrogen could be saved with no or less yield penalty over the current blanket recommendations.



Adoption of *Trichoderma* spp. in Crop Disease Management

Amar Bahadur, Malay M. Sharma and Pranab Dutta



T*richoderma* is one of the most beneficial micro-organism in the agro-ecosystem which influences soil health, acts as biofertilizer, plants growth promoter, bioremediation and increases crop yield by reducing the use of harmful chemicals. The genus *Trichoderma* spp is highly competent root colonizer, fast-growing and produces numerous green spores. Colonization on root enhances root growth & length, increases dry weight, shoot length and leaf area, increases the fertility of soils, improves plant growth and disease management. The antagonistic activity of *Trichoderma* involves mycoparasitism, antibiotics, competition for nutrients and also induces systemic resistance in plants which is used to control plant diseases in sustainable disease management for promoting organic farming among farmers. *Trichoderma* species is parasitic on many soil-borne and foliar plant pathogens. It is used as a bio-control agent which stimulates plant resistance, plant growth and increases crop production. The effective strain of *Trichoderma* species is recognized to control plant diseases and to increase the root growth, crop productivity, resistance to abiotic stresses and uptake of nutrients. *Trichoderma* colonization in the roots and soil helps insolubilization of minerals viz; rock phosphate, Fe, Mn, Cu and Zn and also enhances N-used efficiency. Application in plants prevents

the infection of pathogens through induced resistance, competition for nutrients and space, antibiosis and mycoparasitism. Application of *Trichoderma harzianum* can improve seed germination, increase plant size, leaf area and weight. *Trichoderma reesei* and *Trichoderma harzianum* produce proteinase, mananase, laminarinase and chitinase which act as antagonist in mycoparasitism. *Trichoderma virens*, produces the antibiotics namely gliovirin and gliotoxin which act as mycoparasite; gliotoxin against *Rhizoctonia solani* & *Pythium litimum* and gliovirin against *Pythium* spp. *Trichoderma* spp. has been reported to control soil-borne plant pathogens viz., *Rhizoctonia solani*, *Sclerotium rolfsii*, *Pythium*, *Phytophthora*, *Macrophomina*, *Aspergillus* and *Fusarium* spp. through the mechanism of mycoparasitism, antibiotics and competition for food and space. *Trichoderma viride* and *Trichoderma harzianum* are highly antagonistic against *Botrytis* rot of fruits and *Sclerotium rolfsii* that causes diseases in vegetables and legumes. *Trichoderma hamatum* produces inhibitory volatile compounds that reduce the grey mold. *Trichoderma harzianum* T39 effectively controls *Botrytis* disease, white mold (*Sclerotinia sclerotiorum*), leaf mold (*Cladosporium fulvum*) and powdery mildew (*Sphaerotheca fusca*). *Trichoderma harzianum* through induced

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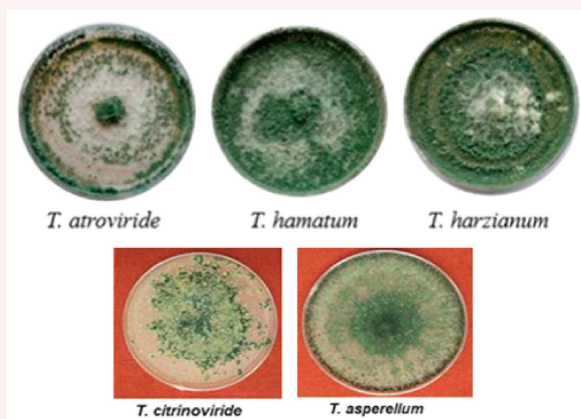
systemic resistance can manage fungal and bacterial diseases as well as it is associated with the reduction of the nematode population by parasitizing and killing in the rhizosphere. It has a rich source of chitinolytic enzymes which might degrade the eggshell during parasitism of eggs and juveniles. *Trichoderma* has no harmful effects on the environment and non-target organisms and can be applied to most food crops. *Trichoderma spp.* is a bio-control agent effective against a large number of soil-borne plants pathogenic fungi, nematodes and useful in plant growth promotion, produces enzymes that can degrade the cell wall, effective against abiotic stresses and also increases fertilizer use efficiency. *Trichoderma* gives long term efficacy by inducing resistance against plant diseases, formulations are applied as dry seed treatment and seed biopriming for the control of several soil-borne diseases. *Trichoderma harzianum* has the best antagonism to *Macrophomina phaseolina* and *Aspergillus niger*, while the *Trichoderma asperellum* is efficient in the reduction of nematode. *Trichoderma* based commercial products are manufactured and marketed worldwide for the management of plant diseases.

Trichoderma in biocontrol

Trichoderma species have been used as biological control agent, biofertilizer, enzyme and protein producer. Its common fungal bio-control agents are used worldwide for the management of various foliar and soil-borne plant pathogens. It

can be isolated from forest and agriculture soils and wood. Several species are beneficial in agriculture viz., *Trichoderma harzianum*, *Trichoderma viride*, *Trichoderma hamatum*, *Trichoderma virens*, *Trichoderma asperellum*. It multiplies and grows very fast in different nutrient sources such as Malt Agar, Czapek Dox Agar as well as Potato Dextrose Agar and produces conidia of various shades characterized by green color. It can be produced in a liquid or solid fermentation medium. *Trichoderma* species can be identified based on the morphology and colour of the colonies on the potato dextrose agar medium and confirmed based on the morphology of the conidia and conidiophores of different *Trichoderma* species. Green colony pigmentation appears after incubation for 7 days at 28°C on potato dextrose agar.

Conidiophores are highly branched and often formed in distinct concentric rings, producing three kinds of propagules; hyphae, chlamydospores and conidia. *Trichoderma* strains produce only asexual spores; the sexual stage of *Trichoderma* belongs to the ascomycete genus *Hypocrea*. *Trichoderma spp.* hyphae, chlamydospores and conidia have been used as the active ingredients of *Trichoderma spp.* based production. *Trichoderma* formulation available in the market are *Trichoderma harzianum* (Root Shield, Plant Shield, Trichodex, F- stolp, Binap-T) *Trichoderma viride* (Tricho-X, Biocon, Defense SF, Trichogourd, Ecofit, Funginil, Trichopel, Antagon-TV, Ecofit, Biogourd, Bip T, Trieco), *Trichoderma virens* (GlioGard and SoilGard), *T. viride* + *T. harzianum* (Bioderma, Ecoderma, Trichoject, Trichodowe), *Trichoderma atroviride* (Plant helper), *Trichoderma koningii* (Promot Plus WP and Promot Plus DD). *Trichoderma* formulation is used against wilt, root rot, damping-off, dry root rot and grey mold for successful disease control.



Colony of *Trichoderma spp.* on PDA medium

Mass multiplication

The mass production of *Trichoderma* for field application is done by two methods (i) solid-



state (ii) liquid-state fermentation. However, sporulation is higher on solid substrates than the liquid media. For solid state mass production *Trichoderma spp* is widely grown on sorghum grain, wheat straw, wheat bran, tea leaf waste, coffee husk and sawdust. The dark green spore coating on the grains can be powdered and used for seed treatment or grains may be used with farmyard manure (FYM) for soil application. The commercial formulation is prepared by diluting talcum powder containing 1% carboxymethyl-cellulose. In liquid fermentation, *Trichoderma* is grown in a liquid media which is used for field application. In the liquid state, fermentation includes molasses and brewer's yeast. *Trichoderma harzianum* and *Trichoderma viride* can be obtained in a short time (within 96 h) by using the appropriate medium. Molasses yeast medium is used for mother culture; it is prepared by adding molasses 30g, yeast 5g and distilled water 1000 ml.

Viability of *Trichoderma*

The shelf life of the bio-control product depends on the storage temperature and carriers used in the formulation of biocontrol agents. The bio-agent loses viability of the propagules over time. The shelf life of bio-control agent plays a significant role in successful marketing. *Trichoderma* spp. is multiplied on bio-degradable substrates for long shelf-life and is beneficial for field application. The shelflife of talc formulations of *Trichoderma* can be increased by using various ingredients (chitin and glycerol) in production medium which can increase the shelf life up to one year. Peat, lignite and kaolin based formulations of *Trichoderma* have a shelf life of 3-4 months.

Application of *Trichoderma* formulation

The formulation standard air dried mats, mixed with the carrier contain 10^8 - 10^9 propagules per gram. *Trichoderma* which is grown in the liquid medium is mixed with talc powder in the ratio

of 1: 2 and dried up to 8% moisture under shade. Commercial formulations based on carriers are available for controlling plant diseases. Oil-based formulations are suitable for foliar sprays under dry weather conditions with prolonged shelf life. *T. harzianum* is an emulsion based formulation with a shelf life of 8 months used for the control of post-harvest decay caused by *Botrytis cinerea*. *Trichoderma* can be used by following methods:

(a) Seed treatment- Seed coating with commercial dry formulation before sowing at the rate of 3 to 10g/kg seed (based on seed size) is an effective method for management of soil-borne diseases. 10gm *Trichoderma* formulation mixed in one litre of cow dung slurry is used for treatment of 1kg seed of cereals, pulses and oilseeds before sowing. *Trichoderma harzianum*, *Trichoderma virens* and *Trichoderma viride* were found effective seed protectants against soil-borne fungi such as *Pythium* spp., *Rhizoctonia solani*, *Sclerotinia* and *Macrophomina* species.

(b) Seed bio-priming- This technique includes coating of seeds which results in rapid and uniform seedling emergence and reduces the quantity of bio-control agents. Treated seeds are incubated until radicle emergence, conidia germination on the seed surface which form a layer around seeds. Such seeds tolerate adverse conditions of the soil than the non-primed seeds.

(c) Seedling root dip treatment- This method is generally used for transplanting of rice and vegetable crops. The seedlings can be treated with the spore suspension by mixing 10g of *Trichoderma* powder with 100g of well rotten farmyard manure in one litre of water and dipping roots for 10 minutes before transplanting. Sheath blight disease of rice can be controlled by root dipping in spore suspension of seedlings before transplanting. It also reduces the severity of root-knot nematode (*Meloidogyne incognita*) in vegetables.

(d) Soil treatment- *Trichoderma* spp. colonizing on farmyard manure (FYM) are applied to the soil before/at the time of planting which is most effective in the management of soil-borne diseases. Soil application of *Trichoderma viride* alone and



in combination, reduced red rot caused by *Colletotrichum falcatum* and seedling blight, stem rot, color rot and root rot disease. Soil treatment is done with 5 Kg powder per hectare mixed after turning of green manuring (sun hemp/dhaincha) into the soil or 1 kg formulation in 100 kg of farmyard manure. Then, field is covered for 7 days with polythene and mixture is turned in every 3-4 days interval then broadcasted in the field. Drench nursery beds with 5 gm *Trichoderma* formulation per litre of water before sowing.

(e) Aerial spraying/ Wound dressing- *Trichoderma* has been successfully applied to the aerial plant parts and on wounds of shrubs and trees. *Trichoderma harzianum* and *Trichoderma virens* talc-based formulations are used for foliar sprays that reduce incidence of sheath blight of rice.

Trichoderma in crop disease management

Trichoderma is a good bio-control agent as well as a fertility promoter. *Trichoderma* reduces growth, survival and infections of pathogens by different mechanisms like competition, antibiosis, mycoparasitism, hyphal interactions, cell wall degrading enzyme secretion and induces resistance by modifying environmental conditions. *Trichoderma* is playing an important role in controlling plant pathogens, especially soil-borne fungal pathogens. The indirect interaction with pathogens is competition for nutrients and space and directly with the pathogen by hyperparasitism or antibiosis. In hyper-parasitism of biocontrol agent towards the target by coiling and dissolution of pathogen cell wall through the activity of enzymes, lectins during the initial recognition and enzymes viz., α -1,3-glucanases, chitinases, proteinases and lipases during cell wall-degrading penetration. Chitin and glucan are the major constituents of many fungal cells. *Trichoderma harzianum* has excellent mycoparasitic activity against *Rhizoctoniasolani* and involves chitinase, α -1,

3glucanases. Antibiosis is a condition of antagonism for suppression of pathogenic microorganisms through toxic compounds (antibiotics). Bio-control agents and pathogens compete for nutrients and space in the environment. It competes for nutrients like iron and manganese, as iron is a limiting factor in alkaline soils for microbial growth and development. Siderophore is chelator and binds up the siderophore-Fe-complex, making iron unavailable to the pathogen. *Trichoderma* spp produces low molecular weight ferric iron chelators (Fe^{3+}) termed siderophores which prevent the growth and development of fungal pathogens like *Fusarium* wilt. *Trichoderma* application induces resistance against the diseases in plants and provides long-term protection, defense by induced immunity. *Trichoderma* produces several metabolites that act as elicitors of plant which result in the synthesis of phytoalexins, PR proteins that increase resistance against several plant pathogens and abiotic conditions. *Trichoderma* in the rhizosphere can protect plants against aerial pathogen infections through the induction of resistance via hypersensitive response (HR), systemic acquired resistance (SAR) and induced systemic resistance (ISR).

Chemical pollution in the agriculture field is a serious threat affecting the productivity of agriculture. *Trichoderma* is effective against foliar and soil borne plant pathogens. It fights with plant pathogenic microorganisms and effectively manages various plant pathogens. *Trichoderma viride*, *Trichoderma harzianum* and *Trichoderma virens* are being successfully used for the control of diseases such as foot rots, root rots, damping-off, collar rots and *Fusarium* wilts of crops. The talc-based formulations of *Trichoderma* manages several soil-borne diseases of various crops by seed treatment. Soil-borne plant pathogens are successfully managed through seed coating, furrow application and root dip of seedlings. *Trichoderma* has the potential to manage fungal and nematode diseases as well as host defense inducing ability in plants.



Water Saving Technologies in Field Crops

Amit Salaria, Gobinder Singh, Satbir Singh and Sanjeev Ahuja



Ground water has steadily emerged as the backbone of Indian agriculture and drinking water security. Contribution of ground water is nearly 62 per cent in irrigation, 85 per cent in rural water supply and 50 per cent in urban water supply. However, the ever increasing water demand has led to extraction of ground water in excess of its annual replenishment in several parts of the country. This has resulted in adverse environmental impacts including declining ground water levels, de-saturation of aquifers and deterioration of its quality. This decline in water level is more evident in Northern states of Punjab, Haryana and Uttar Pradesh where large scale acceptance for paddy-wheat monoculture has increased farmers dependence

on irrigation water resources. If we talk about the case of Punjab only, there are presently about 15 lakh tube-wells which contribute to more than 70 per cent of the irrigated area and threaten the state ground reserves. Despite of various efforts for crop diversification, the paddy area in Punjab has reached to 31.49 lakh hectares and ultimately paddy cultivation become the main cause for the over-extraction of groundwater. Out of the 150 assessment units (blocks) in Punjab, 117 units (78 per cent) have been categorized as ‘Overexploited’, 6 units (4 per cent) as ‘Critical’, 10 units (6.67 per cent) as ‘Semi-Critical’, and 17 units (11.33 per cent) as ‘Safe’ (National compilation on ground water resources of India, 2020). Therefore, the ground water situation in Punjab has be-

Dynamic ground water resources of India and Punjab (Year: 2020)

Parameter	India	Punjab
Total Annual Ground Water Recharge (BCM*)	436.15	22.80
Annual Extractable Ground Water Resources (BCM)	397.62	20.59
Annual Ground Water Extraction (BCM)	244.92	33.85
Stage of Ground Water Extraction (%)	61.60	164.4

Source: Central Ground Water Board, Government of India (* billion cubic meter)

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come grim and once called the land of “Five Rivers (*Punj-aab*)” has now become the most “over-exploited” state of India.

In addition to this, lifting of water from lower depths also requires more energy which has resulted in more cost of cultivation. This alarming situation demands efficient water management practices to prevent the indiscriminate use of precious groundwater resources. Some of the practical alternatives and efficient water management techniques in agricultural crops are as follows:

1. Repair and cleaning of irrigation channels:

Repairing and cleaning of irrigation channels should be done prior to sowing of crops during the season. Use of underground pipeline system can reduce the conveyance losses of irrigation water. In addition to this, divide large field areas into smaller ones. This practice helps in uniform application of irrigation water, reduces irrigation time and consequently saves water.

2. Laser land leveling:

Precision land leveling is the foremost step for judicious use of water and laser land leveler is one such device which could promote efficient utilization of water. Laser leveling is a laser guided precision leveling technique used for achieving very fine leveling with desired grade



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on the agricultural field. Laser leveling uses a laser transmitter unit that constantly emits 360° rotating beam parallel to the required field plane. This beam is received by a laser receiver (receiving unit) fitted on a mast on the scraper unit. The signal received is converted into cut and fill level adjustments and corresponding changes in scraper level are carried out automatically by a two way hydraulic control valve. The field is cultivated and planked before using the laser land leveler. Laser leveling not only conserves water, electricity and time but also improves the judicious use of other agricultural inputs like fertilizers, pesticides and herbicides etc. This also results in uniform maturity of the crop, better quality and higher yield. It saves about 15-25 per cent of irrigation water with 5-10 percent of additional yield advantage.

3. Avoid early transplanting of rice:

In Punjab, restrict to timely transplanting (20 June to 5 July) schedule of rice for better grain quality, water saving and low build up of stem borers. During early transplanting conditions, the temperature and evaporation are on the higher side thereby increasing the water requirement of the crop. On the other hand, seedlings transplanted after 20th June requires lesser irrigations as the monsoon generally arrives in end of June or else relative humidity starts increasing thus lowering the temperature and evaporation rate. Irrigation water to the tune of 23.6 cm can be saved with delay in transplanting from June 15th to July 5th along with significantly higher apparent and total water productivity.

4. Short duration varieties:

Grow short duration PR varieties as per the recommendation of Punjab Agricultural University, Ludhiana. These short duration varieties viz. PR 126, PR 130, PR 127, PR 129, PR 121 and PR 128 take 93, 105, 107, 108, 110 and 111



days, respectively to mature after transplanting and stay in the field for lesser time, hence require lesser number of irrigations. Besides saving irrigation water, these short duration varieties also vacate the field early thus allowing easy straw management for timely sowing of wheat crop. Avoid cultivation of non-PR varieties as these are having higher maturity period thus require 15-20 per cent more water as compared to PR varieties.

5. Alternate wetting and drying:

Keep the water standing continuously for only two weeks after transplanting so that the seedlings get properly established. After continuous submergence for two weeks, irrigation is applied two days after the ponded water has infiltrated into the soil. Thus, the field gets alternately flooded and non-flooded but care should be taken that field does not develop cracks. Hence, alternate wetting and drying (AWD) is water-saving technology that farmers can easily execute in their fields to reduce irrigation water requirement. This technology has recorded 15-25 per cent saving in irrigation water without any yield reduction. On the other hand, continuous submergence does not have any yield advantage rather it wastes irrigation water and may promote higher incidence of insect-pest and diseases.

6. Direct seeding of rice (DSR):

Direct seeding of rice (tar-wattar conditions) in medium to heavy textured soil also helps in saving of 15 to 20 per cent irrigation water as compared to puddled transplanted rice. In DSR technol-



ogy, apply first irrigation at around 21 days after sowing. After that, apply irrigations at 5-7 days interval depending on soil type and rainfall.

7. Crop diversification:

It aims at replacing water guzzling paddy (currently cultivated on over 85% of the cropped land in Punjab) with less water-intensive crops and it is being viewed as a felicitous strategy to mitigate agri-water challenges in Punjab. The state targets to shift 1.2 million ha paddy (out of total 3 million ha) to alternative crops (maize, sugarcane, oilseeds and pulses, vegetable crops and fruit plantation) for groundwater conservation. The literature also indicates several benefits of crop diversification viz: groundwater conservation, revitalization of soil through cultivation of nitrogen fixing crops, improved productivity, resource use efficiency, ecological gains, employment generation and sustainable agriculture.

8. Ridge/ Bed planting:

In heavy textured soils, paddy can be transplanted on ridges (60 cm) or beds (67.5 cm) to save irrigation water. Irrigate the furrows and immediately transplant seedlings on the middle of the slopes (both sides) of ridges or beds by maintaining a plant to plant distance of 9 cm on beds and 10 cm on ridges. During the first 15 days after transplanting, apply irrigation on daily basis. Thereafter, apply irrigation in furrows only two days after the ponded water has infiltrated into the soil. Every care should be taken that field does not develop cracks in the furrows. Likewise in wheat crop, two rows can be sown 20 cm apart on 37.5 cm wide bed with a 30 cm wide furrow between



two beds. Other crops like gobhi sarson, soybean, maize, cotton, moong, mash, mentha, chickpea etc. can also be sown on beds for efficient use of water and fertilizers along with reduced weed emergence.

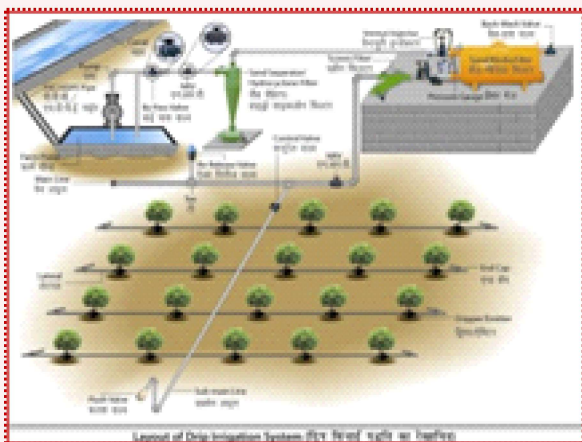
9. Drip irrigation:

Drip irrigation is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent (usually every 1-3 days) than with other methods and this provides a very favourable moisture level in the soil in which plants can flourish. Water and nutrients enter the soil from the emit-

ters, moving into the root zone of the plants through the combined forces of gravity and capillary. In this way, the plant's withdrawal of moisture and nutrients are replenished almost immediately, ensuring that the plant never suffers from water stress, thus enhancing quality, its ability to achieve optimum growth and high yield. In potato, chilli, onion, wheat, spring maize, pea, brinjal, turmeric cotton, mentha, gobhi sarson and kinnow crops, drip irrigation can save about 26-46 per cent of irrigation water.

10. Sub surface drip irrigation:

Subsurface drip irrigation is a low-pressure, high efficiency irrigation system that uses buried drip tubes or drip tape to meet crop water needs. The tubes are inserted below the soil surface, using an attachment pulled by a tractor. The placement depths vary from 6 to 24 inches, depending on the soil, top soil depth and crop. Since the water is applied below the soil surface, the effect of surface irrigation characteristics, such as crusting, saturated conditions of ponded water and potential surface runoff (including soil erosion) are eliminated when using subsurface irrigation. With an appropriately sized and well maintained system, water application is highly uniform and efficient. Subsurface irrigation saves water and improves crop yield by elimi-





Use of paddy straw mulching in field crops

S. No.	Crops	Paddy straw mulch (q/acre)
1	Maize	30
2	Sugarcane	20-25
3	Mentha	24
4	Turmeric	36
5	Chilli, Potato, Garlic	25
6	Okra	24



nating surface water evaporation and reducing the incidence of weeds and diseases. Water is applied directly to the root zone of the crop not to the soil surface where most weed seeds germinate after cultivation. As a result, germination of annual weed seed is greatly reduced which lowers weed pressure on crops. When managed properly with a fertilizer injector, water and fertilizer application efficiencies are enhanced, and labour needs are reduced. Field operations are also possible, even when irrigation is applied. Recently PAU, Ludhiana has recommended the subsurface drip irrigation in maize-wheat-summer moong, zero till direct seeded rice-wheat, maize-wheat (raised on permanent beds), cotton-wheat cropping systems.

11. Mulching:

It is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development and efficient crop

production. Basically, mulching conserves soil water by reducing soil evaporation and regulating soil temperature which decreases irrigation demand during crop cultivation periods. Mulch reduces the germination of weeds by preventing sun light to reach the top layer of soil. Mulch also reduces the kinetic energy of rain and slows down the impact of rain water, which averts runoff and gives the soil more time to absorb the rain water. The supplementary moisture enhances growth of plant roots, which further results into the stabilization of soil. Mulching can be done by using polythene sheet or left-over of crop e.g. paddy straw, sugarcane trash etc. Punjab produces enormous amount of paddy straw which can be easily utilized for the purpose of mulching in field crops, thus also helps in addressing a major problem of residue burning in the state.





Dregea: A Promising Medicinal Plant for the Future

V. Suchitra and L. Saravanan



Indian forests are the principal repository of large number of medicinal and aromatic plants, which are largely collected as raw materials for manufacture of drugs and perfumery products. Adilabad district of Telangana State is having lot of biodiversity with a considerable range of underutilized horticultural crops in tropical deciduous forests. During a survey conducted in 2019 in the region, an underutilized vegetable was collected from the tribal areas of the district which was identified by M.S. Swaminathan Research Foundation Community and Agro Biodiversity Centre (Collection No.0265) as *Dregea volubilis*, a medicinal plant consumed by tribal people as vegetable. Therefore an attempt was made to describe the plant botanically and list out the medicinal importance which has scope for domestication and commercial exploitation.

Botanical Description

Dregea volubilis is commonly called as Sneeze Wort or Green wax flower or Hemajivanti and belongs to family Apocynaceae. It is found from the subtropical to tropical regions of southern Asia in both areas of high and low rainfall. It thrives in well-drained soil or compost. It is native

of India and is distributed in Java, Sri Lanka, Myanmar, Indonesia, Thailand, and China. In India, this plant is mostly found in Western Ghats of Tamil Nadu and Kerala, particularly in Nilgris and Wayanad Districts and in forest areas of central and north east India.

Dregea volubilis is a woody twining vine. Its new leaves have silvery gray, soft woolly growth. As the leaves mature the hairy growth becomes less. The flowers grow in a cluster (drooping umbel) and are absolutely green in colours which are bisexual sweet scented flowers in long glabrous branches. These flowers are mildly scented but the scent is exuded only in the evening and at night. The fruits are borne as twins and seeds are elliptic, concave, smooth, shining, sharp-edged, and crowned with very fine, white, silky hairs.

Medicinal uses

- ◆ Flowers and tender fruits of *Dregea volubilis* are consumed as seasonal vegetable in tribal areas of India.
- ◆ Leaves are traditionally used to treat inflammation, boil, abscesses, dyspepsia, piles, asthma, tumours, leucoderma, paralysis, rheumatism,

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Dregia volubilis flowers and fruits

- tonsils and neck pain. It is also antihelmintic.
- ◆ Roots and tender stalks are used as emetic and expectorant. Juice exuding from cut roots is inserted into the nose to cause sneezing.
 - ◆ Leaf and stem extracts have been reported to possess anti-diabetic properties.
 - ◆ It is also used for treating cough, fever and severe cold.
 - ◆ The root is used in snake bites and given to women to cure head ache after child birth in tribal areas.
 - ◆ In India, the Gond tribe of Sironcha tehsil uses plant extracts to cure piles and fissures and fruit decoction to cure anaemia.

- ◆ Commonly used in Siddha and Ayurveda for treatment of Hepatotoxicity, Diabetes mellitus.

Conclusion

Over the past two decades and more particularly in the recent years due to Covid pandemic situation, there has been a tremendous increase in the use of herbal medicine. Blind dependence on synthetic drugs is over and people are returning to the naturals with hope of safety and security. In spite of all such developments there is still a significant lack of knowledge sharing and research data. Hence, there is need to promote such plants like *Dregea* and to save human lives globally.





Beekeeping: An Enterprise for Income Enhancement

R.K. Singh



Beekeeping is an important agri-business that not only promises good returns to the farmers but also helps in increasing agricultural productivity. Beekeeping is a good source of income for the farmers in Bundelkhand region especially during the period when growth of crop is still under process. District Chhatarpur has vast potential for Beekeeping because of diverse flora and fauna which provides more opportunities for development of beekeeping industry. Beekeeping is an agro-based activity which is being undertaken by farmers/landless labours in rural area as an integrated farming practice. Beekeeping supplements income & employment generation and improves nutritional intake of rural population. Though honeybees are best known for the honey they produce, their economic role in nature is to pollinate thousands of flowering plants for setting of seed or fruit. Honey bees have been offering services to the society through ensured pollination in cross-pollinated crops as well as by providing honey and a variety of beehive products. Honey bees have vital role in sustaining plants bio-diversity resulting in environmental stability.

Shri Babulal Prajapati is a landless farmer who resides in Gram Panchayat Kalapani of the Chhatarpur district. Due to family constraints, he was practicing low paying jobs to fulfil the basic



needs of his family. Then he learnt about the practices of beekeeping which were being promoted in the region and visited KVK Morena (MP) as per the instruction of KVK Chhatarpur. In KVK Morena, he participated in 7 days vocational training programme. After this he purchased 2 bee boxes initially. Later, with his hard work and perseverance he managed to purchase 20 more bee boxes within 2 years period by his successful venture. Presently, his team collects raw honey from different villages, gets it processed in honey processing unit provided by KVK under RKVY project. The processed, good quality honey is sold at different outlets in the district and state. Presently, beekeeping is the main source of income to fulfil all the basic requirements of his fam-

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Details of enterprise:

S.No	Particulars	Units
1	Honey Plate /box	9
2	Production/box/year	40 kg
3	Total Production cost /box	Rs.5,000/-

ily. He is working as Master Trainer and providing training to rural youth through KVK, Chhatarpur. His story of establishing a successful enterprise was broadcasted for the first time in Bundelkhand Region. This innovation is benefitting the farmers and increasing their income. This innovation gave an opportunity to other farmers also to shift from field crops to beekeeping. Now, seven farmers from four villages, Kalapani, Kathokar, Nowgoang and Matguwa have started beekeeping but Shri Baburam Prajapati contributes 80-85% of total production of honey in Chhatarpur District. This innovation has also resulted in an increase of 20-25 per cent in crop yield.

Adoption of Beekeeping Scientific Modules

Economics of adopted technology:

Production, processing and packaging cost (70 boxes)	Gross Return (Rs/ton)	Net return (Rs/ton)	B:C ratio
350000	504000	154000	1:1.4

has contributed to increase the income level of farmer which have resulted in positive socio-economic changes in his life. The horizontal spread of this technology is very fast and 7 farmers have approved it in 4 villages successfully along with cultivation of field crops. At present, each farmer

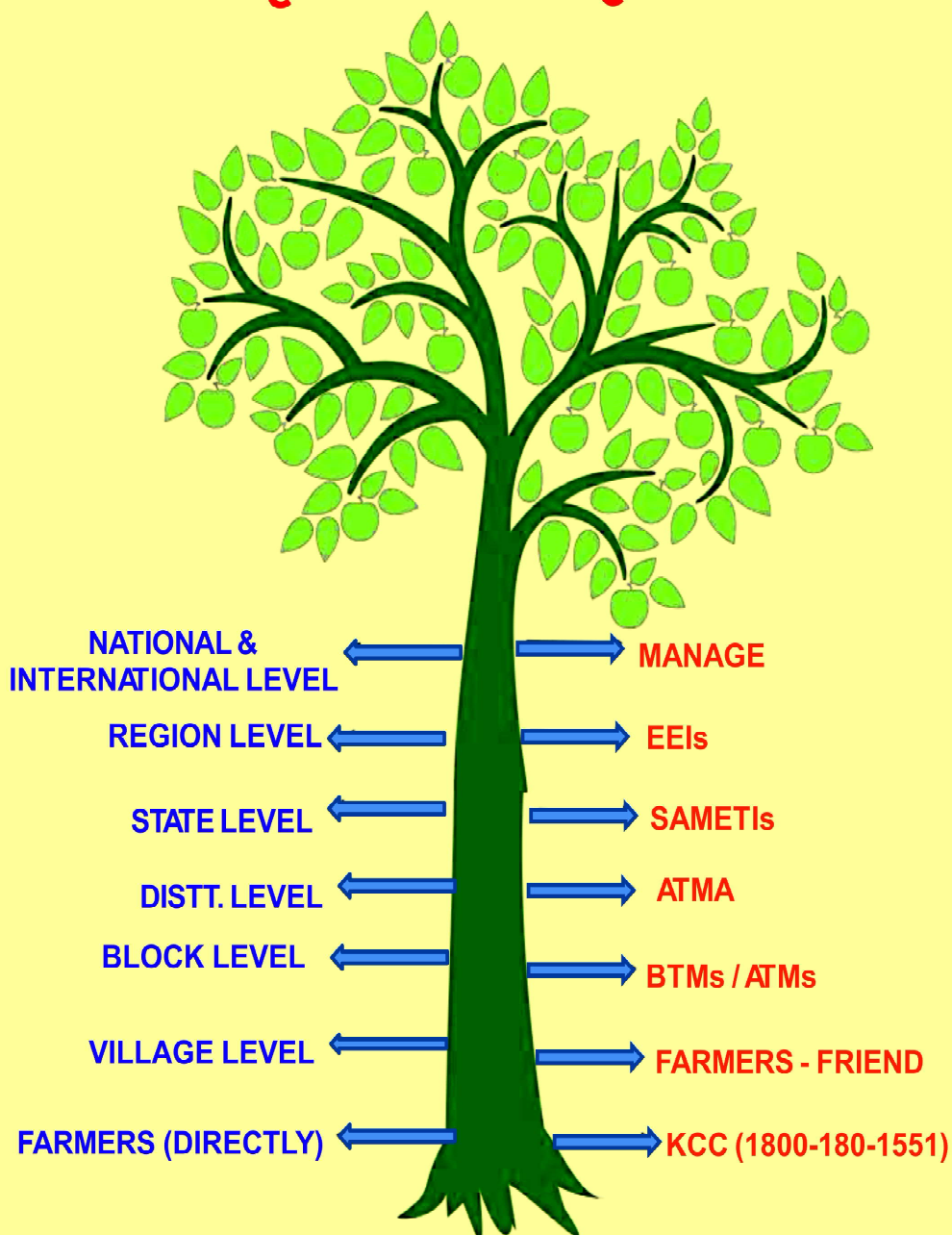


is fetching profit of Rs. 2145/annum/year/box from beekeeping. This farmer has reared honey bees even in high temperature zone by adopting refined techniques of Apiculture. He produced 25-28 qtl. honey and earned Rs. 1.5 lakh in a year.

This innovation is much useful to the farmers for getting more money and employment round the year.



कृषि विस्तार वृक्ष



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