Study Material
on Natural Farming

NATIONAL INSTITUTE OF AGRICULTURAL EXTENSION MANAGEMENT (MANAGE)
(An Autonomous Organization of Ministry of Agriculture and Farmers Welfare, Government of India)
Rajendranagar, Hyderabad-500030, Telangana State, India.
www.manage.gov.in

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About the Publication

Natural Farming- Study Material for Master Trainers was prepared with the help of experts from different organisations like WASSAN, CSA, Patanjali, Isha Foundation, Art of Living, ICAR, SAUs, NCOF, PRAN and Natural Farming Practitioners who participated in the **"National Workshop for Module Development for Natural Farming during 24-29 July, 2023"** and contributed study material through online and offline.

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FOREWORD

Green Revolution has transformed India from Food Deficit to Food surplus country. But, now the country is facing second generation problems especially sustainability of natural resources such as deterioration of soil health, depletion of groundwater, depletion of bio diversity, degradation of ecology and environment, poor nutrition and less farm income due to high input cost etc.

Government has realized the need for long term strategy to address these challenges and to ensure sustainable food system. Hence, various schemes and programmes such as Paramparagat Krishi Vikas Yojana (PKVY), Rashtriya Krishi Vikas Yojana (RKVY), National Mission on Sustainable Agriculture (NMSA) and Bharatiya Prakritik Krishi Paddhati Programme (BPKP) etc., were launched to address these challenges.

In addition to this, Government is also promoting Natural Farming as one of the strategy to optimize the efficiency of natural resources, conserve and enhance agro biodiversity, augment climate resilience and ensure economic viability of farm. The Hon'ble Prime Minister of India Shri. Narendra Modi Ji has also highlighted "Need to take farming out of chemistry lab and connect it to nature's lab" in the National Conclave on Natural Farming at Gujarat on 16th December, 2021.

In this context, Ministry of Agriculture and Farmers Welfare has designated National Institute of Agricultural Extension Management (MANAGE) as the Nodal Organization and Knowledge Repository for promoting Natural Farming.

As a part of this, National Institute of Agricultural Extension Management (MANAGE) has conducted a National Workshop for Module Development for Natural Farming during 24-29 July, 2023 by inviting experts and practitioners of natural farming such as State Agricultural Universities, ICAR institutes, Isha Foundation, Art of Living, Patanjali, WASSAN, National Centre for Organic Farming (NCOF), Centre for Sustainable Agriculture etc.. With the help of these organizations a comprehensive study material covering various aspects of Natural Farming has been developed for Master Trainers. The study material will help Master Trainers and Extension Functionaries to create awareness and sensitize the farmers at Grass root level.

I thank all the practitioners and scientists for sharing their study material. I congratulate WASSAN and Centre for Climate Change and Adaptation (CCA) team, MANAGE for collating the available material and bringing out a very comprehensive study material for the benefit of various stakeholders associated with Natural Farming.

(P. Chandrashekara)
Director General
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Introduction to Natural Farming

1. OVERVIEW OF NATURAL FARMING

The production of food within India was insufficient in the years from 1947 to 1960 as there was a growing population. Food availability was only 417 g per day per person. Many farmers were in debt, and they had become landless laborers. There was a severe shortage of food grains as well as agri-based raw material for industries.

What Is Green Revolution?

Green Revolution is a period that began in the 1960s, by introducing high-yielding varieties of rice and wheat to increase food production, during which agriculture in India was converted into a modern industrial system by the adoption of technologies such as-

1. The use of high-yielding varieties (HYV) seeds.
2. Mechanized farm tools.
3. Irrigation Facilities.
4. Pesticides and fertilizers.

The Green Revolution was initiated in the 1960s by Norman Earnest Borlaug. He is also known as the 'Father of the Green Resolution' in the World. It led him to win the Nobel Peace Prize in 1970 for his tremendous work in developing High Yielding Varieties (HYVs) of wheat also credited with saving over a billion people worldwide from starvation.

The Green Revolution was substantially led by M.S. Swaminathan, known as the 'Father of the Green Revolution' in India. He initiated a program under which high-yield varieties of wheat and rice seedlings were planted in the fields of poor farmers. The Green Revolution in India commenced in 1966, leading to an increase in food grain production, especially in Punjab, Haryana, and Uttar Pradesh. (Ref: https://www.careerpower.in/green-revolution.html)

After the green revolution, the production of cereal crops tripled with only a 30% increase in the land area cultivated. Studies also showed that without the green revolution, caloric availability would have declined by around 11–13%. The green revolution helped India move from a state of importing grains to a state of self-sufficiency. However, critics observed that this 'self-sufficiency' in food grains was achieved withthe increase in imports of crude oil, fertilizers, edible oil, etc. Further, some adverse effects ofthe green revolution were noticed. Hence, it needs to be checked for its eco-friendliness and sustainability features.

Risks Involved in Green Revolution

No doubt there were numerous benefits after the Green Revolution but along with the advantages, risks were also urged. Some of the risks are as follows:

Risk of Pest- Attack: The HYV Crops were more prone to a risk that small farmers who had adopted this technology could lose everything in a pest attack. However, this risk was considerably reduced by the services provided by the Research Institute Established by the Government of India.

Risk of Increase in Income Inequalities: There was a risk for costly inputs (HYV Seeds, Fertilizers, etc.) required under the Green Revolution. This is the cause that creates an increase in the disparities between the poor and rich farmers, since only the farmers who can afford to buy such costly techniques can use them.

Environmental Damage: Over-use of soil, nutrients depleted, beneficial insects for the crops were also killed, and the loss of biodiversity. Due to excessive and inappropriate use of fertilizers and pesticides, farmers were illiterate and were not given proper training to use this modern technology. (Ref: https://www.careerpower.in/green-revolution.html)

Carrying forward intensified usage of pesticides is not advisable in an ever-deteriorating environment, and alternative solutions that can promote economic growth, increased yield, and less harm to the environment can be implemented. The vicious cycle of problem-solution-negative impacts has to be broken at some point of time. Instead of this, techniques to promote sustainable agriculture can be considered. Hence, there has to be a wake-up call before the repetition of history.

Impacts of the Green Revolution

Impacts on Agriculture and Environment

Pests and Pesticide

There has been a significant increase in the usage of pesticides, and India became one of the largest producers of pesticides in the whole of Asia. For instance, it is reported that the presence of pesticides within freshwater is a costly concern with detected levels exceeding the set limits of pesticide presence. Although the average amount of pesticide usage is far lower than in many other countries, there is high pesticide residue in India. This causes a large amount of water pollution and damage to the soil. Another major issue is the pest attack, which arises due to an imbalance in the pests. Due to increased pesticide usage, the predator and prey pests

are not in balance, and hence there is an overpopulation of one kind of pest that would attack certain crops. This leads to an imbalance in the production of those kinds of crops. These crops would need stronger pesticides or pesticides of new kinds to tackle the pests attacking those. This also has led to the disruption in the food chain.

Water Consumption

India has the highest demand for freshwater usage globally, and 91% of water is used in the agricultural sector now. Currently, many parts of India are experiencing water stress due to irrigated agriculture. The crops introduced during the green revolution were water- intensive crops. Most of these crops are cereals, and almost 50% of dietary water footprint is constituted by cereals in India. Since the crop cycle is less, the net water consumed by these crops is also really high. The production of rice currently needs flooding of water for its growth. Canal systems were introduced, and there were irrigation pumps that sucked out water from the groundwater table to supply the water-intensive crops, such as sugarcane and rice. Punjab is a major wheat- and rice-cultivating area, and hence it is one of the highest water depleted regions in India. It is predicted that Punjab will have water scarcity in a few years. Diminishing water resources and soil toxicity increased the pollution of underground water. The only aim of the green revolution was to increase food production and make it sufficient to feed everyone. The environmental impacts were not taken into account. Based on the previous allocation of budget, irrigation was allotted 9,828 crore INR as compared with 3,080 crore INR for agriculture, excluding irrigation. This pattern has been persistent in the past 3 years. Overall, the GDP from agriculture is 380,239 crore INR 16.5% of GDP. This indicates that there has been a higher investment on irrigation of water due to its increased need in comparison with the other inputs required for agriculture.

Air Pollution

Air pollution introduced due to the burning of agricultural waste is a big issue these days. In the heartland of the green revolution, Punjab, farmers are burning their land for sowing the crops for the next cycle instead of the traditionally practiced natural cycle. The next crop cycle arrives very soon because the crop cycle is of short duration for the hybrid crops introduced in the green revolution. This contributes to the high amount of pollution due to the burning of agricultural waste in parts of Punjab. This kind of cultivation can lead to the release of many greenhouse gases, such as carbon dioxide, methane, nitrogen oxides, etc.

Impacts on Soil and Crop Production

There was a repetition of the crop cycle for increased crop production and reduced crop failure, which depleted the soil's nutrients. Similarly, as there is no return of crop residues and organic matter to the soil, intensive cropping systems resulted in the loss of soil organic matter. To meet the needs of new kinds of seeds, farmers used increasing fertilizers as and when the soil quality deteriorated. The application of pesticides and fertilizers led to an increase in the level of heavy metals, especially Cd (cadmium), Pb (lead), and As (arsenic), in the soil. Weedicides and herbicides also harm the environment. The soil pH increased after the green revolution due to the usage of these alkaline chemicals. The practice of monoculture (only wheat–rice cultivation) has a deleterious effect on many soil properties, which includes migration of silt from the surface to subsurface layers and a decrease in organic carbon content. Toxic chemicals in the soil destroyed beneficial pathogens, which are essential for maintaining soil fertility. There is a decrease in the yield due to a decline in the fertility of the soil. In addition, the usage of tractors and mechanization damaged the physicochemical properties of the soil, which affected the biological activities in the soil. In the traditional methods, soil recovers in the presence of any kind of stressors. However, this does not happen with these modern methods. In a study conducted in Haryana, soil was found to have water logging, salinity, soil erosion, decline, and rise of groundwater table linked to brackish water and alkalinity, affecting production and food security in the future.

Although for around 30 years there was an increase in the production of crops, the rice yield became stagnant and further dropped to 1.13% in the period from 1995 to 1996. Similarly with wheat, production declined from the 1950s due to the decrease in its genetic potential and monoculture cropping pattern. The productivity of potato, cotton, and sugarcane also became stagnant. Globally, agriculture is on an unsustainable track and has a high ecological footprint now.

Extinction of Indigenous Varieties of Crops

Due to the green revolution, India lost almost 1 lakh varieties of indigenous rice. Since the time of the green revolution, there was reduced cultivation of indigenous varieties of rice, millets, lentils, etc. In turn, there was increased harvest of hybrid crops, which would grow faster. There is a large increase in the cultivation of wheat, soybeans, and rice. In addition, there is a large decrease in the cultivation of sorghum, other millets, barley, and groundnuts. The increase in certain crops was due to the availability of HYVs of seeds and an increase in

the area of production of these crops. The preference of farmers also changed in terms of the cultivation of crops. The native pulses, such as moong, gram, tur, etc., and some other oilseed crops, such as mustard, sesame, etc., were not cultivated further on a larger scale than it was before. Traditionally grown and consumed crops, such as millets, grow easily in arid and semi-arid conditions because they have low water requirements. However, there was the unavailability of high-yielding seeds of millets, and hence farmers moved to only rice and wheat.

Impacts on Human Health

Food Consumption Pattern

Traditionally, Indians consumed a lot of millets, but this became mostly fodder after the green revolution. The Cambridge world history of food mentions that the Asian diet had food items, such as millets and barley. As already mentioned, after the period of the green revolution, there were significant changes in food production, which in turn affected the consumption practices of Indians. The Food and Agriculture Organization (FAO) has recorded that over the years, there are a decrease in the production of millets and an increase in the production of rice; thus, rice became the staple diet of the country. Though the green revolution made food available to many, it failed to provide a diverse diet but provided increased calorie consumption.

Health-Related Impacts on the General Population

Most of the pesticides used belong to the class organophosphate, organochlorine, carbamate, and pyrethroid. Indiscriminate pesticide usage has led to several health effects in human beings in the nervous, endocrine, reproductive, and immune systems. Sometimes, the amount of pesticide in the human body increases beyond the capacity of the detoxification system due to continuous exposure through various sources. Of all, the intake of food items with pesticide content is found to have high exposure, i.e., 103-105 times higher than that arising from contaminated drinking water or air.

Impacts on Farmers

Most of the farmers who use pesticides do not use personal protective gear, such as safety masks, gloves, etc., as there is no awareness about the deleterious effects of pesticides. Pesticides, applied over the plants, can directly enter the human body, and the concentration of nitrate in the blood can immobilize hemoglobin in the blood. Organophosphates can also develop cancer if exposed for a longer period. Since it is in small quantities, the content may

not be seen or tasted; however, continuous use for several years will cause deposition in the body. Dichloro Diphenyl Trichloroethane (DDT) was a very common pesticide used in India, now banned internationally as it is found to bio accumulate and cause severe harmful effects on human beings. However, there is still illegal use of DDT in India. In India, women are at the forefront of around 50% of the agricultural force. Hence, most of these women are directly exposed to these toxins at a young age and are highly vulnerable to the negative impacts including effects on their children. It is proven that there is a significant correlation between agrochemical content in water and total birth defects. The damaging impact of agrochemicals in water is more pronounced in developing countries.

Discussion

Efforts are underway to produce genetic variants of millets that can withstand biotic and abiotic stresses. Earlier, the introduction of genetic variants of rice and wheat and pesticides was the solution for malnutrition, but it led to environmental destruction in a few years. In the short term, food scarcity might rise again due to increased water depletion and soil damage. Any new interventions should be carefully introduced not to disrupt other systems to prevent future adversities. A domino effect is expected to occur when there is any disruption in the ecosystem, such that if even one link in the food chain is affected, it affects other parts of the chain also. Most of the ecological disruption is by human intervention. Pesticides used for agricultural activities are released to the environment through air drift, leaching, and run-off and are found in soil, surface, and groundwater. This can contaminate soil, water, and other vegetation. Pesticide residues are found to be present in almost all habitats and are detected in both marine and terrestrial animals. The mechanisms include absorption through the gills or teguments, which is bio concentration, as well as through the consumption of contaminated food, called bio magnification or bio amplification. In marine systems, seagrass beds and coral reefs were found to have very high concentrations of persistent organic pollutants. It also affects the activities of insects and microbes. It kills insects and weeds, is toxic to other organisms, such as birds and fish, and contaminates meat products, such as chicken, goat, and beef.

This can lead to bioaccumulation in human beings along with poor food safety, thus impairing nutrition and health. Repeated application leads to loss of biodiversity. Consumption of pesticide-laden food can lead to loss of appetite, vomiting, weakness, abdominal cramps, etc. There is a decline in the number of pollinators, for instance, the destruction of bumblebee

colonies that are an important group of pollinators on a global scale. There is an extinction of honeybee populations, and it poses a great threat to the survival of human beings. The residue level of these pesticides depends on the organism's habitat and position in the food chain. This is a serious issue because the predicted usage of pesticides is that it will be doubled in the coming years.

In addition, it is not nearly possible to get back the lost varieties of indigenous rice. Likewise, further advancements should not lead to the extinction of the other indigenous varieties of grains, such as millets.

In conclusion, the effects of the green revolution are persisting. The green revolution, which was beneficial in ensuring food security, has unintended but harmful consequences on agriculture and human health. This requires new interventions to be tested and piloted before implementation, and continuous evaluation of the harms and benefits should guide the implementation. An already fragile food system is affected due to the aftermaths of the green revolution. The potential negative impacts are not part of the discourse as it can affect the narratives of development and prosperity. Developments introduced due to necessity may not be sustainable in the future. Organic ways of farming need to be adopted for sustainable agricultural practices. Similarly, alternative agriculture techniques, such as intercropping, Zero Budget Natural Farming (ZBNF) with essential principles involving the enhancement of nature's processes, and elimination of external inputs, can be practiced. The government of Andhra Pradesh (AP), a Southern state in India, has plans to convert 6 million farmers and 8 million hectares of land under the state initiative of Climate Resilient Zero Budget Natural Farming because of the positive outputs obtained in the ZBNF impact assessments in the states of Karnataka and AP. In AP, it was observed that yield of crops increased to 9% in the case of paddy and 40% in the case of ragi. Net income increased from 25% in the case of ragi ranging to 135% in the case of groundnut.

There is a need for a systems approach in dealing with food insecurity and malnutrition and other similar issues. Like the already mentioned example, the green revolution was brought in to reduce the problem of reduced yield. Now, there is a green revolution 2 that is planned. Before such interventions are taken, environmental risk assessments and other evaluation studies should be conducted for a sustainable future.

A detailed retrospective of the Green Revolution, its achievement and limits in terms of agricultural productivity improvement, and its broader impact at social, environmental, and

economic levels is provided. Lessons learned and the strategic insights are reviewed as the world is preparing a "redux" version of the Green Revolution with more integrative environmental and social impact combined with agricultural and economic development. Core policy directions for Green Revolution 2.0 that enhance the spread and sustainable adoption of productivity enhancing technologies are specified.

Substantial growth in food production has occurred from a narrowing diversity of crops over the last 50 years Agricultural policies have largely focused on the single objective of maximizing production with less attention given to nutrition, climate, and environment. Decisions about sustainable food systems require quantifying and assessing multiple dimensions together. In India, diversifying crop production to include more coarse cereals, such as millets and sorghum, can make food supply more nutritious, reduce resource demand and greenhouse gas emissions, and enhance climate resilience without reducing calorie production or requiring more land. Similar multidimensional approaches to food production challenges in other parts of the world can identify win–win scenarios where food systems meet multiple nutritional, environmental, and climate resilience goals.

Natural Farming

Agriculture is the science, art, or practice of cultivating the soil, producing crops and raising livestock and in varying degrees the preparation and marketing of the resulting products in congruence with the laws of nature. Natural farming in India started as a grassroots movement and spread across the country by empowering farmers to escape from high-cost chemical-intensive farming.

As modern agriculture deals with the optimization of four elements of the nature viz.land, water, air and energy over a given space which has been is well described in the Vedic Agricultural System of India which considers the importance of rain, cloud, water, earth and land, heat or tejas and space. Without space crops cannot take shape. So, agriculture depends on all the natural phenomenon. New technologies were introduced through Green Revolution to increase agricultural productivity. This increase in productivity helped the country to become self-sufficient in food production and to mitigate hunger and poverty.

However, post green revolution has many challenges such as deterioration of soil health, depletion of water table, unsustainable food production, deterioration of ecology, environment, health, etc. In order to overcome the challenges, several initiatives were taken by the central and state governments in India.

Today, conventional farming is a common method of farming using external inputs and use of chemicals and fertilizers giving more emphasis on yield maximization rather than yield optimization leading to soil fatigue, high cost of production, declining factor productivity and causing imbalance in the ecosystem and lead to high dependency of the farmers on the market forces.

Looking to the agro-ecological conditions and resources with the small and marginal farmers in India, natural farming is emerging as an alternative farming focusing on optimum utilization of native local resources according to principles of agro-ecology which are based on the cause and effect theory prevalent in the given niche land scape but in the same time follows the universal laws of nature for maintain balance among the components of ecosystem and wellbeing of human beings. Practices of natural farming are rooted in the concept defined by the Vrikshayurveda, the ancient Indian Science of plant life.

The natural farming is gaining momentum in India and is being practiced over 6.50 lakh hectares of agricultural land in 11 states of the country (NITI Aayog).

Natural farming is based on the laws of nature which covers the universal laws of existence of the universe and its interaction with many cause and effect theories. The laws based on the various theories which are proven by the scientific facts may be in the past or in the present or in future but at the same time the practices following different theories should be the ultimate part of universal laws of nature.

In this regard, Natural Farming as practice of farming is based on the adoptable and workable practices of farming in a given agroecology which covers the theories of science, a set of practices in the land scape for management of production processing, distribution and marketing and a social movement and has evolved over recent decades to expand in scope from its focus on fields and farms to encompass whole agriculture and food systems.

Natural farming is a broader term which not only covers agro-ecological science but involves the other transdisciplinary fields encompassing socio-cultural, technological, economic and political dimensions of food systems from production to consumption. Natural farming, therefore involves all aspects of living harmony with nature based on the foundation of agro-ecological principles in context to setting up the universal sustainable food systems and healthy life.

Natural Farming emphasize on use of chemical free practices and easily available farm resources which are manageable for better economy and conservation of nature in long term. It considers the principles of agro-ecology in its centre integrating crops, trees and livestock with functional relationship fulfilling the need of all living organisms. It helps to reduce dependency on purchased inputs and will help to ease smallholder farmers from burden of high cost of inputs and promotes sustainable life. The important aspects of natural farming it is considered as a cost- effective farming suitable for livelihood of large number of farmers and rural development.

Natural farming system is diversified farming system that integrates crops, weeds, grasses, forest trees and Livestock allowing optimum use of functional biodiversity. Natural farming practices based on ecological principles and laws of nature are being advocated by United Nation to promote sustainable food systems to enhance food and nutrition security. Under the alarming risk of climate change on agriculture, the practices of natural farming are the need of hour for sustainable agriculture and creating the green economy. India having the diverse agro-climatic conditions have many niche areas where natural farming principles can play a vital role to promote sustainable livelihood and reduce the risk of high input agriculture under given agro-climatic conditions and unpredictable shift in market based management of basic amenities of life.

2. NATURAL FARMING – PRINCIPLES, CONCEPTS AND COMPONENTS

The serious ecological and economic crisis in farming community in India and other countries has led to the evolution of new models of agriculture which are based on sound ecological principles making effective use of local resources and natural processes. The alternative approaches are collectively called as agro-ecological approaches. But, based on the primary focus of the promoters the activities may vary significantly. While some focus on restoring the natural agroecosystems, some focused on making farming an ecologically sustainable model. While some believe in reviving traditional crops and practices, others use this as a tool for seed and food sovereignty.

1. Understanding Different Farming Models

Across the Indian states, lakhs of farmers are now switching over to adopt agro-ecological practices to sustain their livelihoods. While some are driven by revived interest in moving back to traditional practices, majority are driven by the need to move away from high input use and reduce costs of cultivation.

The serious ecological and economic crisis in the farming community in India and other countries has led to evolution of new models of agriculture. The main objective of this ecological movement is based on principles of agroecology viz; a) local context (soil, weather, and available water) based cropping/farming systems and seed varieties/animal breeds, b) improving soil structure and fertility by natural means, c) preventive care to manage pests and diseases, d) effective use of locally available resources.

These sets of practices have evolved from reinterpreting the traditional farming practices with modern scientific learnings. As many believe this is continuation of the old traditional practices which are not relevant today but contemporary innovations with new science of ecological farming evolved at different nodes by farmers, civil society organisations and few agriculture scientists.

Various alternatives to the existing agriculture practices have emerged over the decades. At the core of it all, these have emerged out of a need for efficient farming practice that is local, resilient and adaptable agro-ecological farming practice.

Do Nothing (Natural) Farming: Natural farming is an ecological farming approach established by Masanobu Fukuoka (1913–2008), a Japanese farmer and philosopher, and popularised in his 1975 book The One-Straw Revolution. After working for about two decades

on his farm he developed a system where there is no need of tillage, no chemical fertilisers, no chemical pesticides and no weeding.

Subhash Palekar (Zero Budget) Natural Farming (ZBNF/SPNF/SPK): Promoted by Padmashree Shri Subhash Palekar the ZBNF/SPNF/SPK is a model of agriculture which is largely based on four wheels practiced as Beejamrita (Seed Treatment using local cow dung and cow urine), Jeevamrita (applying inoculation made of local cow dung and cow urine without any fertilizers and pesticides), Mulching (activities to ensure favorable microclimate in the soil), and Waaphasa (soil aeration with optimum moisture).

Organic Farming: This shuns chemical fertilizers and pesticides but the approach is similar to it. For example, nutrients required by the crops are supplied through various organic manures based on their nutrient contents. Similarly biological pesticides are used to 'kill' the insects instead of chemical pesticides. Modern organic farming also allows some bio fertilisers and biopesticides which are industrially made.

Permaculture: Permaculture is a design approach to land management that adopts arrangements observed in flourishing natural ecosystems. It includes a set of ethics and design principles derived using whole systems thinking. Farm efficiency is increased through optimised and efficient design principles. It uses these principles in fields such as regenerative agriculture, rewilding, and community resilience.

Biodynamic agriculture: is a form of alternative agriculture very similar to organic farming, but it includes various esoteric concepts drawn from the ideas of Rudolf Steiner (1861–1925). Initially developed in 1924, it was the first of the organic agriculture movements. It treats soil fertility, plant growth, and livestock care as ecologically interrelated tasks, emphasizing spiritual and mystical perspectives.

Conservation Agriculture: As the ill effects of conventional agriculture particularly on soil structure with use of heavy machinery and cascading effects on soil biology and moisture holding capacity, a shift towards Conservation Agriculture has begun. Conservation Agriculture is a farming system that promotes minimum soil disturbance (i.e. no tillage), maintenance of a permanent soil cover, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production. In principle ploughing is mainly to reduce weeds and pest and diseases by exposing them to sun.

Sustainable Agriculture: Farming practiced in sustainable ways, which means meeting society's present food and textile needs, without compromising the ability for current or future generations to meet their needs. It can be based on an understanding of ecosystem services.

Regenerative Agriculture: Regenerative Agriculture describes farming and grazing practices that, among other benefits, reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity – resulting in both carbon drawdown and improving the water cycle. Regenerative Agriculture is a holistic land management practice that leverages the power of photosynthesis in plants to close the carbon cycle, and build soil health, crop resilience and nutrient density.

Agroecology: Farming that centres on food production which makes the best use of nature's goods and services while not damaging these resources.

Agroforestry: An intensive land management system that optimizes the benefits from the natural interactions created when trees and/or shrubs are deliberately combined with crops and/or livestock.

Climate Smart Agriculture: A model that approaches farming from the perspective of building climate resilience through climate mitigation, adaptation and resilient practices. The focus here is on building climate resilience and not on the products used.

2. Basic universal principles of Natural Farming

a. **Co - existence in Natural Farming**: It is the state or fact of living or existing at the same time or in the same place. Coexistence is defined as a dynamic but sustainable state in which humans and wildlife co-adapt to living in shared ecosystem, landscapes, where human interactions with wildlife are governed by effective institutions that ensure long-term wildlife population persistence, social legitimacy, and tolerable levels of risk

b. **Principal of Complementary**: It is the quality of being different but useful when combined form strongest matches. Every living organism complements each other in nature to keep balance of nature intact.

c. **Principal of Diversity**: It is the variations in ecosystems within a geographical location and its overall impact on human existence and the environment. Ecosystem diversity addresses the combined characteristics of biotic properties and abiotic properties.

d. **Principal of crop density**: It is the principle which deals with number of crop, plants

species that occurs within a farm unit. Number of plants per unit area in the cropped field is the plant population or plant density.

e. **Principal of Ecology**: It is the principle that deals with relationships between living organisms, including humans, and their physical environment; it seeks to understand the vital connections between plants and animals and the world around them.
(Ref – Bharat Bhushan Tyagi)

f. The Generic Principles that Govern Natural Farming

A healthy soil microbiome is critical for optimal soil health and plant health, and thereby animal health and human health, use of bio stimulants as Catalyst. Use of local and indigenous seeds and plant varieties, the seeds and varieties should be suitable for specific agro-ecology, so that local soil microbes support their germination and growth.

Soil may be covered with crops for maximum period of the year, 365 days crop cover. The soil across a farm or larger field /collection of fields should have diverse crops, a minimum of 08 crops over the year. The greater the diversity, the better. Minimal disturbance of soils is critical, hence no till farming or shallow tillage is recommended. Animals should be incorporated into farming. Integrated farming systems are critical for promoting Natural farming. Healthy soil microbiome is the key to retaining and enhancing soil organic matter. Bio stimulants are necessary to catalyze this process. There are different ways of making bio stimulants. In India, the most popular bio-stimulants are based on fermentation of animal dung and urine, and uncontaminated soil. Increasing the amount and diversity of natural residues returned to the soil is very important. These include crop residues, grasses, cow dung etc.

Pest and disease management should be done through better agronomic practices, as treasured in Integrated Pest and disease management and through applications of botanical pesticides, only when required. Use of synthetic fertilizers and other biocides is harmful to this process of regeneration and is not allowed.

g. Definitions and Concepts you should know before starting Natural Farming

- **Crop diversity or Crop biodiversity**

  Is the variety and variability of crops, plants used in agriculture, including their genetic and phenotypic characteristics. It is a subset of and a specific element of agricultural biodiversity. Over the past 50 years, there has been a major decline in two

components of crop diversity; genetic diversity within each crop and the number of species commonly grown.

- **Ecosystem**

  It is a community or group of living organisms that live in and interact with each other in a specific environment.

- **Ecology**

  Is the study of the relationship between living organisms, including humans and their physical environment, it seeks to understand the vital connections between plants and animals and world around them.

  Ecology is the study of organisms and how they interact with environment around them, it's a relationship between living things with their habitats.

- **Balanced ecosystem**

  A balanced ecosystem signifies a habitat which is sustainable. It consists of animals, plants, microorganisms and more which depend on each other and their surroundings. These ecosystems exhibit resourceful energy and material cycling. It also displays interconnectedness amid primary producers and predators.

- **Ecological Balance**:

  The balance of nature, also known as ecological balance, is a theory that proposes that ecological systems are usually in a stable equilibrium or homeostasis, which is to say that a small change (the size of a particular population, for example) will be corrected by some negative feedback that will bring the parameter back to its original "point of balance" with the rest of the system. The balance is sometimes depicted as easily disturbed and delicate, while other times it is inversely portrayed as powerful enough to correct any imbalances by itself.

- **Ecological Balance:**

  It is a term describing, how ecosystems are organised in a state of stability where species co-exist with other species and with their environment.

- **Disturbance:**

  Any change that cause disruption in the balance of an ecosystem.

- **Mutualism** - Association between different kinds of organisms that benefits both.

  Mutualism plays a key part in ecology and evolution. For example, mutualistic interactions are vital for terrestrial ecosystem function as about 80% of land plants species rely on mycorrhizal relationships with fungi to provide them with inorganic compounds and trace elements.

- **Crop diversification:**

  Crop diversification means growing more than one crop in an area. Diversification can be accomplished by adding a new crop species or different variety, or by changing the cropping system currently in use. Commonly it can mean adding more crops into an existing rotation.

- **Agro Biodiversity**

  Sufficient diversity in the farm land shall be maintained through diversified plantations, multiple cropping, mixed cropping, intercropping, sequence cropping, cover crops, trap crops, multi-layered farming and crop rotations etc.

- **Crop density:** Density in plant ecology is defined as the number of individuals of a given species that occurs within a given sample unit or study area. Number of plants per unit area in the cropped field is the plant population or plant density.

- **Optimum plant population:**

  It is the number of plants required to produce maximum output or biomass per unit area. Any increase beyond this stage results in either no increase or reduction in biomass.

- **Resource**

  A resource is a physical material that humans need and value such as land, air, and water. Resources are characterized as renewable or nonrenewable; a renewable resource can replenish itself at the rate it is used, while a nonrenewable resource has a limited supply.

- **Resource management**

  Is the practice of planning, scheduling, and allocating people, money, and technology to a project or program.

  Resource management is a series of processes and techniques used to ensure you have all the necessary resources to complete a project or meet objectives.

- **Buffer zone**

  A clearly defined and identifiable boundary area bordering natural farming production site that is established to limit application of, or contact with, prohibited substances from an adjacent area.

- **Trap crops**

  Crops grown on the borders or peripheries of fields, which are preferred more by a pest species are known as trap crops for that pest. By growing such crops on the border of the fields, pest population develop there which can be either killed by using pesticides or its natural enemies are allowed to develop there for natural control.

- **Cover crop**

  Plants or a green manure crop grown for seasonal soil protection or soil improvement. Cover crops help control soil movement and protect the soil surface between crops. Cover crop reduces wind erosion by shielding the soil with vegetation and anchoring the soil with roots. Cover crops consist of any vegetative cover that maintains more than 60 percent ground cover. Short-term cover is grown between major crops. Plants are then tilled into the soil prior to or during major crop planting. Longer-term cover may be maintained by periodic mowing to maintain at least 60 percent cover.

- **Concoctions**

  Concoctions are prepared by combining different ingredients of cow-based dung, urine mixed with natural on-farm resources.

- **Conventional Farming**

  The farming systems dependent on input of artificial chemical fertilizers and/or chemicals and pesticides or which are not in conformity with the basic standards of natural farming.

- **Conversion**

  The process of changing an agricultural farm from conventional to natural farm. This is also called transition.

- **Part Conversion**

  Part conversion is when part of a conventional farm or unit has already been converted to natural production and a part is still under conventional system.

- **Conversion period**

  The transition from conventional to natural farming within a given period of time, during which the provisions concerning natural production have been applied.

- **Crop rotation**

  A process of growing different crops in succession on a piece of land in a specific period of time with an object to get maximum profit from least investment without impairing soil fertility.

- **Farm Unit**

  The agricultural farm area managed under natural package of practice, by a farmer or a group of farmers.

- **Green manure**

  Manure consisting of fresh green plant matter, which is ploughed in or turned into the soil for the purpose of soil improvement.

- **Habitat**

  The region where a plant or animal naturally grows or lives; native environment. The area in which a plant or animal species naturally exists. The area or natural environment in which an organism or population normally lives.

- **Humus**

  A dark brown or black substance formed by the decomposition of leaves and other plant/ organic material by soil microorganisms which improve the fertility and water retention of the soil and is therefore important for plant growth.

- **Intercropping**

  The cultivation of two or more crops simultaneously on the same field. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources or ecological processes that would otherwise not be utilized by a single crop.

- **Indigenous Technical Knowledge**

  Indigenous Technical Knowledge (ITK) is specifically concerned with actual application of the thinking of the local people in various operations of agriculture and allied areas.

- **Livestock**

  Shall mean any domestic or domesticated animal including bovine (including buffalo and bison), porcine, caprine, equine, poultry and bees raised for food or in the production of food. The products obtained by hunting or fishing of wild animals shall not be considered as part of this definition.

- **Mulching**

  The practice of adding live or dead matter to help with weed suppression, soil fertility, water retention, check losses of evapotranspiration etc.

- **Multiple cropping**

  Growing two or more crops on the same piece of land in one agriculture year is known as 'Multiple cropping'. It is the intensification of cropping in time and space dimensions i.e., more number of crops within a year and more number of crops on the same piece of land. It includes intercropping, mixed cropping and sequence cropping.

  a. **Intercropping** - Growing two or more crops simultaneously on the same piece of land with a definite row pattern.

  b. **Mixed cropping** - the process of growing two or more crops together in the same piece of land. This system of cropping is generally practiced in areas where climatic hazards such as flood, drought, frost etc. are frequent and common.

c. **Sequence cropping** - growing of two or more crops in sequence on same piece of land in a farming year. Depending on number of crops grown in a year. It is called double, triple and quadruple cropping involving two, three and four crops respectively.

- **Multi-Layered farming:**

  Growing of plants of different heights in same field at the same time.

- **Mono-cropping:**

  The practice of growing a single crop year after year on the same land.

- **Plant Protection Product**

  Any substance intended for preventing, destroying, attracting, repelling, or controlling any pest or disease including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food, agricultural commodities, or animal feeds.

- **Natural pesticides**

  Are pesticides that come from natural sources - generally plant or mineral derivatives. Nicotine (extracted from tobacco), Pyrethrum (extracted from chrysanthemum flowers), and Rotenone (extracted from the tuber Derris elliptica) are plant-derived, while pesticides like Boric Acid, Cryolite, and Diatomaceous Earth are mineral-derived.

- **Bio-Input Resource Centre (BRC)**

  A resource centre, where time tested, locally prepared Inputs/formulations utilizing biological entities or biologically derived inputs useful for improving soil health, crop growth, pest or disease management and habitat management are made available for purchase by farmers in a defined geographical area.

h. Crop Geometry:

The arrangement of the plants in different rows and columns in an area to efficiently utilize the natural resources is called crop geometry. It is otherwise area occupied by single plant. This is very essential to utilize the resources like light, water, nutrient and space.

Importance of crop geometry (Plant Population) in Natural farming

1. Yield of any crop depends on final plant population
2. The plant population depends on germination percentage, and survival rate in the field.
3. Under rainfed conditions, high plant population will deplete the soil moisture before maturity, whereas low plant population will leave the soil moisture unutilized.
4. When soil moisture and nutrients are not limited, high plant population is necessary to

utilize the other growth factors like solar radiation efficiently.

5. Under low plant population individual plant yield will be more due to wide spacing.
6. Under high plant population, individual plant yield will be low due to narrow spacing leading to competition between plants.
7. (Ref-https://www.Ramauniversity.ac.in/online-study-material/agriculture/bsc/isemester/fundamentalsofagronomy/lec-4.pdf)

Role of Natural Cycles in Plant Growth

Biogeochemical Cycle

It is a constant flow of energy between various organisms. There is an exchange of nutrients, which basically translates to exchange of energy.

Nutrients ultimately are chemical compounds. So, there is this natural pathway where the living matter is constantly circulated. Nutrients are never lost from an ecosystem. Recycling of these nutrients happens at every stage. This recycling of the nutrients through different components in an ecosystem is called the nutrient cycle or biogeochemical cycle.

Here, the chemical elements are always recycled, whereas heat is dissipated. Energy flows but the matter is always recycled. To get a better idea, see the movement of water, which is a chemical compound (H_2O). It moves between different living and non-living forms in various places in the biosphere.

Types of Biogeochemical cycles

Broadly, the biogeochemical cycles can be divided into two types, the gaseous biogeochemical cycle and sedimentary biogeochemical cycle based on the reservoir. Each reservoir in a nutrient cycle consists of an abiotic portion and an exchange pool, where there is a rapid exchange that occurs between the biotic and abiotic aspects.

1.The gaseous cycles exist in the atmosphere (air) or Oceans through evaporation. The different gaseous cycles are the nitrogen cycle, carbon cycle, oxygen cycle, and the water cycle.

2.The sedimentary cycles have the earth's crust as the reservoir pool. These cycles include the chemical components that are more earthbound, such as iron, calcium, Sulphur etc. The gaseous cycles move more rapidly when compared to the sedimentary cycles. One of the primary reasons for this could be the large atmospheric reservoir.

Let us understand the basics of a few important nutrient cycles.

Carbon Cycle

Any matter is called organic if it has carbon in it. Carbon is essential and is required to produce the molecules of nutrients such as carbohydrates, proteins, and fats. Plants use carbon dioxide and prepare food. Animals, in turn, consume plants. When plants and animals decompose, they release carbon dioxide.

Animals also release carbon dioxide during their respiration process. Carbon is also released when organic matter in burnt. In this way, carbon dioxide finds its way back to the atmosphere. This is again taken up by plants and the biogeochemical cycle continues.

Water Cycle

Water is absorbed from the soil by plants. When transpiration occurs in plants, they release water. In animals, most of the body is made up of water. Animals also drink water. Also when they perspire, water is released and gets evaporated into the atmosphere.

When animals are eaten by other animals, the water goes from one organism to the other. When animals and plants decompose, they release water, due to the chemical processes that occur. In this way, there is a continuous recycling of water through the various components of the ecosystem.

Nitrogen Cycle

Nitrogen is a very important element that is present in the genetic material – DNA and RNA. The nitrogen cycle is considered as the most complex of all biogeochemical cycles and it exists in nature in many forms. Nitrification, Denitrification, Nitrogen fixation etc. are all processes that are associated with the nitrogen cycle.

In conclusion, all these different biogeochemical cycles do not occur in isolation. The most important connecting link is the movement of water through the water cycle. The movement of water is very important for the discharge of phosphate and nitrogen into the various water bodies, including the oceans. The ocean is a major reservoir that holds carbon, another important element in the biogeochemical cycles.

Concept and Definitions of Natural Farming

Concepts

Natural Farming is hence as the direction and process of transition towards a more local, resilient and adaptive agro-ecology based farming.

Natural Farming offers a solution to various problems, such as food insecurity, farmers' distress, and health problems arising due to pesticide and fertilizer residue in food and water,

global warming, climate change and natural calamities. It also has the potential to generate employment, thereby stemming the migration of rural youth. Natural Farming, as the name suggests, is the art, practice and, increasingly, the science of working with nature to achieve much more with less.

Irrespective of the different farming models, at the core, all of these schools of thoughts have the following principles in common:

- Using natural locally found products and inputs which the farmer can make on their own or buy from their local region.
- Increase cropping intensity through multiple cropping systems increasing soil organic matter.
- Increasing soil health particularly microbial population

Definitions of Natural Farming

Natural Farming

Natural farming is not a technique but a view, or a way of seeing ourselves as a part of Nature, rather than separate from or above it. Natural farming is working in harmony with Nature with care for Ecology, it is built on principle "Nature works on his own"

An agricultural production system which mainly emphasizes on use of locally available on farm/traditional inputs integrated system with good agronomic practices that encourage coexistence, soil health, ecology, natural cycles, natural micro flora and fauna, diversity, production density and good production management system.

Natural Farming is a chemical-free farming system rooted in Indian tradition enriched with modern understanding of ecology, resource recycling and on-farm resource optimization. It is considered as agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity. It is largely based on on- farm biomass recycling with major stress on biomass mulching, use of on-farm cow dung- urine formulations; maintaining soil aeration and exclusion of all synthetic chemical inputs. Natural farming is expected to reduce dependency on purchased inputs. It is considered as a cost- effective farming practice with scope for increasing employment and rural development.

Current Scenario of Natural Farming in India

Many states have taken up initiatives for natural farming promotion Andhra Pradesh, Himachal Pradesh, Gujarat, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh and Tamil Nadu are among the leading states. As of now more than 10 lakh ha. area is covered under natural farming in India.

Aims and Objectives for Natural Farming promotion:

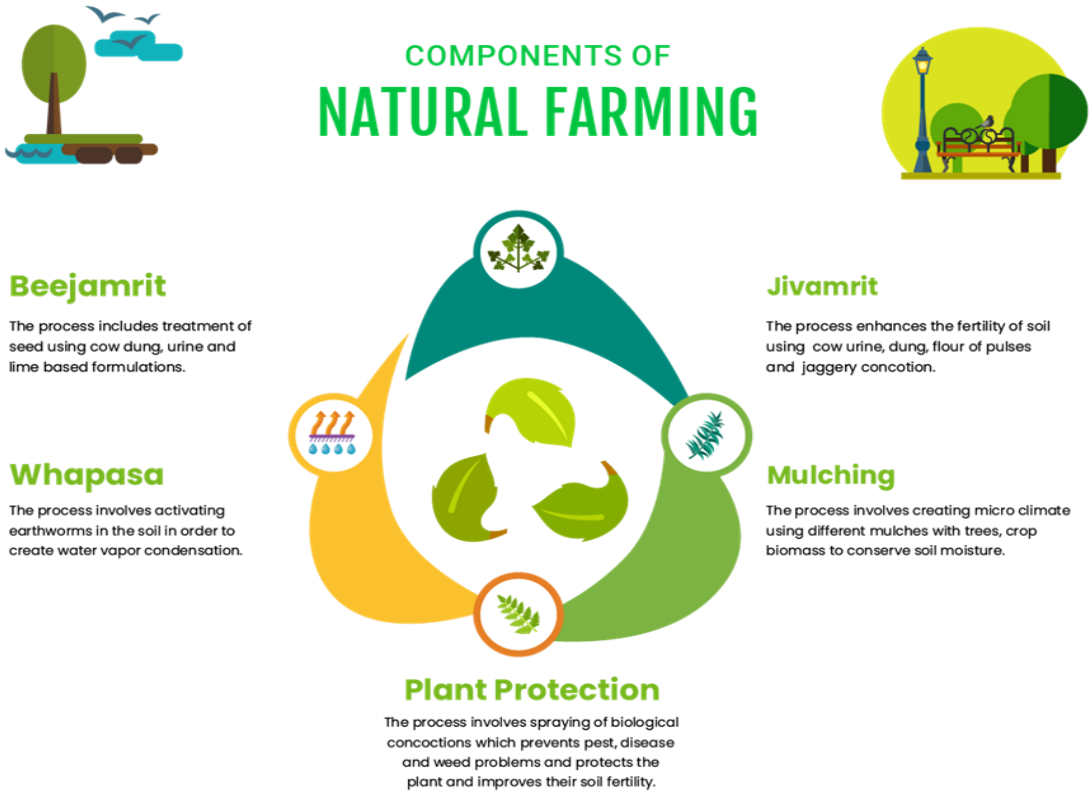
- Preserve natural flora and fauna
- Restore soil health and fertility and soil's biological life
- Maintain diversity in crop production
- Efficient utilization of land and natural resources (light, air, water)
- Promote natural beneficial insects, animals and microbes in soil for nutrient recycling and biological control of pests and diseases
- Promotion of local breeds for livestock integration
- Use of natural / local resource-based inputs
- Maintain healthy, nutritional agricultural produce for consumption
- Reduce input cost of agricultural production
- Improve economics of farmers

Natural farming Practices

Natural farming aims at restoring soil health, maintenance of diversity, ensure animal welfare, stress on efficient use of natural/local resources and promote ecological fairness. Natural farming is an ecological farming approach where farming system works with the natural biodiversity, encouraging the soil's biological activity and managing the complexity of living organisms both plant and animal to thrive along with food production system. Important practices, essential for adoption of natural farming includes:

- No external inputs,
- Local seeds (use of local varieties)
- On-farm produced microbial formulation for seed treatment (such as Beejamrita),
- On-farm made microbial inoculants (Jivamrita) for soil enrichment,
- Cover crops and mulching with green and dry organic matter for nutrient recycling and for creating a suitable micro-climate for maximum beneficial microbial activity in soil.
- Mixed cropping,
- Managing diversity on farm through integration of trees
- Management of pests through diversity and local on-farm made botanical concoctions (such as Neemastra, Agniastra, neem ark, Dashparni ark etc);
- Integration of livestock, especially of native breed for cow dung and cow urine as essential inputs for several practices and water and moisture conservation.

Components of Natural farming



As per the farmers who are regularly practicing natural farming the following practices has been considered as the most important components of Natural Farming.

Beejaamrut

It is a fermented microbial solution, with loads of plant-beneficial microbes, and is applied as seed treatment.

Jeevaamrut

It is a fermented microbial concoction which enhances the fertility of soil through microbial activity using cow urine, cow dung, gram flour and jaggery and hand full of soil.

Acchadana / Mulching

The process of mulching involves adding cover crops, organic debris, or agricultural residue to cover the top soil.

Whapsaa

Whapsaa means the mixture of 50% air and 50% water vapor in the cavity between two soil particles. It is the soil's microclimate on which soil organisms and roots for optimum uptake of their moisture and nutrients.

Plant Protection

The process involves spraying of biological concoctions which prevents pest and diseases and protects the plants like Agniastra, Neemastra, Dashparni ark, Sour butter milk etc.

Features of Natural Farming:

1. Natural farming practices hold that plants receive 98% of their nutrients from the air, water, and sunlight. And healthy soil with lots of helpful microbes can fill the remaining 2% of the gap.
2. The soil must always be covered with organic mulch, which produces humus and promotes the development of beneficial microbes.
3. Instead of using fertilizers, farm-made bio-cultures called Jeevamrita, Beejamrita, etc. are put into the soil to boost the microflora. Jeevamrita and Beejamrita are made from very little desi cow breed cow manure and urine.
4. It can potentially increase farmers' income while providing a wide range of advantages, including mitigating and reducing greenhouse gas emissions, restoring soil fertility, and environmental health.
5. The process needs cow dung and cow urine (Gomutra), which can only be acquired from cows of Indian breed. In terms of the microbiological composition of cow dung and urine, Desi cow appears to be the cleanest.
6. Neither chemical nor organic fertilizersare put into the soil in natural farming. In fact, neither the soil nor the plants receive any exogenous fertilizers.
7. In natural farming, earthworms and bacteria are encouraged to break down organic materials on the soil surface, gradually adding nutrients to the soil over time.
8. In natural farming, weeding is done as it would be in natural ecosystems without using fertilizers, ploughing, or soil tilting.
9. To fight pests and diseases, farms utilize natural insecticides like Dashparni Ark and Neem Astra.
10. Weeds are employed as a live or dead mulch layer and are considered necessary.
11. Multiple cropping is recommended over single crop

What makes farming a sustainable production system?

Drawn from various schools of thought and various models here is the summary of what makes farming a sustainable production system. One can make choice on each of these and integrating more the elements better.

A. **Natural Resource Management**: Sustainable use of natural resources is the main key to sustain farming as it is largely dependent on soil, water and biodiversity. Mention Forests and Commons are as part of farming systems.

1. **Water**: plants needs moisture and not water. Improving moisture holding capacity and making it available in critical stages in plant root zone is important. All practices from water harvesting, efficient application etc contributes towards this.

2. **Soil**: Soil not only holds plants and trees but provide nutrients for their growth. The physical properties like compaction, erosion, chemical properties like pH (acidity/alkalinity), EC (Salinity), biological properties like microbial diversity, presence of earthworms etc together contribute to sustainable production. Together all three need to be addressed.

3. **Seeds**: Any seed variety (traditional or improved) which has a value for cultivation- local soil suitability, fitting into the cropping patterns, resistant to locally common pest and diseases and value for use -utility value for the consumer or processor can be used.

4. **Restoring Ecosystem**: Agriculture is not the sum of the total practices, there is a need of transition to regenerative functions and ecological services particularly with respect to soil, water, biodiversity and other biological services are ensured here the role of land scape approach becomes important which includes commons (forest and pastures) in addition to farm lands.

B. **Land Utilization**: as most of the farmers have small piece of land, effective planning and maximizing the land use is important. Here local conditions in terms of soil type, water availability, weather place an important role in determining the choices.

1. **Cropping patterns**: More the number of crops, diverse the species low would be pest and disease problem. However, agronomic management is based on the needs in terms of time to be spent, optimal utilisation of resources and local demand. From growing intercrops to mixed crops there are various models designed to accommodate more than one crop in the farm during the same season. They are also based on meeting home nutritional needs to market needs. We can also use the vertical space effectively if plants and trees growing different heights and different duration can be put together. There is wide spread literature available in terms of best crop/tree combinations.
2. **Integrated farming systems**: for small and marginal farmers with small holdings income from crops alone may not be sufficient. In broadening the income sources adding on allied

activities like poultry, small ruminants, dairy, fisheries etc. can help. These can also effectively use the crop residues.

C. **Intercultural operations**: during the season managing the crop growth and effectively managing the spaces between crop plants and trees becomes important as increased weed growth may smother the crops.

1. **Mulching**: however, the best practice would be to cover the soil completely using the dried/fresh biomass or cover crops like green gram, horse gram, velvette bean, etc. which are small leaved and short plant type or creepers. This reduces moisture loss from soil, prevents weed growth and also helps to harvest atmospheric humidity and helps plants to grow even in rainfed conditions.

D. **Pest and Disease Management**: Most of the chemicals are used here. So effective non pesticidal management is very important.

1. **Weed management**: Good cropping patterns can reduce the weed problem. Weed types also depends on the soil. Weeds can find economic use as well. Mechanical weeders also help in management of the weeds. The role of crop geometry (line sowing) as an important factor for weed management.

2. P**est Management**: Pest incidence is based on the cropping patterns, production practices and weather conditions. Depending on the situation local resource based NPM practices are available

3. **Disease Management**: Disease is a symptom of underlying physiological problem often infectious. Again situation specific resource based NPM practices are available.

However they need effective Surveillance (farm level, village/regional level), diagnostic support whenever farmers face a problem.

What is essential to practice Natural Farming?

1. Knowledge of the practices (in such a way that the farmers have the space and power to make their own decision based on their contexts)
2. Technology that is beneficial now and for the next 50 years minimum
3. Scientific understanding of the biological systems and the natural processes happening in nature
4. Creating values beyond yield, inputs and products; which embraces diversity, and supports the systemic transition process

Core approaches to be looked into for practicing Natural Farming (These are covered in detail in the respective sessions)

1. **Water and Moisture Management**
   - Cropping pattern must be based on the local water resource and weather parameters.
   - Rainwater harvesting practices such as grid block, trenches, ponds etc. must be adopted.
   - Harvest atmospheric moisture by increasing soil cover, designing cropping patterns for 365 days**.**
   - Increasing soil water and moisture holding capacity by increasing soil organic matter.
   - Improving water use efficiency through micro-irrigation systems, lifesaving irrigation plans, efficient cropping systems.
   - Monitoring weather and soil moisture.

2. **Adaptive cropping systems**
   - Cropping patterns based on soil types, water and weather parameters
   - Increasing cropping intensity (horizontal and vertical) through crop rotations and inter/multiple/poly crops.
   - Designing farms taking an integrated farming systems approach
   - Managing living roots and green cover for 365 days
   - Staggered production system and crop rotation for fresh fruits and vegetables

3. **Sustainable Soil Nutrient Management**
   - Soil quality indexes such as the physical factors (soil structure, water holding capacity etc), chemical factors (EC, pH, Available nutrients etc) and Biological factors (Organic microbial diversity, soil fauna etc) are to be managed.
   - Prevent erosion
   - Prevent compaction; minimising tilling, shift to animal drawn tools
   - Manage soil salinity and pH; Organic amendments, cropping pattern changes, increasing soil organic matters.
   - Increasing soil organic matter; composting, mulching, manuring
   - Biological nutrient management using home-made bio-fertilizers, EMOs/IMOs

4. **Natural seed system**
   - Identifying, conserving and documenting local diversity; mapping and characterization.
   - Participatory varietal selection to establish value for cultivation and use: Diversity

blocks, generating data on local performance, user preferences, seed catalogues etc.

- No GMOs to be used due to biosafety issues.
- Natural seed hub; Manage parental lines, maintain breeding, training, capacity building on seed production, coordinating between conservators, breeders, seed producers and markets.
- Institutionalizing production and distribution through community seed banks, community seed enterprises, farmer service centres for local production and distribution.
- Open source seed licensing; arrangements that facilitate and preserve freedom of access and use of plan genetic material, prohibit exclusive rights and apply to any subsequent derivatives of those materials.
- Creating value for diversity by developing processing and value addition in production to increase use.

5. Integrating livestock to increase soil organic matters and for production of inputs

6. Non Pesticidal Management

- Integrating management practices to prevent insects, diseases and weeds fromreaching damaging stage or proportions.
- A natural ecological balance will ensure that pests do not reach a critical number in the field that engages the yield.
- Nature can restore ecological balance if it is not meddles with too much, hence no chemical pesticides at all.
- Understanding the insect biology and crop ecology is important to take up right management practices - botanicals or microbial, farm made or commercial.
- Pest surveillance: Farm level and village level surveillance to identify pests and disease using various traps to give alerts and advisories.
- Simple tools such as flip charts, apps, manuals etc. for problem diagnosis.
- Building local entrepreneurship for production and sale of bio-fertilisers and inputs
- Weekly advisories based on local surveillance.

Soil Health Management

3. IMPORTANCE OF SOIL HEALTH AND PRESENT DAY CONCERNS WITH SOIL

Agriculture has seen several technological advancements both globally as well as in India. However, today, the environmental sustainability of agricultural production systems is a major concern. Soil and crop management practices have a large impact on the relationship between soil processes and agro-ecosystem function, and thus on the sustainability of agricultural production systems. Sustainable farming is dependent on soil quality, which provides crops with water and essential nutrients. Management of soil health is critical to the success of natural farming systems.

Soil health and present-day concerns with Soil

Soil is a vital and necessary natural resource for all living beings. The capacity of a soil to perform within ecosystem boundaries to sustain biological productivity, preserve environmental quality, and promote plant and animal health is characterized as soil health or quality. A productive, economical, and environmentally responsible agricultural system is built on healthy soil. A healthy soil would ensure correct water and nutrient retention and release, encourage and sustain root growth, preserve soil biotic habitat, respond to management, and resist degradation.

Alluvial soil, Red soil, Black soil, Laterite soil, Arid soil, and Forest & mountain soil are the six major soil types in India. Each soil type has unique physical and chemical qualities, such as alluvial soil, which is particularly productive with high phosphate and potash content. Laterite soil is acidic, whereas black soil is high in potassium and magnesium but low in phosphorus. Red soil is high in iron and potassium but low in phosphate.

Intensive crop cultivation with imbalanced fertilizer, high nutrient mining through monoculture, decline in organic matter status, decreased biodiversity, deficiencies of secondary and micronutrients, and other factors have deteriorated soil health throughout the country, resulting in declining crop productivity growth. Unbalanced fertilizer use has resulted in poor crop yields as well as deterioration of the soil's physical health and also environment. Furthermore, in many parts of the country, an uneven use of chemical fertilizers results in a deficit of secondary and micronutrients in the soil. Rachel Carson in her book ‘Silent Spring’ has highlighted the adverse effect of synthetic pesticides. Many investigations have shown their adverse effects of change in soil nature, soil contamination, groundwater pollution, decrease in soil micro flora etc.

In some circumstances, N fails to respond in the absence of P. Long-term N use reduced soil productivity even lower than the control. The use of N alone most likely encouraged an imbalanced removal of soil nutrients, whereas nutrient depletion in the control was in natural proportion. Overall, about 59 and 36 per cent of Indian soils are low and medium in available N, respectively. Similarly, soils of about 49 and 45 percent area are low and medium in available P, respectively; while soils of around 9 and 39 per cent area are low and medium in available K, respectively. Among various soil characteristics that affect the availability and uptake of micronutrients, soil pH and organic carbon content are the two most important factors.

The sustainability of agriculture depends on soil fertility and health, but excessive use of chemical fertilizers and pesticides, as well as poor management of soil resources, have led to new problems like secondary salinization, surface crusting, and a decline in honey bee pollination (which required optimum pollination and higher yield). Thus, soil management techniques such as organic farming and nature-based soil management enable the availability of naturally occurring carbon and nitrogen sources. Sustainable agricultural and food systems, safe food, environmentally balanced development, and climate action through GHG reduction are all made possible by nature-based soil management.

Analysis of more than two lakhs soil samples during 2011-2017 revealed huge variation in different types of micronutrients deficiency in India soils. On an average, 36.5, 23.4, 12.8, 11.0, 7.1 and 4.2% soils are deficient in zinc, boron, iron, molybdenum, manganese, and copper, respectively, across the country. Our soils are very low in organic matter content and thus have poor soil fertility. Organic carbon is an index of good soil health and application of organic manures helps in maintaining high organic carbon content of the soil.

As per the Ministry of agriculture and farmer's welfare, GoI, Pesticide consumption is increasing year by year (2018-19 (59,670 MT), 2019-20 (61,702 MT), 2020-21 (62,193 MT), and 2021-22 (63,284 MT)). Pesticides pose substantial risks to the soil ecosystem and human health since many pesticides and their derivatives persist in the soil system for extended periods of time. Most pesticides have a deleterious impact on soil microorganisms, including their diversity, composition, and metabolic processes. Pesticides disrupt soil fertility, which has a direct impact on agricultural yield. Changes in the variety and composition of the beneficial microbial population are detrimental to plant growth and development because they reduce nutrient availability or increase disease incidence (Meena et al. 2020).

Fertilizer use has increased from 12.4 Kg/ha in 1969 to 137 Kg/ha in 2021 (an increase of over 11 times). Despite the usage of enormous amounts of agrochemicals, the rise in

productivity is not proportionate. Furthermore, the fertilizer subsidy provision in the 2021-22 Union Budget was Rs 79,530 crore; the final total was Rs 1.62 lakh crore; and it jumped to Rs 2.25 lakh crore in 2022-23. The government has allocated Rs 1.75 lakh crore for fertilizer subsidies in the 2023-24 Budget, a reduction of about Rs 50,000 crore. Fertilizer price increases will make production systems even less sustainable.

- Furthermore, water is a significant limiting resource that has a substantial impact on agricultural productivity.
- India, a water-stressed country, has seen per capita water availability fall from 5178 m^3/yr in 1951 to 1544 in 2011, with the figure anticipated to fall to 1140 m^3 by 2050.
- Agriculture system consumes 89% of groundwater, and diminishing availability puts further strain on production systems.
- According to the 2019 Economic Survey, the emphasis should move from "land productivity" to "water productivity." As a result, there is an urgent need to focus on farming system sustainability and create alternative farming systems with eco-friendly techniques that ensure an adequate supply of nutrients and water to agricultural plants.

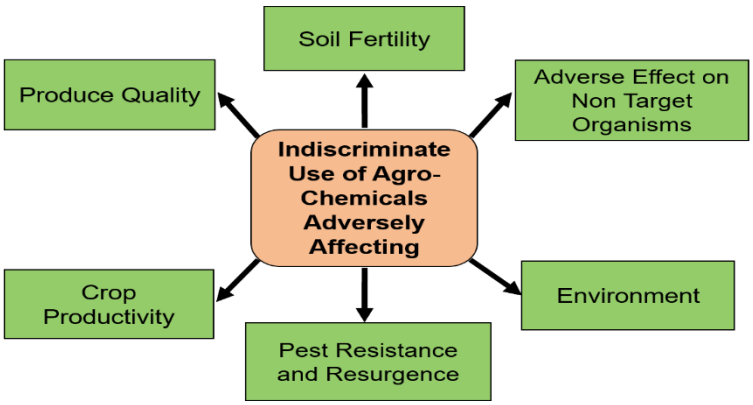


Figure 1: Adverse effects on indiscriminate use of agro-chemicals

1. AT FARMERS END

Ever increasing farmer distress: Conventional agriculture practices induces farmers to rely significantly on synthetic fertilizers and pesticides, resulting in high cultivation expenses. The green revolution increased agricultural production for many Indian farmers and resulted in major increases in food security. However, many small-farmers in rain-fed and resource-poor places did not gain significantly from green revolution technology.

Most smallholders who have been using chemical fertilizers and pesticides have become indebted as a result of the high cost of chemical inputs, a lack of credit, poor access to

markets, and a lack of investible surplus, which has resulted in low profitability agriculture, forcing smallholders to leave the sector. Farmers are required to invest more money on farming every year. Reasons include a high seed rate, limited water supplies, and fertilizers. These costs are gradually growing while output levels are declining.

2. AT CONSUMER END

Due to urbanization, soil degradation, and growing desertification, available agricultural land is dwindling, while population is expanding. The COVID outbreak has also put a strain on our food systems. As a result, many people may confront food scarcity. Over time, it has been discovered that 20-30% of the nutrients consumed by people are deficient. According to who reports, 50% of ailments are caused by the food that humans consume. It has been reported that pesticides are one of the causes of cancer in humans.

The current method of chemical agriculture leaves chemical residues in the food and reduces nutrient density, posing extra health risks. Agrochemical-treated foods impair soil organisms' ability to mobilize nutrients in the proper amounts, forms, and ratios. The nutritional integrity of such crops has been impaired.

3. ENVIRONMENTAL CRISIS

(Agrochemical Pollution, Global Warming, Extreme Weather Events, etc)

Soil degradation, water stress and loss of biodiversity: The use of synthetic chemicals in agriculture lowers soil life and, as a result, puts plant health at danger. It destroys soils, causing erosion, salinization, compaction, and other problems. It contaminates groundwater and other water-dependent ecosystems, resulting in agriculture biodiversity loss and insect biodiversity loss. Furthermore, prevalent agricultural techniques such as mono-cropping contribute to crop biodiversity loss.

Reduced agricultural output is caused by the loss of fertile soil caused by severe rainfall and soil erosion. The use of cover crops to minimize soil erosion while also giving nutrients and carbon is an important climate-smart approach for decreasing greenhouse gas emissions (GHGs) and adjusting to climate shocks. Raindrops directly break soil aggregates in the top layers of traditional systems, which have a high proportion of bare soils. This clogs soil pores and eventually closes the soil surface, blocking water infiltration, which then flows off the surface, carrying some of the soil with it, a process known as water erosion.

Global warming and climate justice: Climate change is having a significant impact on the agriculture sector globally, perhaps reducing revenue by 15 to 25%. In the end, this leads to a food shortage, several nutrient deficiencies in the body that make individuals vulnerable to health problems, and an increase in hunger and poverty in already vulnerable communities, particularly in rainfed dryland ecosystems around the world. According to UN-India, approximately 195 million people in India are undernourished, and there is a challenge of tripling food production by 2050 to meet the food needs of the ever-growing population. Thus, it is past time to appreciate and carefully execute the rationale for managing various agro-ecosystems using appropriate methodologies. Soil management is critical for climate change adaptation and lowering greenhouse gas (GHG) emissions.

Temperature rises are occurring at an alarming rate all around the world. If current trends continue, the world will soon be 20^{o} C warmer. All of the aforementioned problems are being exacerbated by global warming. It has made children, women, and landless farm laborers the most vulnerable communities, the least to blame for the climate problem, and the most affected, and they suffer the most and face the most serious repercussions. Governments have begun to adapt to this scenario by experimenting with alternatives to conventional agricultural practices, as 'business as usual' is no longer viable.

4. AGRO-ECOLOGY & SOIL PROPERTIES INFLUENCING PLANT GROWTH

1. Cover crops

Cover crops can be defined as close-growing crops that provide soil protection, and soil improvement between periods of normal crop production, or between trees in orchards and vines in vineyards (SSSA, 1997). Cover crops are grown not for market purposes, but when plowed under and incorporated into the soil, cover crops may be referred to as green manure crops. Cover crops are sometimes called catch crops. Covering soil with living crops is one of the most important strategies for building soil faster by adding carbon to the soil, as well as providing additional money from the crops.

Live crops enhance soil carbon in a short period of time through a process known as rhizodeposition (the release of photosynthates into soil via root hairs). Energy is obtained by ingesting food by all living beings. Plants are the principal producers of food (by photosynthesis), and all other organisms obtain energy from ingesting food prepared by plants. Plants prepare food (carbon compounds) by utilizing CO2 gas from the atmosphere. Approximately 40% of the food material is used for shoot development, 30% for root development, and the remaining 30% is discharged into the soil via root hairs. These root exudates initiate the soil food web.

When the crop is in the vegetative stage, the amount of residue exhaled from the roots is greater. Soil should be ensured of living roots throughout the year to ensure that soil organic carbon accumulates consistently. When these roots exude from root systems that spread to various depths, the depth of soil that receives this carbon pumped in rises, and soils swiftly improve. It is anticipated that the rate of soil organic carbon growth caused by root exudates is 5-30 times greater than the addition of organic wastes to the soil.

A portion of these exudates, being rich in carbon also convert to soil organic carbon which contributes to

a) Improved soil biology
b) Better soil structure resulting in improved water holding capacity of the soil;
c) Better infiltration capacity of the soil;
d) And improved root ability of plant roots to easily grow deep in such soil.

In order to ensure crop cover, strategies to fill fallow periods need to be done with the help of proven practices like PMDS (Pre-Monsoon Dry-Sowing) and Year-long crop cover.

PMDS (Pre Monsoon Dry Sowing)

- Diverse crop seeds pelletized with clay and bio stimulant to be sown with minimal moisture from rain or irrigation the seeds germinate and establish themselves.
- Provide a thick organic mulch.
- In this manner, it's possible to establish a crop cover with less resources.
- Foliar application of liquid bio stimulants ensures crop growth.
- Greater the seed diversity greater are the results for the development of organic carbon content in the soil.
- Leafy vegetables, vegetables, fodder, can be sowed in PMDS cropping.
- Some biomass may be used as cattle fodder, harvesting the above ground portion of the crop. Keeping the roots intact in the soil.
- Balanced biomass may be incorporated into the soil.

2. Crop diversity

Crop diversification boosts the land's total production (in terms of biomass). According to the experimental results, there should be a minimum of four plant groups and a minimum of 12 crop species at any one time.

Each crop has unique microbial relationships with its roots in the soil. Increasing crop diversification promotes microbial diversity in the soil. Aboveground diversity represents microbiological diversity in the soil. Crop diversity should be planned with the plant species that provide (1) income potential from a variety of short to long duration crops in mind. (2) Organic residues in big volumes (3) fodder sources (4) protection to soil by covering it and holding the soil together for longer durations.

Ensuring diversity while growing crops is very important for the following reasons:

a) Diverse food available for consumption
b) Different root depths of root systems of different crops improve the depth of Soil quickly
c) Crop losses due to specific insects, diseases is minimised
d) Pest build up in slowed down or stopped in fields with diverse crops

e) Productivity (yield) of whole land increases with increase in diversity.

3. No/minimum tillage

Tillage is a technique that is used to loosen the soil for it absorbs precipitation and helps seeds grow deeper roots. However, this technique affects the soils in a variety of ways, as follows:

a. The oxidation process releases highly valuable soil carbon into the soil as a gas.

b. The soil structure is damaged, and the soil becomes powdery, resulting in pore sealing. After-rain led to increased compaction

c. Compact soils do not allow crop roots to grow deeper and have a lower water retention capacity to promote crop growth.

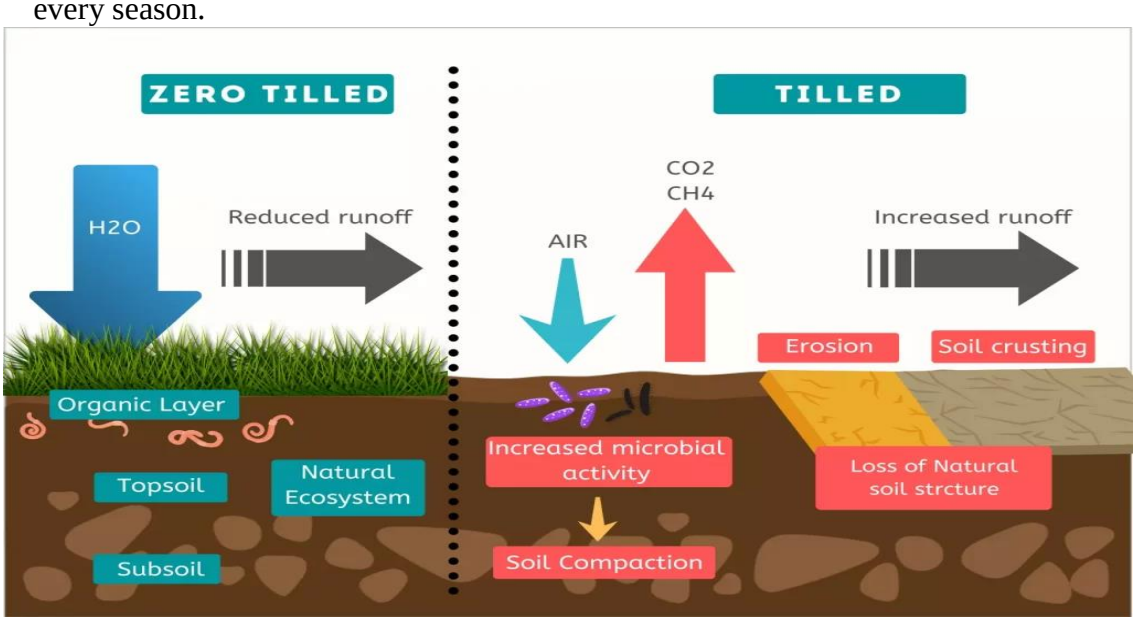
d. Soil biology suffers as soil carbon levels fall.

The following results will be obtained if a soil is not tilled.

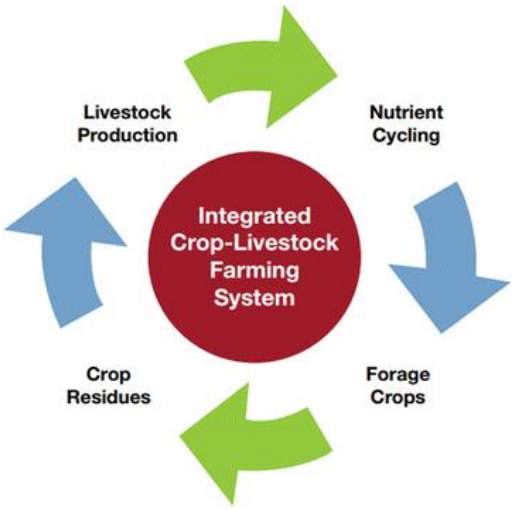
a. The tunnels formed as a result of crop root activity, earthworm activity and other insect's activities will become stronger over time if not removed by plowing.

b. The tunnels allow a lot of water to absorb into soil and reduce run off.

c. The tunnels will allow crop roots to grow deeper and provide stronger anchorage to plants during floods, as well as allow roots to receive nutrients and water from deep strata. Deep summer ploughings result in significant oxidation of soil organic carbon. Every farmer is urged to create farm models that include permanent trees integrated with crops rather than land preparation or intercultural activities that require tillage every season.



4. Integrate animals



Trees and animals in nature relay on one another to grow. Crop planning should incorporate fodder crops, as well as animal (buffalo or cow) by-products (such as dung and urine) to be used in the manufacturing of natural farming inputs (such as Jeevamrit, Beejamrit, etc) in agriculture crop production. When growing a PMDS (Pre-Monsoon Dry-Sowing) crop for green manuring, letting cattle to graze on the fields is preferable to absorbing the crop into the soil. Cattle will consume well-grown feed. When PMDS crops are grown on soil, important carbon in plant matter is lost up to 90% during the decomposition process. Soil, water, and natural resources are all conserved when animals are raised for food. This reduces even the need for water and electricity by 90%, resulting in the lowest possible cultivation costs. Additionally, just 10% of the irrigation water used in farming would be used with this strategy. Aside from the fact that animal based farming has various benefits, there are also less pollutants and reduced electricity use.

5. Bio-stimulants

Bio-stimulant is any substance or microorganism applied to plants with the aim to enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrient content. When applied in tiny amounts, compounds other than fertilizers known as "bio stimulants" which encourage plant growth. Certain chemicals found in plants and animal byproducts function as bio stimulants. In Natural Farming, little amounts of Jeevamrit, Beejamrit, and other similar products are being utilized as a bio-stimulants with excellent effects. To boost plant vigour, crop yields, and alleviate plant stress, bio stimulants are a diverse range of biological agents, microbes, and compounds can be administered directly to plants, seeds, or soil. Bio stimulants can be used at any stage of a plant's life cycle, beginning with the germination of seeds. Bio stimulants work by enhancing the plant’s ability to absorb nutrients so it can develop properly. When applied to soil, bio stimulants improve the soil's complementary microbes that help a plant’s roots thrive and form a beneficial symbiotic relationship. Plants benefit from bio stimulants by creating higher yields, stronger growth, enhanced water absorption, better overall appearance, and an improved tolerance for heat, dry spells, pests, diseases, and transplanting shock, etc.

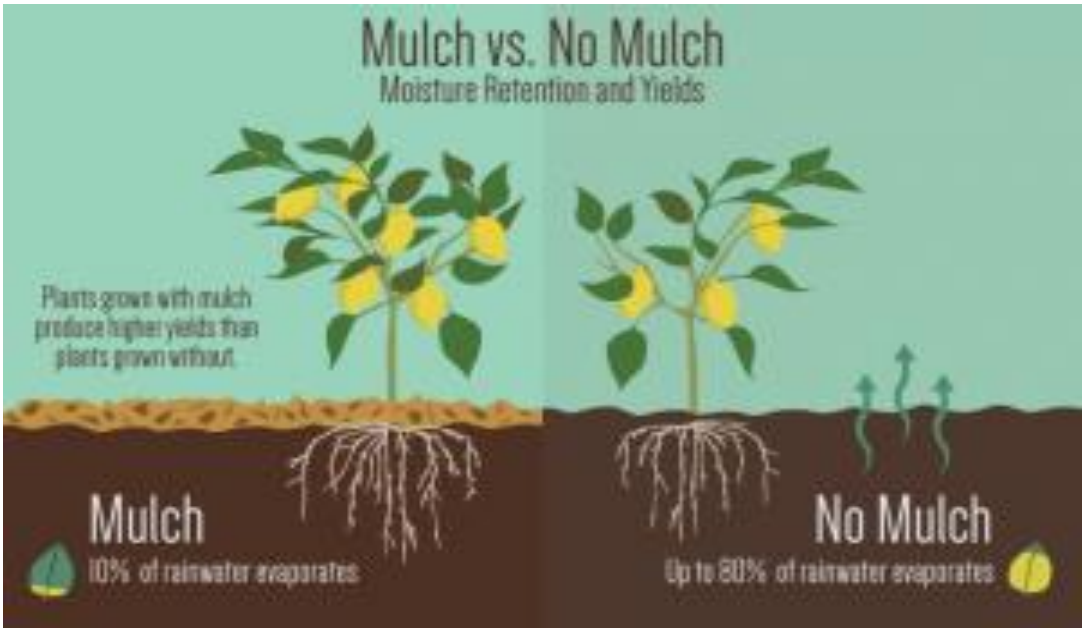
Normally in conventional agriculture, crop residues are seen as sources of plant nutrients and that's why they are composted and applied to soil; and also, FYM is seen that way and is applied in large quantities. But in natural farming, only small quantities are being used. Bio stimulants are all natural and biologically derived. Examples of bio stimulants – Beejamrit, Jeevamrit, Saptadhanyankura tonic, etc.

6. Addition of diverse organic residues

It is advised to apply 2-3 inches of crop leftovers as mulch, or roughly 2-3 tons/acre, as it provides the required benefits. It is not advised to use rice husk as mulch because farmers have expressed dissatisfaction with this practice. It is necessary to preserve the diversity of organic leftovers. It is crucial to remember that adding organic matter does not serve as a source of nutrients; rather, its primary benefits are in protecting soil and enhancing soil life.

Besides a live crop, having organic residues spread on soil as a mulch is very beneficial. Mulch provides the following benefits:

a) Avoids compaction of soil caused by beating action of rain
b) Protects soil from the heat of the sun and it helps retain more soil moisture, and provides better living conditions for the soil organisms.
c) The nutrients and water in the residues locked in the residues are gradually released into soil upon decomposition
d) During rains, presence of mulch on soil surface reduces the erosion of soil and reduces runoff of rainwater.



7. No use of agrochemicals (fertilizers, insecticides, fungicides, weedicides, etc.)

Agrochemicals are the chemicals used in agriculture like fertilizers, insecticides, fungicides, weedicides, etc.

These chemicals work in a way to meet the temporary need for the crop without working along with nature and living things in the agriculture ecosystem. For example, fertilizers provide nutrients directly to plant by harming soil structure and soil biology; pesticides try to kill all insects including beneficial ones and leave harmful chemical residues in food products, water and soil.

Soil properties influencing plant growth

Soil properties plays a crucial role in influencing plant growth and development. Different soil characteristics directly or indirectly impact the availability of essential nutrients, water retention, root development, and overall plant health. Here's an overview of how various soil properties affect plant growth:

Soil Texture:

Soil texture refers to the relative proportions of sand, silt and clay particles in the soil. Sandy soils have larger particles and drain quickly, often requiring more frequent irrigation. They have low water holding and nutrient retention capacity. Clay soils have smaller particles, which leads to higher water retention but also result in poor drainage and aeration problems. Loam soils is an equal proportions of sand, silt, and clay particles. Loamy soils are considered ideal for plant growth due to their balanced water-holding capacity and drainage.

Soil Structure:

Soil structure refers to the arrangement of soil particles into aggregates. Good soil structure allows for proper root penetration, water movement, and air circulation. Compacted soils have poor structure, hindering root growth and water infiltration.

Soil pH:

Soil pH affects the nutrient availability. Most plants are prefer a soil pH between 6 and 7 to absorb more nutrients from the soils. Acidic soils (pH < 6) can limit the availability of essential nutrients like phosphorus, calcium, and magnesium. Alkaline soils (pH > 7) can lead to micronutrient deficiencies.

Nutrient Content:

Soil nutrients, including macronutrients (primary nutrients: Nitrogen, Phosphorus, Potassium; secondary nutrients: Calcium, Magnesium and Sulphur) and micronutrients (iron, zinc, copper, manganese, boron, molybdenum, chlorine, nickel), are essential for plant growth. Soil fertility influences nutrient availability. Nutrient-rich soils promote healthy growth.

Organic Matter:

Organic matter improves soil structure, water holding capacity, and nutrient retention. It serves as a source of slow-release nutrients and provides a favourable environment for beneficial micro-organisms.

Water retention and drainage:

Adequate water retention is vital for plant hydration and nutrient uptake. Poor drainage can lead to waterlogged conditions, suffocating roots and causing root diseases.

Aeration:

Good soil aeration ensures the exchange of gases (oxygen and carbon dioxide) between the soil and the atmosphere. Oxygen is essential for root respiration. Compacted or waterlogged soils limit oxygen availability.

Cation Exchange Capacity (CEC):

CEC indicates a soil's ability to retain and exchange cations (positively charged ions) like calcium, magnesium, and potassium. Soils with higher CEC can hold more nutrients and release them to plants as needed.

Salinity and Sodicity:

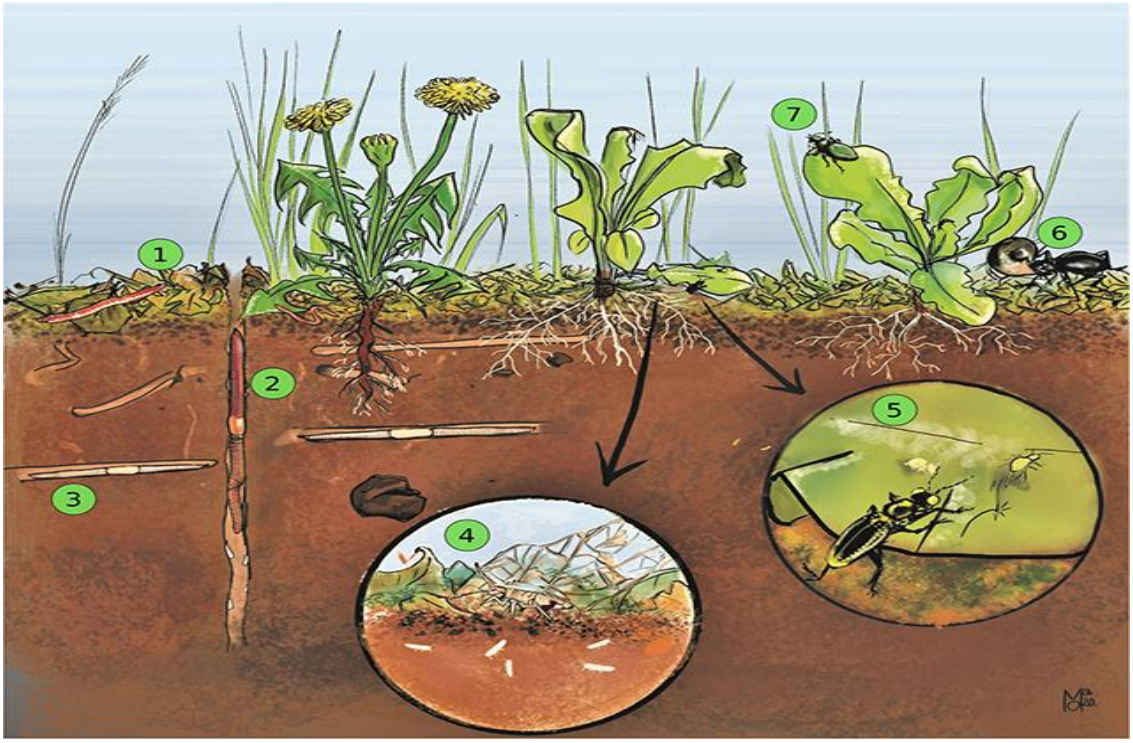
High salinity (salt content) can disrupt water uptake by plants and lead to osmotic stress. Sodicity (sodium dominance) can degrade soil structure, reducing root penetration and water movement.

Soil Compaction:

Compacted soils limit root growth and restrict water movement and air circulation. It can lead to poor drainage and increase susceptibility to erosion.

Microbial Activity:

Soil microorganisms contribute to nutrient cycling, organic matter decomposition, and disease suppression. Healthy soils with diverse microbial populations support vigorous plant growth.



5. SOIL PROPERTIES

Soil Organic Carbon, Soil Biology and Physical Environment

The major emphasis of different practices under natural farming is to enhance the soil organic matter (SOM) or soil organic carbon (SOC), and the population and activity of soil microbes and other soil fauna like earthworms and micro-arthropods. The increase in SOC and soil biological activity improve the nutrient availability to plants, soil structure, aeration and hydrothermal regime in the rhizosphere.

Soil organic matter (SOM) or soil organic carbon (SOC) is the key constituent which dictates soil physical condition, chemical properties including nutrient status and biological health of a soil. SOC is the prime indicator of soil health and index of the productivity of the soil. Normally, soil without any organic matter is considered as dirt which are tightly packed to restrict the infiltration of water, and are nonporous and non-permeable.

SOC creates a granular condition of soil which maintains favourable condition of aeration and permeability. It increases water holding capacity of soil and reduces surface runoff, erosion etc. SOM is food source for soil microorganisms. Highly decomposed organic matter (humus) provides a storehouse for the exchangeable and available cations, and acts as a buffering agent which checks rapid chemical changes in pH and soil reaction. Soil organisms, both animals (fauna/micro-fauna) and plants (flora/micro-flora), are important for maintaining the overall soil quality, fertility and stability of soil.

Soil organic matter helps soils hold onto water and nutrients and supports soil microbes that recycle nutrients. Soil microbes are intimately associated with biological and biochemical transformations occurring in soil. Management practices that reduce SOM/SOC in soils, or bypass biologically-mediated nutrient cycling also tend to reduce the size and complexity of soil communities.

According to the estimates by ICAR-NBSS&LUP (2017-18), there is huge variation in SOC stock across states. The SOC stock of Indian soils is 10 to 12% of the tropical regions and about 3% of the total carbon mass of the world.

Soil Biology

Healthy soil is the most important factor for sustainable farming. Plants growing in healthy soils are part of a rich ecosystem including numerous and diverse microorganisms in the soil. Soil Microbes perform various biogeochemical functions.

It has been long recognized that microbes play important roles in plant nutrition. However, the full range of microbes associated with plants and their potential to replace synthetic agricultural inputs has only recently started to be uncovered.

There is clear evidence that plants shape microbiome structures, most probably by root exudates, and also that bacteria have developed various adaptations to thrive in the rhizosphere. The mechanisms of these interactions and the processes driving the alterations in microbiomes are, however, largely unknown.

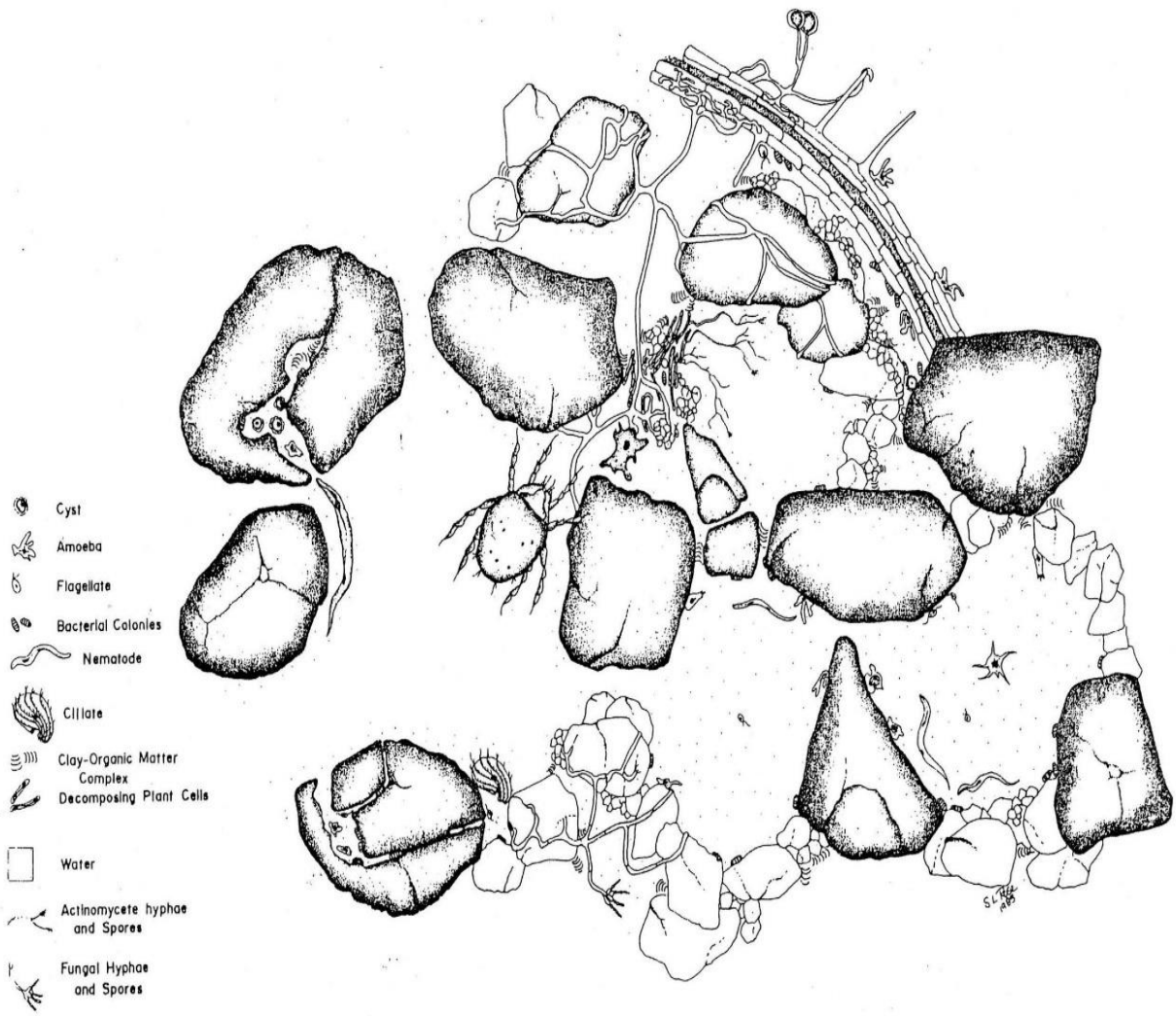
Soil microbiologists believe that healthy soil means living soil, which involves trillions upon trillions of living microorganisms consuming first organic matter, then each other, and releasing nutrients in the process.

Soil biological properties viz. microbial populations, enzymatic activity and soil bio-diversity are important indicators of soil quality, and they help in stimulating plant growth by influencing nutrient availability and soil hydro-thermal regime.

Soil microorganisms play an essential role in decomposing organic matter, cycling nutrients and fertilizing the soil.

Soil microbial activity that reflects microbiological processes of soil microorganisms (soil bacteria, actinomycetes, fungi, etc) is the potential indicator of soil quality, as plants rely on soil microorganisms to mineralize organic nutrients for growth and development. Soil microorganisms also process plant litter and residues into soil organic matter, a direct and stable reservoir of carbon and nitrogen that consists of living and dead organic materials subject to rapid biological decomposition. Soil microbes are also important for the development of healthy soil structure.

Soil bacterial species in plant rhizosphere which grow in, on, or around plant tissues and stimulate plant growth by a plethora of mechanisms.



Arbuscular Mycorrhizal Fungi (MF) colonise the root systems of plants. Plants offer photosynthetic sugars to MF, which in turn assist the plant by facilitating the uptake of mineral nutrients and water. In healthy soil, mycorrhizal fungi grow immensely which works like a sponge. It helps in improving soil aggregate stability, build soil carbon, improve water use efficiency and increase the efficiency of nitrogen, phosphorus and sulphur. To increase the mycorrhizal fungi, it needs to reduce/eliminate chemical use, reduce/eliminate tillage, reduce/eliminate synthetic fertilisers and living plant cover as long as possible. Cover crop also moderates soil temperature, which improves soil moisture condition and in turn helps in soil bacterial growth.

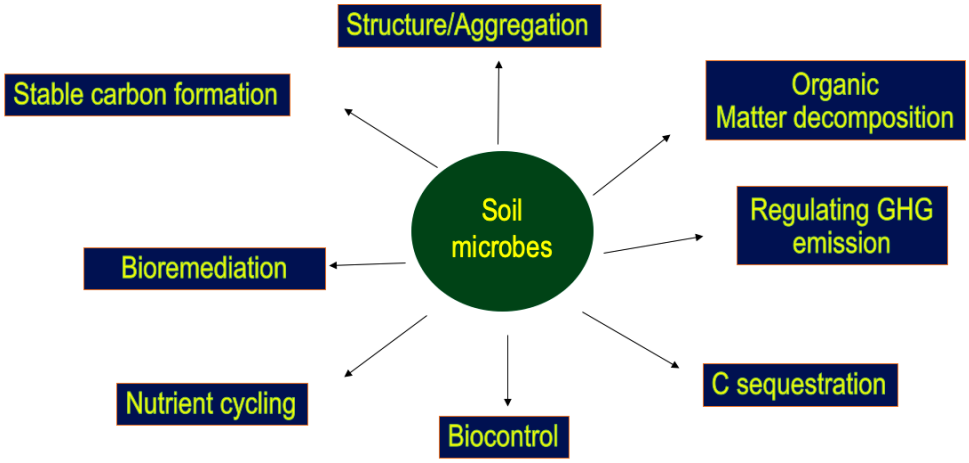


Figure showing role of soil microbes

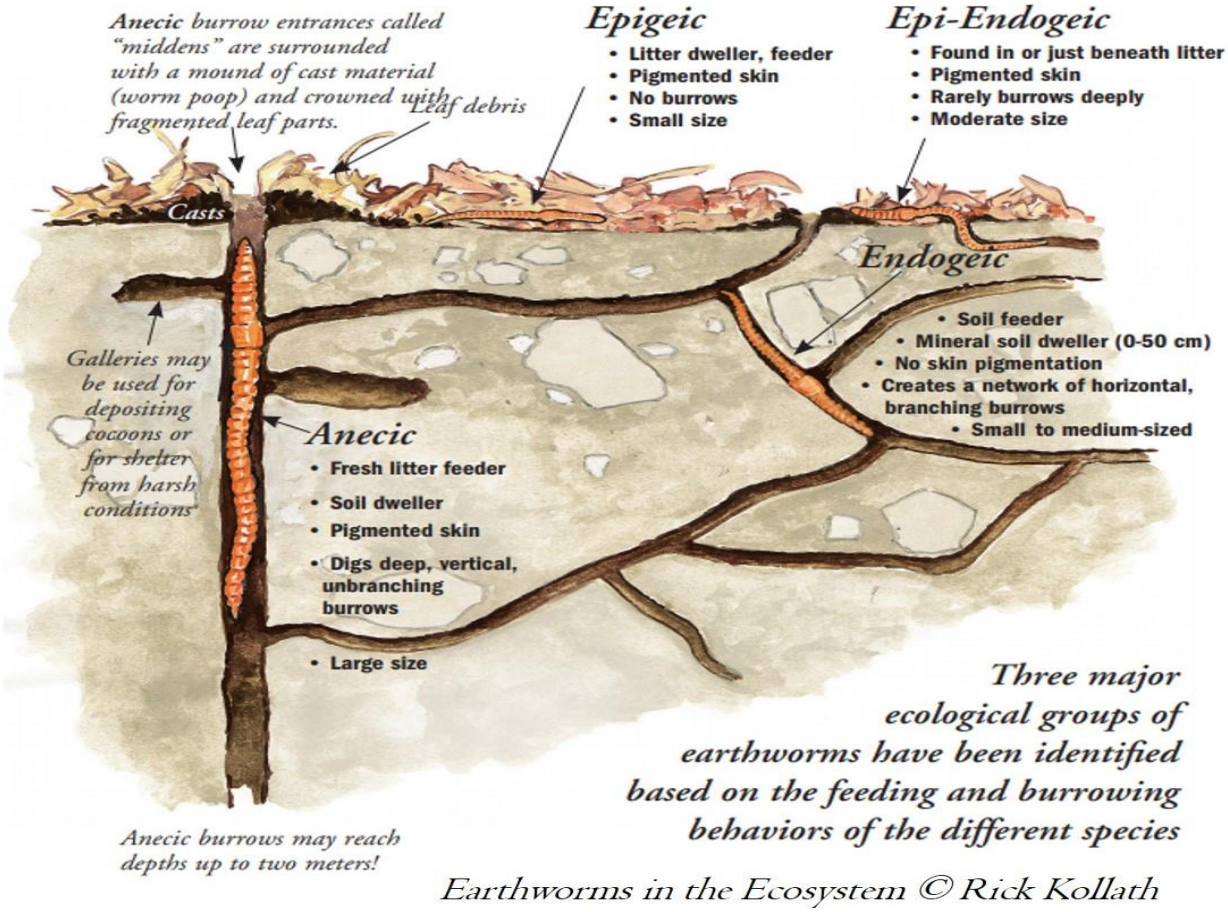
In healthy soil, these fungi together with the full coteries of soil microbes help in regeneration, resilience and revitalization of soil system making all needed nutrients available to the plants through fixation, decomposition, solubilization and mineralization. Thus, it also helps in building a soil carbon sponge, which absorbs water and makes it available to the plants. The application of chemical fertilisers, biocides, tilling of lands, etc. is detrimental to these soil microorganisms, and consequently roots of the plants act simply as straw sucking mainly those nutrients, which has been supplied externally in the forms of chemical fertilisers. Through biological processes, all the nutrients are made available to the plants through decomposition of root biomass of previous crops or mulches.

Changes in farming practices are foremost reflected in the changes in biological properties such as microbial populations and soil enzymatic activity. These occupy a pivotal role in reactions associated with organic matter decomposition and nutrient cycling. Soil enzymes have been suggested as one of the important indicator of soil quality, and for evaluating the degree of alteration and assessing the effect of different cropping systems on nutrient dynamics and soil quality.

Microbes provide crucial ecosystem services. The microbiota in the soils in which these grow provide nitrogen, phosphorus and other essential nutrients. Microbes in the oceans produce 50% of the oxygen we breathe, and remove roughly the same proportion of carbon dioxide from the atmosphere. They also remove up to 90% of methane from the world's oceans.

Soil fauna

Soil fauna is crucial to soil formation, litter decomposition, nutrient cycling, biotic regulation, and for promoting plant growth. Yet soil organisms like earthworms and micro-arthropods remain under-represented in soil processes. Earthworms are a major component of soil faunal communities in the natural farming ecosystem.



Source: https://kollathdesign.com/portfoliotype/natural-history-illustration/

Earthworms move the soil around and in the process create tunnels that alter soil in a beneficial way. Earthworm tunnels bring in oxygen, drain water and create space for plant roots. The natural feeding habits of earthworms involve ingestion of small amounts of soil through their bodies and then they excrete it in the form of earthworm casts, which improve soil fertility status.

Earthworms improve soil structure by dragging down organic matter, mixing soil and creating tunnels that improve drainage. Worm casts are rich in recycled plant nutrients, and can contain up to 40% more beneficial humus than the plough layer. Research has shown that a fresh worm cast can hold as much as five times more accessible nitrogen, seven times more accessible phosphorous and 11 times more accessible potash than the surrounding top soils

(Farming Connect 2019). Earthworms work throughout the soil from the surface to deep down in the soil profile. Their activity results in

- Improved nutrient availability - the casts they produce are rich in nutrients and when their bodies decompose, more nutrients are released to the soil;
- Improved drainage - their burrows allow movement of air and water through the soil; this is most noticeable in no till systems where movement of water through the soil can be much greater than in cultivated soil
- Improved soil structure – through improving the top soil by creating stable soil aggregates able to store moisture
- Improved productivity – as a result of all of the above

Earthworms affect the SOM dynamics. There is sharp increase of mineralization during digestion. Large amounts of mineral nutrients are present in fresh casts, which are reorganized in microbial biomass at the scale of days to weeks depending on soil properties. Also there is blocking of mineralization at the scale of months to years in the compact structure of ageing casts (i.e. older than 1–2 weeks), which help in Carbon sequestration.

Tillage, chemical fertilisation, and pesticide usage regularly influence earthworm populations. However, natural farming practices allow earthworms to proliferate. Cabbage intercropped with fenugreek, pea and coriander under Subhash Palekar Natural Farming (SPNF) found higher population count of earthworms (183.33 m^{-2}) in SPNF as compared to CF (41.67 m^{-2}) (cabbage as sole crop). The result showed that the application of cow urine and dung based inputs help in promoting earthworm activity in soil. Similarly earthworm cast weight was also higher in SPNF (57.23 gm^{-2}) than CF system (14.87±0.56 gm^{-2}) during the rainy season.

A systematic comparison between natural farming and non- natural farming fields conducted in Andhra Pradesh reveals that the natural farming fields host an average 232 earthworms per square metre compared with just 32 on non – natural farming fields.

Soil micro-arthropods include small invertebrate animals with an exoskeleton and segmented body that are visible to the human eye with some magnification for identification.

Among soil micro-arthropods, springtails (Collembola) and mites (Acari) play a primary role in the recycling of nutrients within terrestrial ecosystems. In particular, they are consumers of microbes such as bacteria and fungi. In fact, their feeding activity is better described as ‘grazing’. Through this grazing they stimulate microbial activity and contribute to

the mineralization of nitrogen and thereby to plant growth. As such they play an important role in soil fertility.

Soil microarthropods impact many soil processes that affect crop production. Most notably, microarthropods affect soil organic matter decomposition and nutrient cycling. They can also impact plant pathogen suppression and transmission, seed germination, root exudates, plant nutrient allocation and growth. Though soil mesofauna primarily affect crop production through their interactions with other factors in the soil environment, these indirect effects can add up to big impacts on crops.
(https://soilsmatter.wordpress.com/2023/06/01/how-do-soil-microarthropods-affect-crop-production/)

Studies shows that soil microarthropods have been found to be sensitive to changes in land management practices and are thus being used as indicators of soil quality. The abundance of soil microarthropods has been observed to be positively correlated with soil Carbon and Nitrogen.

Soil physical environment

It is essential to ensure good soil drainage, aeration, and optimum humidity for the growth of plants. Soils with reduced drainage may accumulate higher amounts of water than is needed and thus negatively affects plant growth. While insufficient soil moisture availability also adversely affect plant growth. Thus, it is important to maintain congenial soil physical environment.

Soil physical environment governs the ease of seed germination, root growth, soil aeration, soil hydrothermal regime, water retention and transmission in the rhizosphere. The soil and crop management practices affect the density and structure of soil and thus the physical properties which directly affect the plant growth namely soil water, soil air, soil temperature and soil hardness or penetration resistance.

Soil structure is a dynamic property which can be defined as “the shape, size and spatial arrangement of individual soil particles and clusters of particles (aggregates)”. Soil structure is generally characterized in terms of aggregate characteristics. Soil aggregates determine the air-water relationship and influence most of the soil physical properties and thus provide better environment for root development and plant growth. Moisture retention and availability depends upon the soil structure and pore geometry of soil.

Soil porosity and pore-size distribution depends upon the soil aggregation and thus the structure of soil. Soil structure includes the creation of secondary coarser pores and the

formation of intra-aggregate finer pores. Structural degradation changes the pore size distribution and functionality, thus affecting soil air and water distribution and biological activity, it is essential to have a high proportion of pores with capacity to retain water available to plant roots.

Higher SOC and microbial diversity (fungal hyphae or bacteria) helps in the formation of porous spaces, thereby leading to increase in the absorption of water. Therefore, water adheres to the surface of particles or organic matters leading to water infiltration & increase in the holding capacity. Water transmission characteristics viz. infiltration rate and hydraulic conductivity, are affected by texture and structure. These will be higher, if the soil is highly porous, fractured or aggregated, than if it is highly compacted and dense. A significant relationship exist between hydraulic conductivity and water stable aggregates. Hydraulic conductivity not only depends on the pore volume but also continuity of conducting pores.

Natural farming practices enhance the soil microbial diversity and soil fauna, and thus lead to improved soil structure and porosity, which leads to better soil physical environment and thus improvement in soil-water-air relations.

6. SOIL FERTILITY

Intensification of conventional farming systems has resulted in significant use of agrochemicals, agricultural technology, and high-demanding varieties, resulting in negative environmental impacts such as groundwater pollution and atmospheric contamination, which intensifies the greenhouse effect. Environmental pressure has a severe impact not only on human health and natural resources, but also on the long-term viability of agricultural output. Natural farming strives to improve soil health by increasing soil biological activity through the addition of microbial inoculants and organic matter. Natural farming practices include the incorporation of microbial cultures to improve decomposition and nutrient recycling, the use of local seeds, the integration of crops, trees, and livestock (primarily native breed cows), effective crop spacing, contouring and bunding to conserve water, intensive mulching, extensive intercropping, and crop rotations. Furthermore, mulching has a significant positive impact on SOC content due to improved soil and water conservation, lower average and maximum soil temperatures under mulch than on unmulched soil surfaces, biomass return to the soil, increased soil biodiversity, and strengthening of nutrient cycling mechanisms. Natural farming has a lower – or even net positive - environmental and/or social impacts.

As previously stated, natural farming approaches increase SOC, microbial, and soil faunal activity, which improves nutrient cycling and availability to crop plants while also maintaining a favorable environment in terms of soil moisture and aeration in the rhizosphere. Soil management strategies such as organic farming help to improve soil fertility and health. It improves water percolation, retention, and clean and safe drainage. It improves biodiversity, ecosystem health, and resiliency; and it converts our existing agriculture's carbon emissions into very significant carbon sequestration, so cleaning the atmosphere of legacy CO_2 levels.

Bacteria and Archaea are the only organisms that can decrease and extract significant amounts of nitrogen from the atmosphere to replenish the soil. A variety of bacterial species from the genera Azospirillum, Alcaligenes, Arthrobacter, Acinetobacter, Bacillus, Burkholderia, Enterobacter, Erwinia, Flavobacterium, Pseudomonas, Rhizobium, and Serratia are associated with the plant rhizosphere are able to exert a beneficial effect on plant growth. Plants have a major role in choosing and enriching the types of bacteria through the contents of their root exudates. Thus, the bacterial population in the rhizosphere develops in response to the nature and amounts of organic elements in exudates, as well as the bacteria's ability to use these as energy sources. Rhizospheric bacterial populations have effective absorption and catabolism mechanisms for organic compounds present in root exudates. Natural farming offers a unique chance to improve rhizobacteria utilization in order to maximize crop output.

Ladha *et al.* (2016) developed a top-down global N budget for maize, rice, and wheat from 1961 to 2010. According to their findings, non-symbiotic nitrogen fixing appears to be the primary source of crop N uptake. Other than fertilizer- or soil-N contributed an estimated 48% (737 Tg) of crop N, equivalent to 29, 38, and 25 kg ha^{-1} yr^{-1} for maize, rice, and wheat, respectively. Non-symbiotic nitrogen fixation is responsible for approximately 370 Tg or 24% of total N in the crop, equating to 13, 22, and 13 kg ha^{-1} yr^{-1} for maize, rice, and wheat, respectively.

Natural farming has been reported to reduce soil deterioration and bring yield benefits to low-input farmers. Nitrogen fixation, whether by free-living nitrogen fixers in soil or symbiotic nitrogen fixers in legumes, is expected to supply the majority of available nitrogen accessible to crops. They also calculated the maximal potential nitrogen fixation and release and concluded that biological nitrogen fixation is likely to supply 52-80% of the national average nitrogen applied as fertilizer.

Phosphorus (P) is a one more major essential macronutrient for biological growth and development. Microorganisms offer a biological rescue system capable of solubilizing the insoluble phosphorus present in soil and make it available to the plants, like orthophosphate, is an important trait in a rhizo-bacterium for increasing plant yields. In natural farming, this bacteria act as a growth promoting agent in plants.

Jeevamrit is a formulation based on cow dung and urine on the chemical and microbiological properties of the ZBNF field, as well as metagenomic analysis and the economics of ZBNF, has been studied. Organic carbon, available phosphorus, and available potassium increased by up to 46%, 439%, and 142%, respectively, while micronutrients such as Zn, Fe, Cu, and Mn increased by up to 98%, 23%, 62%, and 55%, respectively, from 2017 to 2019. Proteobacteria predominated in whole genome metagenomic study, as did bacterial phyla such as Bacillus, Pseudomonas, Rhizobium, and Panibacillus. On the other hand, Ascomycota was the most prevalent fungal phylum in the soil sample. Furthermore, functional analysis revealed a significant representation of genes/enzymes involved in amino acid and carbohydrate metabolism, both of which contribute to soil fertility, plant growth, defence and development.

Bio Formulations (Jeevamrit and Ghanjeevamrit)

In Vrikshayurveda, fermented liquid natural manure is described. Jeevamrit and Ghanjeevamrit are the two main bio- formulations used in natural farming to promote soil health.

Jeevamrit

Jeevamrit is a fermented microbial culture. It provides nutrients, but most importantly, acts as a catalytic agent that promotes the activity of micro-organisms in the soil to synthesize/ to make bio-available plant nutrients in situ, increases the population of native earthworms and protect against pathogens.

Natural Farming argues that the dung of indigenous cows/livestock and undisturbed soil from the field has a huge number of diverse microorganisms which help in increasing the bioavailability of nutrients to the plants. Soil is a complex ecosystem hosting bacteria, fungi, plants, and animals. Soil microbes metabolise recalcitrant forms of soil-borne nutrients to liberate these elements for plant nutrition. In natural ecosystems, most nutrients such as N, P, and S are bound in organic molecules and are therefore minimally bioavailable for plants. To access these nutrients, plants are dependent on the growth of soil microbes such as bacteria and fungi, which possess the metabolic machinery to depolymerize and mineralize organic forms of N, P, and S. have isolated many different bacterial genera such as *Citrobacter koseri, Enterobacter aerogenes*, *Escherichia coli*, *Klebsiella oxytoca*, *Klebsiella pneumoniae, Kluyvera spp., Morgarella morganii, Pasteurella spp., Providencia alcaligenes, Providencia stuartii*and *Pseudomonas spp.* from cow dung. It is also found that many cow dung microorganisms have shown natural ability to increase soil fertility through phosphate solubilization. Almost 219 bacterial strains from cow dung, among which 59 isolates displayed nematicidal activity against >90 percent of the tested nematodes. Cow dung has an antifungal substance that inhibits the growth of coprophilous fungi.

Jeevamrit acts as a bio stimulant by promoting the activity of microorganisms in the soil and also the activity of phyllospheric microorganisms when sprayed on foliage. It acts like a primer for microbial activity, and also increases the population of native earthworms.

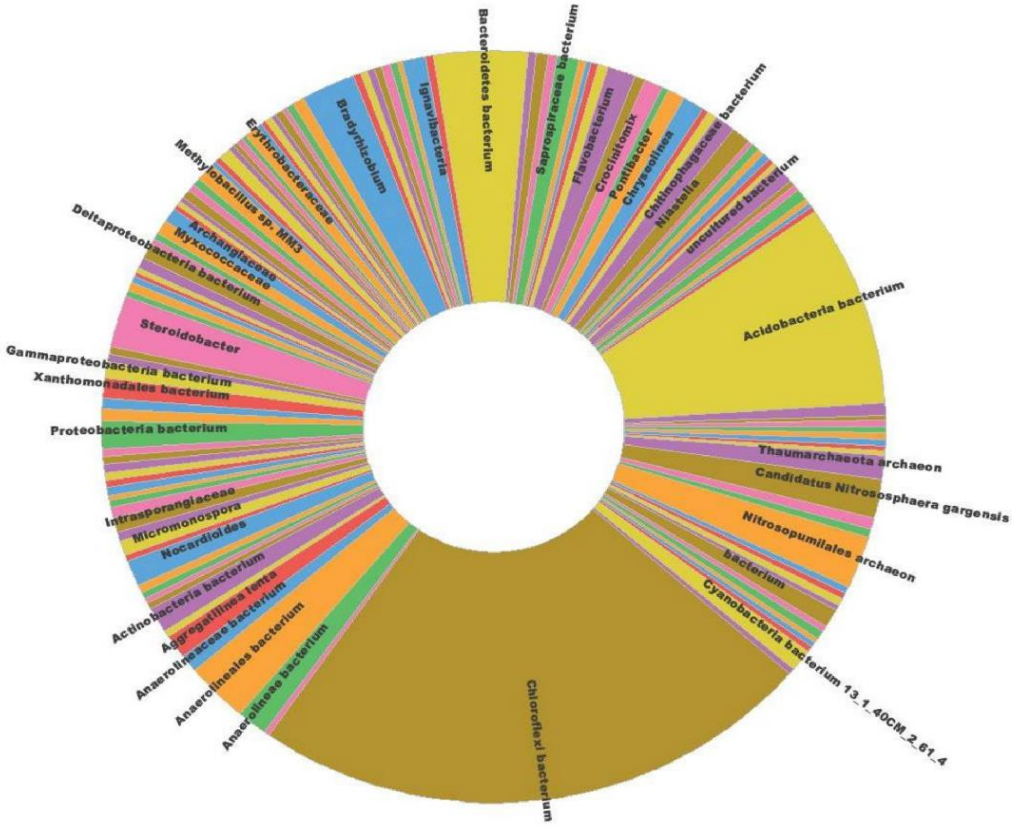
a. Preparation of jeevamrit: Fill a barrel with 200 litres of water. 10 kg of fresh local cow dung. 5 to 10 litres of cow urine should be added. 2 kg jaggery (a form of brown sugar native to India). Add 2 kg of pulse flour and a handful of farm dirt from the bund. Stir the solution thoroughly and leave it to ferment in the shade for 48 hours. Jeevamrit is now available for use.

Apply 400 litre/acre during pre sowing irrigation and 400 litre per acre during every irrigation for the first year, Than one acre of land requires 200 litres of jeevamrit in every irrigation every year.. Aerobic and anaerobic bacteria contained in cow dung and urine proliferate during the 48-hour fermentation process as they consume organic components (such as pulse flour and jaggery).

b. Application of Jeevamrit: This mixture needs to be applied once every two weeks. It ought to be included into irrigation water and 10% diluted sprayed straight onto the crops. It should be used on individual plants when it comes to fruit plants. You can keep the combination in storage for 7 to 9 days and best to use on before 12 days.

Ghanjeevamrit

It is the dry formulation of jeevamrit. Spread 200 kg of cow dung on ground uniformly in the form of a layer and add 20 litres of liquid jeevamrit on it and mix it. Now, make a heap of treated cow dung and cover it using a jute bag for 48 hours allowing it for fermentation then spread it on the floor, and dry in the sunlight. After drying is completed, store it in jute bags in the room. Air should be flowing. Ghanjeevamrit can be stored for 6 months. At the sowing period, use 1000 kg Ghanjeevamrit per acre during first year and 800 kg in second year and 500 kg every year. Again during the flowering period of the crop, add 50 kg of Ghanjeevamrit in between two crop lines on the soil per acre. It helps the soil to activate their available nutrients, microorganisms to make them available for the crop sown in that particular area. It increases the count of earthworms in soil which is beneficial for soil fertility. Ghana Jeevamrit has a large number of microbes which are responsible for making availabilities of nutrients like nitrogen, phosphorus, calcium, and other micronutrients. This will ensure higher yield by



enhancing the availability of nutrients through faster decomposition of bulky organic manures

by boosting the microbial activity in the soil. Many of these formulations are rich in beneficial micro flora and can act as efficient plant growth promoters.

Microbial diversity under natural farming

Aacchadan (mulching)

Mulching is defined as covering of soil surface using either live crops or crop residues like straw (dead plant biomass).

It protects soil from direct exposure from sunlight, produces humus, conserves top- soil, increases water retention and transmission, moderates hydro-thermal regime, encourages soil fauna, and prevents weeds.

Mulching prevents the formation of hard crust after each rain. The use of blade harrows between rows or intercultural operations creates 'dust mulch' on the soil surface by breaking the continuity of capillary tubes of soil moisture and reduces evaporation losses.

Evidence suggests that crop residues are good sources of plant nutrients and can increase yield and water use efficiency, while decreasing weed pressure. Long-term studies of the residue recycling have indicated improvements in physical, chemical and biological health of soil.

Three types of mulching have been suggested under natural farming:

- **Soil Mulch**: This protects topsoil during cultivation and does not destroy it by tilling. It promotes aeration and water retention in the soil. Therefore, deep ploughing should be avoided.
- **Straw Mulch:** Straw material usually refers to the dried biomass waste of previous crops. Any type of dry organic material will decompose and form humus through the activity of the soil biota which is activated by microbial cultures.
- **Live Mulch**: It is essential to develop multiple cropping patterns of monocotyledons and dicotyledons grown in the same field, to supply all essential elements to the soil and crops. Dicot groups such as pulses are nitrogen-fixing plants. Monocots such as rice and wheat supply other elements like potash, phosphate and sulphur.

The natural farming initiatives show promise for transformation at scale and open up a new frontier in thinking about agriculture with efficient utilisation of soil and water resources. Intensive irrigation and deep ploughing is not promoted in Natural Farming. This farming system also promotes soil aeration, minimal watering, intercropping and buds and topsoil mulching. Aacchadan, associated with natural farming which is mulching either by crop residues or live mulch through intercrops, does not allow soil evaporation and transpiration.

Whapasa, is a condition where there is a presence of both air molecules and water molecules in the soil. This condition helps in reducing irrigation requirements and promotes water availability to the crops through soil capillary actions. The drought conditions can be mitigated through Intercropping and Aachhadan. This intercropping and Aachhadan conditions enhance the activities of soil earthworms from top to bottom soils and vice-versa.

As per the Centre for Study of Science, Technology and Policy (CSTEP) report based on a study conducted in Andhra Pradesh in 2020, natural farming requires 50 to 60 percent less water and electricity when compared to conventional farming practices.

Natural farming practices also prevent over-extraction of groundwater, enable aquifer recharge, and eventually contribute to increasing water table levels.

Soil Aeration (Whapasa)

Soil aeration, a result of jeevamrit and achadan- represents water management through improved soil structure and humus content. It increases water availability, water use efficiency, and increases resilience to drought. The advocates of natural farming counter the over-reliance on irrigation in green revolution farming.

Whapasa is the condition, wherein both air molecules and water molecules are present in the soil. Thus, irrigating only at noon, in alternate furrows, may fulfil the moisture requirement of the crops, a significant decline in need for irrigation in natural farming. The ***whapasa*** principle of Natural Farming increases soil aeration and maintains air and soil moisture in equal proportion around plant root zone (rhizosphere). Under irrigated and high rainfall conditions, the excess water makes it very difficult for the roots to get the air that they need, causing them to decay. Thus the ***whapasa*** condition avoids the occurrence of soil and root borne disease.

Soil and water conservation practices

Biological measures (agronomic/agricultural and agroforestry) of soil and water conservation reduce the impact of raindrops through the covering of soil surface and increasing infiltration rate and water absorption capacity of the soil resulting in reduced runoff and soil loss through erosion. These measures are cheaper, sustainable, and may be more effective than structural measures.

Important agronomic measures favouring soil and water conservation are described below:

Green manuring: Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest. Green manuring usually belongs to the leguminous family and is incorporated into the soil after sufficient growth. The plants that are grown for green manure are known as green manure crops. The most important green manure crops are sunn hemp, dhaincha, pillipesara, cluster beans and Sesbania rostrata.

Contour farming: Contour farming is the most common agronomic measures for soil and water conservation in hilly agro-ecosystems and sloppy lands. All the agricultural operations viz. ploughing, sowing, inter-culture, etc. are practised along the contour line. The ridges and furrows formed across the slope build a continual series of small barriers to the flowing water which reduces the velocity of runoff and thus reduces soil erosion and nutrient loss. It conserves soil moisture in low rainfall areas due to increased infiltration rate, whereas in high rainfall areas, it reduces the soil loss. In both situations, it reduces soil erosion, conserves soil fertility and moisture and thus improves overall crop productivity. The effectiveness of this practice depends upon rainfall intensity, soil type and topography of a particular locality.

Choice of crops: The selection of the right crop is crucial for soil and water conservation. The crop should be selected according to the intensity and critical period of rainfall, market demand, climate and resources of the farmer. The crop with good biomass, canopy cover, and extensive root system protects the soil from the erosive impact of rainfall and creates an obstruction to runoff and thereby reduces soil and nutrient loss. Row or tall-growing crops such as sorghum, maize, pearl millet, etc. are erosion permitting crops which expose the soil and induce the erosion process. Whereas, close growing or erosion resistant crops with dense canopy cover and vigorous root system viz. cowpea, green gram, black gram, groundnut, etc. are the most suitable crops for reducing soil erosion. To increase the crop canopy density, the seed rate should always be on the higher side.

Crop rotation: Crop rotation is the practice of growing different types of crops in succession on the same field to get benefits for soil and crop systems. Beneficial effects include lower incidence of weeds, insects, and plant diseases, as well as improvements of soil physical, chemical, and biological properties. Monocropping results in exhaustion of soil nutrients and deplete soil fertility. The inclusion of legume crops in crop rotation reduces soil erosion,

restores soil fertility, conserves soil and water and helps supplement atmospheric nitrogen to the soil. Further, the incorporation of crop residue improves organic matter content, soil health and reduces water requirement. A suitable rotation with high canopy cover crops helps in sustaining soil fertility, suppresses weed growth, decreases pests and disease infestation, increases input use efficiency and system productivity while reducing the soil erosion.

Intercropping/Mixed cropping: Cultivation of combination of different types of crops with different canopy and maturity time simultaneously. It reduces demand of a particular type of plant nutrients and increases availability of different types of crop produce on a regular basis to augment farmers income.

Intercropping: Cultivation of two or more crops simultaneously in the same field with definite or alternate row pattern is known as intercropping. It may be classified as row, strip, and relay intercropping as per the crops, soil type, topography and climatic conditions. Intercropping involves both time-based and spatial dimensions. Erosion permitting and resisting crops should be intercropped with each other. The crops should have different rooting patterns. Intercropping provides better coverage on the soil surface, reduces the direct impact of raindrops and protects soil from erosion.

Cover crops: The close-growing crops having high canopy density are grown for protection of soil against erosion, known as cover crops. Legume crops have better biomass to protect soil than row crops. The effectiveness of cover crops depends on crop geometry and development of canopy for interception of raindrops which helps in reducing the exposure of soil surface for erosion. The legumes provide better cover and better protection to land against runoff and soil loss as compared to cultivated fallow and sorghum crops. The most effective cover crops are cowpea, green gram, black gram, groundnut, etc.

Strip cropping: Growing alternate strips of erosion permitting and erosion resistant crops with a deep root system and high canopy density in the same field is known as strip cropping. This practice reduces the runoff velocity and checks erosion processes and nutrients loss from the field. The erosion resistant crops protects soil from beating action of raindrops, reduces runoff velocity and thereby increased time of concentration which results in a higher volume of soil moisture and increased crop production. Strip cropping is practised for controlling the run-off and erosion and thereby maintaining soil fertility. In natural farming our five layer model is an example of this type of cropping.

Agroforestry: Agroforestry indicates land use systems and technologies, in which woody perennials such as trees, shrubs, palms etc., are effectively combined on the same land-management unit as agricultural crops and/or animals, either in some form of spatial arrangement or in a temporal sequence. In agroforestry systems, there are ecological and economical interactions among different components.

Reduced Tillage: Excessive tillage is harmful to soil health in a number of ways. Tillage increases oxygen in the soil, stimulating microbial activity, and results in the decomposition of organic matter. Tillage also disrupts soil aggregates, exposing particles of organic matter that had been physically protected within aggregates to microbial consumption. Inversion tillage also reduces the soil coverage provided by crop residues, leaving soil more exposed to erosion.

Tillage can also disrupt the hyphal network of mycorrhizal fungi, which can lead to their decline over time. When not managed carefully, most inversion and non-inversion tillage methods compact the subsoil, creating a plow pan, which restricts root growth and access to water and nutrients in the subsoil. Excessive wheel and foot traffic can compact the surface soil, reducing macro porosity and impeding root growth.

Application of bio formulations through micro irrigation

Micro irrigation practices can be integrated under natural farming to reduce the labour cost and further increasing application efficiency. Ingredients for preparing natural inputs like cow dung and cow urine are collected in a tank situated within the gaushala. After automatic filtration, these are used for preparing natural farming inputs like jeevamrit and are applied to the crops through micro-irrigation without the involvement of human labour. A number of innovative farmers have designed and developed systems for flood and drip irrigation of Natural Farming Bio-formulations. These designs involve creation of filtration and percolation chambers for removing waste and particulate matter residue from the liquid formulations. Then with ingeniously designed pump and mixing systems, these are operable with minimum labour interventions.

Cropping Systems

7. CONVERSION FROM CONVENTIONAL FARMING TO NATURAL FARMING

The transition from conventional to Natural Farming requires numerous changes. One of the biggest changes is in the mindset of the farmer. Conventional approaches often involve the use of quick-fix remedies that unfortunately, rarely address the cause of the problem. Transitioning farmers generally spend too much time worrying about replacing synthetic inputs with inputs derived from naturally occurring sources. Natural Farming system relies on sound practices focused on preventive strategies. Since there are often few natural remedies available to natural farming producers for certain problems, prevention is the key element in natural farming. Here are a few steps which a farmer should follow when making the transition to natural farming.

Training and Awareness on Natural Farming

Natural Farming systems are knowledge based. New entrants and transitional producers must become familiar with sound and sustainable agricultural practices. Transitional producers should be prepared to read appropriate information, conduct their own trials and participate in training programmes, seminars, etc.

Visit to Nearby Demonstrations (Govt. KVK, SAU or Progressive/ Champion Farmers' Field) to gain practical knowledge the transitional farmers should be prepared to visit Natural Farming fields of nearby Krishi Vigyan Kendra, Agricultural universities or progressive natural farmers' field and collect all relevant information and photographs related to farm operation, yield, products, certification, processing information, etc.

Start with at least one acre or part of the field

Transitional producers should start Natural farming in at least one acre area or some part of their field and conduct their own trials based on trainings received and exposure visits. Successful natural farmers continuously try new and/ or innovative natural practices. Natural practices such as multiple cropping, cover cropping, intercropping and use of various soil and pest management bio inputs need to be evaluated regularly.

Start increasing the reliance on natural produce for self-consumption. Slowly expand to neighbourhood markets and distant markets. Although, the demand for natural products is continuously growing, ensure reliable market for the natural products while expanding the area under the natural farming.

Converting Whole Farm into Natural Farming

To convert whole farm, various steps to be taken should include realistic time frames. Farmers have to identify their strengths and weaknesses. All necessary tools to begin the transition, such as mechanical weeding equipments, composting equipments, additional handling equipments dedicated to the natural products and processing equipments should be procured.

Arrange Cow or Cattle for Natural Farming

Cow is the basis of natural farming. Dung and urine are essential for preparing bio formulants for maintaining the soil fertility and natural insect repellents. Procure cow or cattle, if not available on the farm. Also appropriate changes in the cow shed should be made for easy collection and storage of urine. Attend trainings on On-farm Input preparation based on dung, urine and green leaves.

Increase Crop diversity and add trees

Management of an appropriate habitat for sustenance of different life forms is an essential component of natural farming. This can be achieved by ensuring crop diversity and by maintaining a wide variety of trees and bushes as per climatic suitability. These trees and bushes will not only ensure the nutrients from air and deep soil layers to surface layer but also attract the birds and predators, friendly insects by providing them food and shelter. There may be some loss of productivity due to shading effect of the trees, but that loss can be compensated with reduced pest problems and reduced cost of cultivation. In a 10 acre farm in the plains, it is suggested to plant at least five to six neem trees (Azadirachta indica), one to two tamarind (Tamarindus indica) trees, two cluster fig (Ficus glumerata), eight to ten ber (Zizyphus Sp) bushes, one to two aonla (Emblica officinalis) trees, one to two drumstick trees and 10-15 wild bushes.

On the wet farms there should be five to six neem trees, one to two wood apples, one to two star fruit, eight to ten guava or soursop, three to four drumstick, one to two fig and 10-15 bushes of mulberry, star gooseberry, curry leaf etc. On the dry farms there must be at least five to six neem, one to two bel fruit, eight to ten ber or custard apple, one to two aonla, one to two drumstick and 10-15 bushes of Vitex negundo, Cassia auriculata etc.

In hilly areas, Alnus nepalensis is considered to be wonder tree as it fixes good amount of nitrogen. It is being promoted in a cropping system mode particularly in north-eastern India. Bushes of Prunus, oak (Quercus glauca), Pinus species along the farm boundary and yarrow (Achillea millifolium), buck wheat (Fagopyrum esculentum), lupin (Lupinus sativus),

Himalayan stinging nettle (Urtica parviflora), marigold, etc., in between the plots invite a lot of predators and attract a large number of pests.

Fruit orchards also need to maintain adequate diversity with at least 3-5 types of fruit plants and few non-fruit trees. Plot bunds (about 1.5m wide) should be planted with Glyricidia, perennial Sesbania (Sesbania grandiflora), Leucaena leucocephala, Cassia siamea, etc. The internal hedgerow should consist of perennial pigeon pea, Crotalaria, seasonal Sesbania, etc. Lops from these trees will provide enough quantity of biomass for various purposes.

In between Glyricidia/ Sesbania rows insert few plants of pesticidal value such as Adathoda vasaca, Vitax nigundo, Calotropis, Datura alba, Jatropha curcas, Ipomea (Besharam), etc. Surrounding the farm or garden, there should be hedgerows or a live fence of coppiced or pollarded, multipurpose, deep-rooted trees and shrubs and medicinal herbs. Ecological diversity is an essential component of any successful organic farming system.

Trees on utility space can be allowed to grow fully. Trees and bushes on farm bunds should be placed randomly at sufficient distance and pruned at repeated intervals. *Glyricidia* plants should be planted at close spacing on all major bunds and all around the farm. They will act not only as biological fence but also provide valuable biomass.

Crop Diversity and Crop Rotation

The objective should be to have the entire farm area covered by crops for as long as possible during the year. Mixed cropping is the outstanding feature of natural farming in which variety of crops are grown simultaneously or at different time on the same land. Mixed cropping increases photosynthesis. It avoids competition for nutrients because different crops draw their nutrients from different depths of the soil. The legume crops fix atmospheric nitrogen and make available for companion or succeeding crops. Deep rooted plants draw nutrient from deeper layer of soil and bring them to the surface of soil through their leaf fall. So, the nutrients leached down to lower strata are further brought back to upper layer by these deep-rooted plants. Farmers should select the crops combination according to their needs and season.

Companion crops should be selected carefully, for e.g., maize gets along well with beans and cucumber, tomatoes go well with onions and marigold. On the other hand, beans and onions do not grow well with each other.

Entire farm should have at least 8-10 types of crops at all the times. Each field/ plot should have at least 2-4 types of crops out of which one should be legume. In case if only one crop is taken in one plot, then adjacent plots should have different crops.

Crop rotation is the backbone of natural farming practices. To keep the soil healthy and to allow the natural microbial systems working crop rotation is must. Crop rotation is the succession of different crops cultivated on same land. Follow 3-4 years rotation plan. All high nutrient demanding crops should follow legume dominated crop combination. Rotation of pest host and non pest host crops help in controlling soil borne diseases and pest. It also helps in controlling weeds. Crop rotation is good for improving productivity and fertility of the soil. Crop rotations help in improving soil structure through different types of root system. Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also find place while planning the rotations. Some important benefits of crop rotations are:

- Soil structure is improved through different types of roots,
- Pest build up is avoided, and
- Rotations help against the build-up of weeds.

Preparation of Bio Inputs

If needed attend training programs on bio input preparations. Gain skill and expertise in preparation and use of bio inputs for soil fertility management and pest and disease management.

Seeds/ Planting Material Treatment

Use of disease-free seed stock is one of the best options in pest and disease. Farmers should be aware and use different methods for this purpose, such as:

- Hot water treatment at 53° C for 20-30 min.
- Cow urine or cow urine-termite mound soil paste.
- Beejamrut
- Asafoetida 250 gm in one lit. of water for 10 kg seed.
- Turmeric rhizome powder mixed with cow urine.
- Panchgavya extract

Soil Enrichment

During conversion period, soil fertility can be improved and maintained initially through use of natural inputs like well decomposed compost and green manure in appropriate quantities. Well- fed healthy soil rich in microflora and microfauna takes care of the crop nutrient requirement.

Lopping from Glyricidia and other plants grown on bunds, animal dung and urine and crop residue should form the major source for nutrients. Changing crop rotations and multiple crops ensure better utilization of resources.

Application of liquid manure (for soil enrichment) is essential to maintain the activity of microorganisms and other life forms in the soil. 3-4 applications of liquid manure is essential for all types of crops. Cow urine & Panchgavya are excellent growth promoters when used as foliar spray. 3-5 sprays after 25-30 days of sowing ensure good productivity.

Pest Management

As synthetic chemicals are prohibited, the pest management is done by cultural or agronomic, mechanical, biological or by naturally accepted botanical extracts. Get acquainted and trained in neem, urine based formulations, fermented butter milk, dashparni extract, mixed leaves extract, chilli-garlic extract, etc.

Follow Mulching and Moisture Conservation

A mulch is natural spread layer of plant residues or other materials on the surface of the soil. Natural mulches are from natural origin materials which can decompose naturally like agricultural wastes which are used as mulch such as grasses, weed plants, wheat or paddy straw, plant leaves and saw dust etc. It decays over time, and increases the water holding capacity of soil. It also provides the soil with nutrients as it breaks down. It also improves water use efficiency indirectly. A mulch layer restricts the weed growth by obstructing light penetration to the soil surface.

Increase biomass production for mulch material by incorporating trees, cover crops, green manure crops into crop rotation, etc.

Follow Good Agricultural Practices

Include the following good practices while starting and expanding the areas under natural farming:

- Crop rotation
- Cover Crops
- Multiple cropping
- Natural Methods for Disease and Pest Management
- Agroforestry Practices
- Soil preparation, sowing, manuring, irrigation, weeding, harvesting, and storage are the some more steps of good agriculture practices.

Post-Harvest Management

Post-harvest management is a system of handling, storing, and transporting agricultural commodities after harvest. During the post-harvest period, handlers and producers focus on preserving quality, quantity, and the safety of the commodities.

Material used for packaging should be eco-friendly. Unnecessary packaging material should be avoided. Recycling and reusable systems should be used. Packaging material should be biodegradable. Material used for packaging should not contaminate the food.

Products integrity should be maintained during storage and transportation of natural products. Natural products must be protected from co-mingling with non-natural products and must be protected all times from the materials and substances not permitted for use in natural farming. The farmers taking up natural farming should be aware and if need be get trained in these aspects.

Maintain Written and Photo Documentation

Record keeping is one of the most important requirements in natural farming. Farmers are expected to keep all detailed information and photographs regarding farm operation, yield, products and processing. Once the record keeping requirements are understood, the reporting procedure established, the paper work becomes regular. This will help in certification process documentation.

Steps for Farmers journey from Conventional to natural farming

1) Desire for conversion from chemical to natural farming is articulated by farmer after being sensitized through NF training program or awareness from various means. The farmer and their family thoroughly understand the NF principles as well as the do and don'ts. The economic benefits of NF vs conventional methods are to be fully understood as well the risks if the package is not applied completely and carefully.
2) Farmer individually or in group conducts self-assessment of existing practices and develop a short term action plan or what he/ she wants to do.
3) Identify Knowledge requirements and gaps and how to overcome the gaps and updation of knowledge.
4) Review of available tools and equipment's and requirements for NF including use of desi breed of animals.

5) Identification of potential resource persons (farmers, KVK scientists, line departments etc) as per the crops and associated requirements for pest and disease management.
6) Conduct soil health assessment including soil testing and plan for improving soil nutrients to have a baseline information, particularly for Organic Carbon.
7) Identify friends and neighbours who are practicing NF or interested to convert to NF. Regular interactions with such like-minded persons to share knowledge.
8) Establishes or modifies the farm including space and methods conducive for NF, e.g. cow shed, dung and urine collection, preparations of inputs for nutrient and pest management etc.
9) Conduct NF trials on crops, fruits and vegetables in first season in small area of upto one acre and observation of the learnings through continuous sharing with other farmers, scientists etc.
10) Failures and successes to be documented carefully of what went right or wrong during the first season. Plan for the next season in terms of expanding area and selection of crops.
11) If possible apply for certification individually or in a group.
12) After meeting the home needs, marketing of Natural Farming products to be done directly to friends and other nearby interested persons and encourage them to visit the farm. Apply concepts like FAMILY FARMER, Visit the natural farm to harvest the crops etc. in the short run. Gradually upscale as much as possible the marketing of the products directly to consumers.
13) Organise visits to farms of well performing NF and also invite them to your farm.
14) Over a period of two to three years (4 to 6 seasons) based on experience the entire land of the farmer can be converted to NF. The availability of Natural materials, labour, market experience etc and past experiences to be considered as part of the upscaling plan and course corrections made from time to time.

8. CROP DIVERSITY AND CROPPING SYSTEM

A system is defined as a set of components that are interrelated and interact among themselves. Cropping systems refer to the comprehensive integration of crops, crop rotations, and management strategies applied over time and space on specific agricultural lands and the interrelationships between them and environment. While the conventional focus was on maximizing output, Natural farming is increasingly oriented towards promoting environmentally sustainable cropping practices. Cropping systems in India are need based, subsistence and low yielding but sustainable. More than 250 cropping systems are adopted in India, but major contribution is from few cereal based systems such as rice-rice, rice-wheat, pearl millet-wheat and maize-wheat *etc*.Across the globe, diverse cropping systems are implemented, including multiple cropping, double cropping, triple cropping, relay cropping, ratoon cropping, and intercropping, each tailored to specific agroecological conditions and sustainable farming principles.

The term cropping system refers to the crops, crop sequences and management techniques used on a particular agricultural field over a period of years. It includes all spatial and temporal aspects of managing an agricultural system

- It involves either growing a single crop consistently on the same land each year or rotating different crops in a systematic pattern.
- The cropping system is location-specific and adapts to changes in environment and geography.
- The primary goal of any cropping system is to optimize the return on investment by effectively utilizing available resources, including solar energy, water, and land.
- The key components of a cropping system include management strategies, planting geometry, and seed genetics.
- It is a dynamic agricultural strategy that responds to local conditions and seeks to maximize productivity while ensuring sustainable resource management.
- Thoughtfully integrating crop varieties and rotations enhances agricultural resilience and maintains long-term land viability for future generations.
- Cropping systems are planned for better input use efficiency (water, nutrient and higher weed control). Cropping system being a dominant module in farming, need to be designed to peruse sustainable livelihood.

Crop intensification technique includes intercropping, relay cropping, sequential cropping, ratoon cropping, etc. All such systems come under the general term multiple cropping.

Need for intensive cropping

- Cropping systems has to be evolved based on climate, soil and water availability for efficient use of available natural resources.
- The increase in population has put pressure on land to increase productivity per unit area, unit time and for unit resource used.
- This cropping system should provide enough food for the family, fodder for cattle and generate sufficient cash income for domestic and cultivation expenses.
  - ✓ **Intensive cropping systems:** aims at maximum possible production on the limited farms with all efforts possible under the circumstances. It is capable of raising more than one crop a year and huge capital and human labour is employed on every hectare of land. It is practiced in most parts of densely populated areas.
  - ✓ **Extensive system:** Modern system of farming done on large farms also known as mechanical farming due to extensive use of machines, and mono-cropping. The employment of labour and capital per hectare of land is less

CROPPING SYSTEM - TYPES

1. Mono Cropping

Mono-cropping is the agricultural technique of producing a single crop year after year on the same ground without rotating through other crops or growing many crops on the same land. Widely produced crops that are frequently grown using mono-cropping methods include paddy, wheat, maize and soybean.

Mono-cropping has catastrophic impacts on the environment and it also raises the possibility of contracting infections and pests.

Example: Rice-Rice-Rice

2. Multiple Cropping:

Multiple cropping is a farming practice where two or more crops are grown simultaneously on the same piece of land in one calendar year with scientific methods of management. It includes intercropping, mixed cropping, and sequence cropping. Multiple cropping systems may be intensive, profit and oriented.

For example, cultivating maize and gram together on the same field as sequence relay and intercrop.

Multiple cropping systems can be sustainable and profitable with sound knowledge of crops and cropping patters. In India multiple cropping systems are more prevalent in various regions, especially on small farms, where farmers aim to produce food for household consumption with limited resources (drylands).

Advantages of multiple cropping systems:

- Increased Yields: Growing multiple crops together ensures efficient utilization of available resources, such as sunlight, water, and nutrients. This leads to increased overall crop yields compared to growing a single crop.
- Risk Diversification: Planting multiple crops provides a buffer against potential risks and crop failure. If one crop is affected by pests, diseases, or adverse weather conditions, the other crop(s) can still thrive, reducing the impact on the farmer's livelihood.
- Efficient Land Use: Multiple cropping optimizes land use by making the most of the growing season. Once one crop is harvested, another is already growing, maximizing productivity from the same plot of land.
- Improved Soil Health: Different crops have varying nutrient demands and root structures. Multiple cropping helps in maintaining soil fertility as various crops utilize and contribute different nutrients to the soil.
- Household Food Security: For small-scale farmers, multiple cropping ensures a diverse and steady supply of food for their households throughout the year, reducing the reliance on a single crop for sustenance.
- Income Generation: By diversifying their crops, farmers can spread the sales of produce throughout the year, allowing for a steady income stream and potentially capturing higher market prices.
- Sustainability: The practice of multiple cropping aligns with sustainable agricultural principles by promoting biodiversity and reducing the reliance on chemical inputs.

However, multiple cropping also comes with some challenges:

- Management Complexity: Cultivating multiple crops requires careful planning, monitoring, and management to optimize crop combinations and resource use.
- Pest and Disease Management: Growing different crops together may attract a broader range of pests and diseases, necessitating effective pest control strategies.
- Crop Selection: Farmers need to select compatible crops that complement each other in terms of growth rate, resource requirements, and market demand.

- Emerging problem of multi and micro nutrient deficiency and resource degradation.

2 a. Sequential Cropping:

Sequential cropping involves the practice of growing two or more crops in succession on the same field within a single growing season.

Once the previous crop is harvested, the subsequent crop is planted, making efficient use of the available growing time and resources. For example, in regions with prolonged and shorter rainy seasons, farmers may plant maize during the prolonged rains and pulses during the shorter rainy season, ensuring optimal utilization of the available water resources.

In some areas with extended wet seasons, it is possible to grow two major crops in succession or one main crop followed by a cover crop to enhance soil health and fertility. The feasibility of growing two crops in succession also depends on the presence of two distinct rainy seasons or sufficient moisture in the soil to support the growth of both crops.

Sequential cropping focuses on maximizing crop intensification solely in the spatial dimension. There is no competition between crops, and farmers manage one crop at a time in the field.

Double, triple and quadruple cropping: Growing two, three and four crops, respectively, on the same land in a year in sequence.

Ex. **Double cropping:** Rice: cotton, Rice - wheat, maize - wheat, soybean - potato

Triple cropping: Rice: rice: pulses;

Quadruple cropping: Tomato: ridge gourd: Amaranthus greens: baby corn

Majority of cropping systems in India were sequential cropping systems.

Benefits of Sequential Cropping:

- Optimal Resource Utilization: Sequential cropping enables farmers to efficiently use available resources, such as water, nutrients, and sunlight, by ensuring continuous crop growth throughout the growing season.
- Efficient weed control: Weeds in the agriculture cause nearly 35-40% of crop loss, especially at initial stages of crop. Relay cropping supresses the weed population thus increasing advantage of growth to second crop.
- Improved Soil Health: Planting different crops in succession can help improve soil health as each crop contributes different nutrients and organic matter to the soil.

- Risk Diversification: By growing multiple crops in succession, farmers can reduce the risk of complete crop failure. If one crop is affected by pests or adverse weather, the subsequent crop may still succeed.
- Enhanced Crop Productivity: Sequential cropping can lead to higher overall crop productivity as the land is productively utilized throughout the growing season.
- Sustainable Farming: By maximizing crop intensification without intercrop competition, sequential cropping promotes sustainable agricultural practices.

Challenges of Sequential Cropping:

- Labour and Management: Managing successive crops may require more labor and attention to ensure timely planting, irrigation, and harvesting.
- Crop Selection: Careful selection of crop combinations is essential to ensure that subsequent crops are well-suited to the local climate and growing conditions.

2 b. Relay Cropping:

Relay cropping is a unique farming practice where a second crop is planted before the previous one has been harvested, allowing both crops to share a portion of the growing season.

Examples of relay cropping include planting rice (or wheat) alongside Black gram, onions, lady's fingers and maize simultaneously. Short duration pulses such as lathyrus, lentil, pea, cowpea (non-viny) in rice and maize in IGP of India. Green manuring crops and fodder as second crop may be a best addition in relay cropping improving both soil fertility and productivity.

This approach reduces risks associated with relying solely on a single crop, as farmers can simultaneously grow multiple crops in the same field.

Benefits of Relay Cropping:

- **Risk Reduction**: By cultivating multiple crops at the same time, relay cropping provides a safety net against potential losses due to crop failure or adverse weather conditions. If one crop faces challenges, the other may still thrive, safeguarding the farmer's overall harvest.
- **Insect Control**: The distribution of crops in relay cropping can help control the spread of pests and diseases. Insects that prefer one crop may be deterred or disrupted by the presence of a different crop, reducing their impact on the entire planting.
- **Improved Labor Efficiency**: Relay cropping optimizes labor distribution as farmers can efficiently manage multiple crops concurrently. This approach ensures better utilization of labor throughout the growing season.

- **Soil Nutrient Enhancement**: Certain relay cropping combinations, especially those involving legumes like peas or beans, contribute nitrogen to the soil through nitrogen fixation. This natural nitrogen enrichment benefits subsequent crops, promoting soil health and fertility.

Relay hopping enhances the efficient use resources, saves money and time, utilises residual moisture and fertility, and reduces the exposure of soil to erosion.

Challenges of Relay Cropping:

- **Crop Selection**: Selecting compatible crops that can coexist harmoniously in the same field is critical for successful relay cropping. Some crops may compete excessively for resources, leading to reduced yields. Example: viny cowpea in maize reduces the maize yield by lodging.
- **Management Complexity**: Managing multiple crops with different growth rates and requirements can be more challenging and require careful planning and attention. Possibilities of negative interactions between component crops, allelopathy etc,.
- **Timing**: Proper timing is essential in relay cropping to ensure that one crop is ready for harvest before the other requires the full use of the field. Poor timing may lead to resource competition and reduced yields.

2 c. Ratoon Cropping

Ratooning is a form of sequence cropping, an ancient technique of crop raising based on the principle of natural propagation and farming. Ratoon cropping is a method of farming in which the remnants of one crop that has previously been harvested are used to cultivate a second crop. As new plants emerge from the harvested crop's stubble, the practice is also known as "stubble cropping." Ratooning saves 90% of seeds, fuel, labour and time besides reducing the greenhouse gas emission.

As production and quality decline after each cycle, ratooning cannot be employed indefinitely. For instance, it is possible for sugarcane to have two or three ratooning crops before new planting is required.

Ex. Sugarcane: ratoon; Sorghum: ratoon (for fodder).

2 d. Intercropping

Intercropping is a method of increasing agricultural productivity by planting two or more crops simultaneously on a specific plot of land in a specific row pattern. Intercropping is typical character of Indian traditional agriculture. The most common goal of intercropping is to increase yield on a given plot of land by utilising resources that would otherwise go unused

by a single crop. It's primarily growing of two dissimilar nature crops (plant architecture, rooting, life cycle, water and nutrient use pattern) Intercropping is both space and time utilising strategies in the cropping system, especially in rainfed environments where soil moisture and soil fertility is a major concern.

Intercropping has a specific row pattern, such as 1:1 or 1:2, which means that the primary crop is in the first row and the other crops are in the second or third row. These crops are blended in this technique despite having different nutrient needs. It guarantees the best possible use of the nutrients given. Inter cropping allows the crops to grow naturally with positive beneficial interactions between them, enhancing natural cycles of nutrient and soil hydrology. Additionally, it stops pests and diseases from spreading to every plant involved in a particular crop.

Ex: Maize+ green gram (1:1), Maize + black gram (1:1), Groundnut + Rred gram (6:1)

Principles of Intercropping

- Crops grown in tandem should have complementary rather than competitive effects.
- The subsidiary crop should be of shorter duration and faster-growing habits to take advantage of the main crop's early slow-growing period, and it should be harvested when the main crop begins to grow.
- Agronomic practices for the component crops should be similar.
- Erect growing crops should be intercropped with cover crops such as pulses to reduce or control soil erosion and weed population. This also aids in reducing water evaporation from the soil's surface.
- The root depths of the component crops should be different so that they do not compete for nutrients, water, and root respiration.
- A standard plant population of the main crop should be maintained, whereas the plant population of subsidiary crops can be increased or decreased depending on the situation.
- Component crops infested with similar pest and disease pathogens and parasites should not be chosen.
- The planting method and management should be simple, less time-consuming, less cumbersome, economical, and profitable in order to be widely adopted.

Intercropping - Prerequisites

- Each crop needs enough space when two or more are growing together in order to increase cooperation and reduce competition.

- Although there may be some variation in the amount of temporal and spatial overlap between the two crops, both conditions must be satisfied for a cropping system to be considered an intercrop.
- Therefore, four factors must be taken into account:
- Spatial Arrangement: The appropriate spatial arrangement maximizes the complementarity between the component crops and improves the physiological effects of the intercropping system in a particular environment.
- However, in order for an intercropping arrangement to be favorable and be used by the farmer, it must meet several criteria.
- Density: Each crop in the mixture has its seeding rate reduced from its maximum rate in order to maximize plant density.
- Both crops wouldn't produce well if planted at full rates due to severe crowding.
- The crops will have a better chance of producing well within the mixture by having lower seeding rates for each.
- Maturity Dates: Intercrops with varied maturity dates or development phases are planted to take advantage of fluctuations in peak nutrient, water, and sunlight requirements.
- The competition between two crops is reduced when one crop matures before the other. Crops having various maturation dates can also help separate and delay the harvesting of grain commodities.
- Plant Architecture: Plant architecture is the practice of allowing one crop to receive sunlight that the other crops in the mix would not otherwise receive.
- A classic illustration would be a canopy of widely spaced corn plants growing over a ground cover of beans and pumpkins.

Cropping System - Factors to Consider for Crop Choice:

- **Profitability**: One of the central considerations in any cropping system is the potential profitability of a crop. Farmers must assess market demand, pricing trends, and production costs to determine which crops offer the best economic returns. Successful intercropping gives higher equivalent yields (yield of base crop + yield of intercrop), higher cropping intensity
- **Adaptability**: The adaptability of a crop to changing environmental conditions is crucial. Climate variability, soil types, and water availability can fluctuate, and selecting crops

that can withstand such changes is essential for a sustainable and resilient cropping system.

- **Disease Resistance**: Crop choice must take into account the crop's susceptibility to prevalent diseases in the region. Opting for disease-resistant varieties can reduce the risk of yield losses and minimize the need for costly pesticide applications.
- **Technology Requirements**: Some crops may require specific technologies for successful growth, harvesting, and post-harvest handling. Farmers need to consider the availability and affordability of these technologies when deciding whether to incorporate a particular crop into their system.
- **Environmental Conditions**: The current environmental conditions on the farm, including temperature, rainfall, and growing season, play a critical role in crop selection. Crops that are well-suited to the local environment are more likely to thrive and produce higher yields. Improvement of soil health and agro-eco system
- **Integration with Production System**: Crop choice should be in harmony with other components of the production system, such as livestock integration, crop rotations, and agroforestry practices. An integrated approach can enhance resource utilization and ecological sustainability.
- **Crop Diversity**: Promoting crop diversity is essential for reducing risks associated with market fluctuations, climate uncertainties, and pest outbreaks. Diversifying the crop portfolio can spread risk and provide greater resilience to the overall cropping system.
- **Market Demand**: Understanding market demand and consumer preferences is vital in determining the viability of a crop. Farmers should align their crop choices with market trends and explore niche markets for specialty crops with higher value.
- **Input Availability**: The availability of seeds, manures and other inputs should be considered when selecting crops. A crop that requires inputs in short supply or with limited accessibility may not be a practical choice.
- **Government Policies and Incentives**: Farmers should be aware of government policies, subsidies, and incentives related to specific crops. Supportive policies can influence crop choices and provide additional benefits for farmers.
- **Yield stability:** even if one crop fails due to unforeseen situations, another crop will yield and gives income.

Planting a deep-rooted crop with a shallow-rooted crop, or a tall crop with a shorter crop that requires partial shade, are examples of intercropping strategies. There are numerous

types of intercropping, all of which vary the temporal and spatial mixture to some extent: mixed intercropping, row inter-cropping, and relay cropping, and so on.

Intercropping - Types

Intercropping is defined by a specific arrangement of plants that serve as the foundation for its classification. Intercropping types include row, strip, parallel, synergistic, relay, multi-storey, alley, etc.

Strip Intercropping

- The term "strip cropping" refers to the practice of cropping different cultures in strips.
- To prevent soil erosion, it is a common practice on sloped terrain.
- Strip cropping in agriculture also applies to even terrains.
- The strips are sufficiently narrow to generate agronomic interactions between neighbouring crops.
- Strip width is therefore essential to the design and operation of this cropping pattern. The strips are frequently changed from year to year.
- Basically, strip cropping agriculture is utilized to either enhance the growth of primary species or improve soil health.
- Examples: Maize/pearl millet+ green gram/cowpea in alternate stripe reduce the soil erosion. Groundnut + redgram (6:4) strip.

Parallel Cropping

- Parallel cropping is the practice of growing crops that have different natural behaviours but no competition.
- An example of parallel cropping is wheat and mustard. After planting wheat, farmers typically broadcast mustard in the same field. Maize + Green gram, Maize +ground nut, Sugarcane +soybean/any short pulse
- It makes greater use of resources like light, nutrients, and moisture.
- The productivity of the system is hampered by inefficient moisture usage and competition between the various root systems of the crops cultivated together.

Synergistic Cropping

- Synergistic cropping is when two crops are grown on a unit area at the same time and produce more as a whole than they would if they were grown separately on a unit area basis.

- This technique is based on agronomic approaches primarily targeted at improving soil fertility.
- As a result, the overall health of the soil-microorganism-plant system is focused, rather than on production alone.

Multi-storey Cropping

- Multi Storey Cropping is the process of cultivation of more than two crops at once on the same plot of land with varying heights.
- Examples: coconut, pepper, cocoa, and pineapple.
- The crops are cultivated together on the land, utilising land, water, and space in the most effective and inexpensive ways possible.
- Plantings having an over story of trees or shrubs and an understory of specialised or agronomic crops or pastures are referred to as multi-story crops.
- There is enough space between trees to allow forage or crops in the understory to receive enough sunlight.
- Multi Storey cropping is sometimes known as "Forest Farming."
- Native forest tree canopies would be controlled to permit the cultivation of such crops or forage.

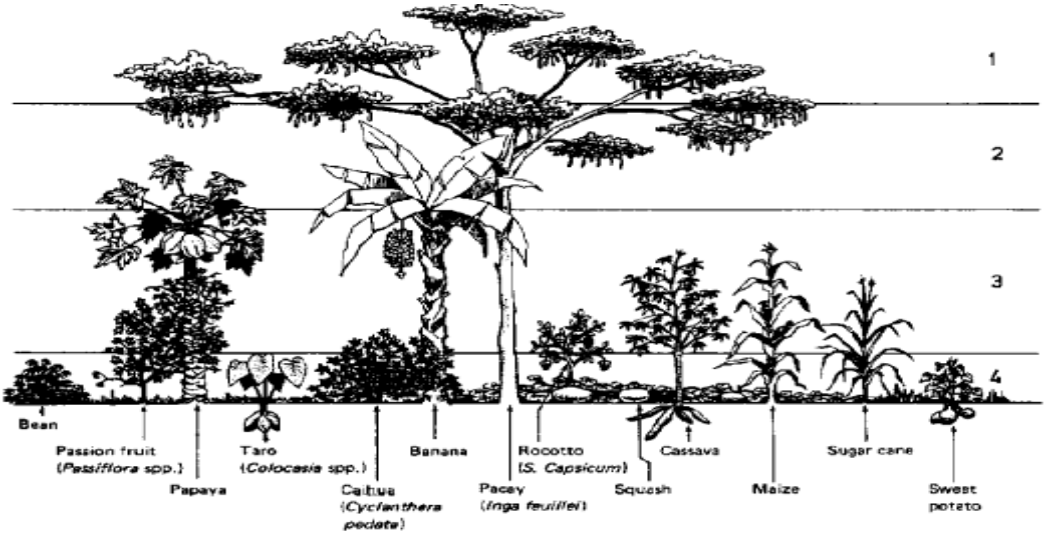


Fig.1 Schematic view of multi-storied cropping system

Relay Intercropping

- Relay cropping is a type of cropping arrangement in which one crop is seeded into a standing second crop well before the second crop is harvested.

- Growing Rice-Cauliflower-Onion-Summer gourds is an example for relay intercropping.
- Relay cropping has the potential to resolve a number of conflicts, including inefficient use of available resources, disagreements over sowing time, Fertilizer application, and soil degradation.
- Relay cropping is a complex set of resource-efficient technologies capable of improving soil quality, increasing net return, increasing land equivalent ratio, and controlling weed and pest infestation.
- Relay planting has less risk because it does not require relying just on one crop.
- Relay cropping is also known as overlapping cropping.

Alley Cropping

- Alley cropping is one of several practices that deal with trees and crops growing on the same plot of land.
- Alley cropping is a method of growing trees or shrubs and agricultural crops in alternate rows.
- Trees are frequently pruned to reduce the shading of agricultural crops. Alley cropping can help with nutrient cycling and erosion control as well.
- Alley cropping can thus be regarded as re-creating a savanna's structure in an agroforestry system with many canopy layers, including an overstory of nut trees, a mid-layer of fruiting small trees and shrubs, and a groundcover of annual crops or perennial grass groundcover.

Row Intercropping

- Growing two or more crops simultaneously during the part of the life cycle of each. A second crop is planted after the first crop has reached its reproductive stage of growth, but, before it is ready for harvest
- Plants are arranged in rows in this case, as the name suggests. Cereals and legumes such as corn and beans are a common and beneficial combination.
- Row ratios can range from single to multiple rows.
- Row cropping provides additional nitrogen fixation by legumes in symbiosis with bacteria of the Rhizobium genus.
- Ex: Rice- rice fallow pulse

Temporal Intercropping

- The combined plants in this intercropping method require different maturing times.
- When the fast-growing plant is harvested, the slow-growing plant is given more room to grow.

Mixed Intercropping

- The practice of intercropping entails sowing different species (two or more) in the same terrain with no distinct arrangement in rows or in the same rows.
- In this case, the sowing and harvesting seasons coincide.
- Mixed cropping protects the primary culture from winds, frosts, droughts, and other extreme weather conditions.
- Ex: Sorghum, pearl millet and cowpea are mixed and broadcasted in rainfed and natural farming conditions.

Trap Cropping

- The intercropping technique, as the name implies, aids in pest trapping to protect the main culture. Among the most common trapping plants are mustard and marigold.
- The basic concept is to attract insects or fungi to the sacrificial secondary crops, protecting the cash crop.
- Blue Hubbard squash is said to be effective against squash bugs, squash vine borers, and spotted and striped cucumber beetles.
- Trap intercropping allows for pesticide savings by requiring no or only partial chemical application to trapping areas.

Border Cropping

- Border crops are thorny or tough plants that grow around cash crops or along field edges.
- Border crops are used as barriers to keep the main species safe from winds and invasions.
- As a result, sorghum is grown next to cotton and safflower next to chickpea.

Repellent Intercropping

- Farmers use pest-repellent plants as a sustainable pest-management technique when using this intercropping method.
- It is based on the repellent effect of specific species, which protects the cash crop.

- The repellent keeps insects away from their host plant, as in the case of planting leeks to keep bean flies away from beans.

Push-Pull Cropping

- For the sake of the cash crop, the intercropping practice combines both trap and repellent plants.
- While trap species attract (or pull) pests, repellent species repel them. Growing Napier grass (to pull) and Desmodium legume (to push) to protect corn from stem boring corn larvae is an example of this technique.

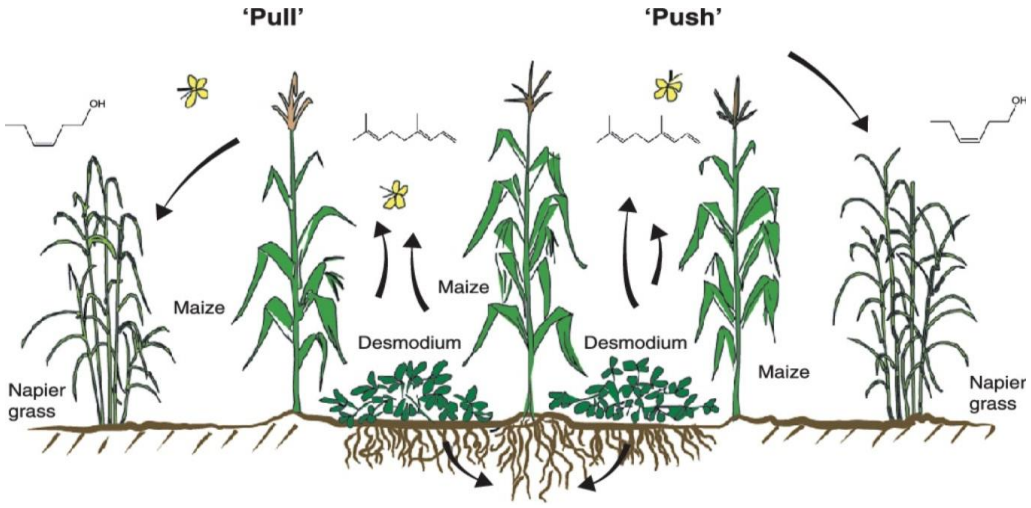


Fig.2 Principle of push-pull in cropping system

Intercropping - Advantages

- **Increased Profit:** Even when the first crop is unsuccessful, secondary crops offer higher yields and guarantee profit.
- **Ergonomic Usage of Land:** Contrary to monocropping, when gaps between rows are left empty, planting species in between rows allows for a more efficient use of the soil.
- **Protection of the Cash Crop:** Intercropping serves a variety of purposes, including warding off or trapping pests, luring in beneficial insects, and providing shade from excessive sunlight or wind. Pest management lowers the number of chemicals used, saving money.
- **Prevention of Soil Erosion and Crust:** Particularly, the roots of plants in alley intercropping and between rows reduce erosion.
- **Added Nutrients for the Main Crop:** Because the leguminous family is recognized for fixing nitrogen, it supplies nitrogen to the nearby species.

- **Reduced Need for Fertilizers:** Intercropping cultures reduce the need to use synthetic fertilizers by improving soil fertility.
- **Efficient Use of Natural Resources:** More efficient use of natural resources like water and solar energy as they are distributed to secondary crops as well.
- I**mproved Weed Management:** In intercropping, beneficial plants rather than weeds fill the empty spaces between the rows.
- **Enhanced Biodiversity and Ecological Stability:** The environment benefits from the increased growth of agricultural species.

Intercropping - Limitations

- **Unsuitable for Mechanized Farming**: Intercropping is not always suitable for a mechanized agricultural system.
- **Time-consuming**: It calls for more focus and, as a result, more intensive, skilled management.
- **Labour Expenses**: Planting, weeding, and harvesting are less efficient, which may increase labor expenses for these tasks.
- **Requires Effective Planning**: Effective planning is crucial and includes things like careful cultivar selection, appropriate spacing, etc.
- **No Effective Reuse**: A larger amount of fertilizer or irrigation water cannot be used effectively since the component crops respond differently to these inputs.

Differences between Intercropping and Mixed Cropping

Mixed Cropping	Intercropping
When two or even more crops are planted and grown simultaneously on the same piece of land, the practice is known as mixed cropping.	Contrarily, intercropping is a type of growing crop in which two different product types are grown and farmed on the same piece of land in a specific pattern.
The objective of mixed cropping is to reduce the possibility of crop failure.	The objective of intercropping is to boost the crop's production.
When mixed cropping is employed, the seeds are properly mixed and assimilated into the soil.	Contrarily, intercropping doesn't require any pre-seeding mixing.

In mixed cropping, the seeds are not sown in sequence.	In the case of intercropping, seeds are sown in several rows in a precise sequence.
In mixed cropping, crops compete with one another.	Contrarily, in intercropping, there is no competition between the crops.
Every crop has a similar life cycle and maturation period.	The length of the maturation period and the life cycle of each crop vary greatly.
In mixed cropping, the entire lot receives the same application of fertilizer, pesticide, and insecticide.	Contrarily, intercropping uses different insecticides and fertilizers for every harvest.

Natural farming is combination of both mixed and intercropping systems, primarily aims at sustainable production with ecological principles.

Cropping patterns in natural farming can be tailored to optimize the principles of minimal intervention, biodiversity, and ecological harmony. Here's how cropping patterns can be approached in natural farming while considering these two methods of planting:

1. **Line Sowing:**

   Line sowing involves planting seeds in straight rows or lines. This method provides more organized spacing between plants and allows for easier management.

2. **Broad casting:**

   Broadcasting involves scattering seeds across a planting area without specific arrangement. This method mimics natural seed dispersal and is suited for more densely planted crops.

What Is Crop Diversification?

Addition of other crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value- added crops with complementary marketing opportunities.

Why is it important? particularly at present times

Lowering your risk by diversifying the crops and productions systems like poultry, goatery, piggery, dairy etc.; also acts as an insurance.

Cropping System: Cropping pattern used on a farm and their interactions with farm resources, other farm enterprises and available technology which determines their makeup.

Cropping Pattern: Yearly sequence and special arrangement of crops and fallows in area

- Mono cropping
- Multi cropping: (Eg: Inter Cropping, Mixed Cropping)

Diverse farming systems are a set of methods and tools developed to produce food sustainability by leveraging ecological diversity at plot, field and landscape scales. It basically depends on diverse cultural practices and governance structures to support the locally adapted management system by supporting the integration of nature, human ecologies and environment. Diverse cropping systems allow critical ecosystem services like pollination and pest control to be generated and regenerated within the agro ecosystem.

Around 583 crops are cultivated in India and around 500 species of ethnic uncultivated greens which are simply collected and consumed. Diversified crop system is successful when agro-ecological principles are synergies in agroforestry. It is not that diverse cropping system is a recent concept in India. Several indigenous cropping systems are available to India which is given in below table. Most of these cropping systems are location specific and row sowing is done and vegetables are mostly cultivated for family consumption.

Sl.No	**Indigenous Cropping System**	**Place**	**State**
1	Hangadi Kheti	Udaipur	Rajasthan
2	Rammol	Kachchh	Gujrat
3	Kurwa	Rajmahal Plateau	Jharkhand
4	Olya/Chat	Dewas	Madhya Pradesh
5	Sat-Gajara	Hoshangabad	Madhya Pradesh
6	Misa Chasa	Koraput	Odisha
7	Baradhanya	Pune	Maharashtra
8	Pata	Wardha	Maharashtra
9	Navadhanya	Anantapur	Andhra Pradesh
10	Akkadi Salu	Raichur And Kolar	Karnataka

11	Poonam Kuthu	Wayanad	Kerala
12	Puradiyakrishi	Idukki	Kerala
13	Punam Krishi	Idukki	Kerala

Why Diverse Cropping System

- It requires one time sowing when there is monsoon and due to different maturity time of each crop gives multiple harvest. The crop harvest starts from September- October and continues up to February.
- The soil is covered with crop till February. So it is not exposed to sun for 9 to 10 months. There is heavy leaf litter leading to improving soil quality over time by retaining moisture and maintaining soil temperature.
- Crops are designed in a multi-tiered canopy to harvest the maximum sunshine for each crop.
- Monsoon rainfall is not used in single rain fed crops but in multiple crops.
- Since, no chemical is used there is frequent, and high population visitors of pollinators.
- In this type of cropping system we take care of all the three aspects of soils: soil chemistry, soil physics and soil biology.
- Diverse cropping system helps in maintaining bulk density, porosity, infiltration rate, moisture holding capacity, aeration, erosion, and surface runoff, hence, improves physical property of soil.

What is Navadhanya Cropping Systems?

> It is an intercropping system in dryland agriculture. It has evolved to sustain crops in erratic rainfall, trapping erratic rainfall and utilising 100% to crops. The farmers used the system as the net of erratic rainfall in drought prone areas for protecting at least 2/3rd of the crops in their fields. Source: http://www.ecosecretz.com/2017/09/navadh anya-cropping-system.html

Main Crop: Groundnut/ Millets/ Sunflower Etc. Harvested In <100 Days (3 Months).

1st Intercrop Row: Harvested In 4 Months.

2nd Intercrop Row: Harvested In 6 Months.

Border Crop: Millets on border rows.

Limited Crops: Mixed within the rows along with the first 3 -- small proportions – a diverse array of crops for self-consumption or sale.

Additional Crops: Leafy vegetables, vegetables and others – very small niches mainly for household consumption.

9. AGROFORESTRY

Agroforestry is not a new concept. Agroforestry is an age-old agricultural system as the process of human evolution has been from forests when man learnt the art of domesticating plant and animals after leaving the hunting and gathering habit. Agroforestry is sustainable land-use system that maintains or enhances overall yields by integrating food crops (annuals) with tree crops (perennials) and/or livestock on the same unit of land, either alternately or at the same time, using management practices that suit the social and cultural characteristics of the local people and the economic and ecological conditions of the area. Communities for generations have been cultivating varieties of crops and plants, mostly for domestic use. To this day, the communities that grow their food which includes crops, vegetables, fruits, pulses, and other crops, are ensuring the nutrition security of the family and the local community. Agroforestry in its different forms has been found worldwide in different agro-climatic zones ensuring better management and resource utilisation. The system, coupled with natural farming practices, generates substantial income for the farmers while regenerating the degraded soil and channelizing restoration of natural resources.

Agroforestry, a method combining food and wood production while preserving ecosystems, gained attention as a land-use approach. Research in this field intensified with the establishment of the International Centre for Research in Agroforestry (ICRAF) in 1977, spurred by a study led by John Bene. This study coined the term "agroforestry" and emphasized trees' crucial role on farms. Agroforestry research has a history spanning over a century. Prior to the 1980s, agroforestry research was conducted under different names such as silvi-pasture, agri-horticulture, and fuel-fodder plantation, specifically targeting degraded lands. Recognizing the potential of agroforestry, Indian Council of Agricultural Research (ICAR) took notice and initiated the All India Coordinated Research Project (AICRP) on Agroforestry in 1983. Later, in 1988, the National Research Centre for Agroforestry was established at Jhansi, mandated to drive agroforestry research and development across the country. Presently, the AICRP on Agroforestry operates through 37 centers situated in diverse agro climates across India.

Agroforestry is complex, integrated, and interactive woody perennial with agricultural crops, livestock and or fodder in same land management unit, promoting efficient utilization of resources than mono-cropping by structural and functional diversification of components. This integration of trees provides various soil-related ecological services such as fertility enhancement, improvement in soil biological, physical and chemical properties along with

food, wood and fodder (Fig 1). Currently, agroforestry fulfils nearly 50% of the nation's demand for fuelwood, approximately two-thirds of the requirement for small timber, 70-80% of plywood needs, 60% of the raw materials necessary for paper pulp, and caters to about 9-11% of the green fodder essential for livestock. Furthermore, it plays a vital role in meeting the daily needs of households, encompassing food, fruit, fiber, medicine, and more.

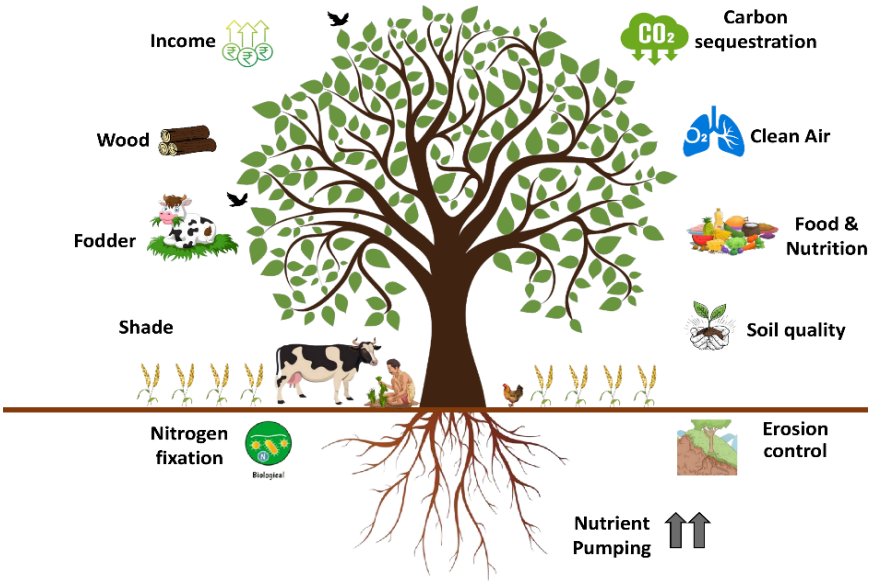


Fig. 2 Concept & multiple benefits of Agroforestry (Source: Dr AR Uthappa, Scientist)

Agroforestry, integrated within natural farming practices, serves as a transformative ally in addressing several critical challenges faced by farmers. While natural farming often encounters productivity constraints compared to conventional methods, agroforestry emerges as a promising solution to bridge this yield gap without compromising sustainability. By harmonizing diverse plant species and optimizing resource utilization, agroforestry systems unlock heightened productivity per hectare compared to monocultures. This approach capitalizes on complementarity between trees, crops, and livestock, leveraging resources that would otherwise remain underutilized. Notably, in regions where natural farming traditionally underperforms, such as in developed countries, agroforestry introduces a dynamic shift by enhancing productivity while fostering environmental conservation. The amalgamation of trees within organic farming diversifies products, fortifies resilience against climatic fluctuations, bolsters farm income, and reinforces soil health by reducing erosion, nutrient leaching, and enhancing carbon sequestration. Moreover, the symbiotic relationship between trees and crops within agroforestry augments biodiversity, offering pest control benefits that align seamlessly with organic pest management principles, thereby reducing reliance on synthetic pesticides. This holistic integration promises a potent combination, where natural farming and

agroforestry synergize to not only elevate productivity but also cultivate sustainability and resilience across agricultural landscapes.

Relationships of Agroforestry and Natural Farming

Agroforestry stands as a time-honoured agricultural practice deeply intertwined with the essence of natural farming. Its fundamental premise involves integrating trees within farm landscapes to harness a myriad of benefits, including mulching, nitrogen fixation, nutrient-rich leaf litter, and microclimate regulation. Across diverse regions like Rajasthan's *Prosopis cineraria*, the Eastern Himalayas' large cardamom systems, or Central India's *Acacia nilotica* setups, agroforestry delivers a suite of ecosystem services - from food and fodder to shade, shelter, and soil fertility enhancements.

Natural farming, on a parallel trajectory, centers on bolstering soil health, optimizing organic matter, and enriching biological activity. In striking similarity, agroforestry echoes these principles by accommodating perennial trees alongside crops and livestock. This harmonious integration reaps rewards that extend beyond the capabilities of conventional agriculture, ensuring provisions of fruits, fodder, fertilizers, and fibers while facilitating microclimate moderation and bolstering soil resilience during extreme weather events.

The compelling example of Prosopis cineraria-based agroforestry in arid Western India reflects substantial crop yield increments of 12-15% under tree canopies compared to open conditions. Many studies by researchers underscore the agricultural advantages, revealing a notable 18-20% increase in grain yield of annual crops within the Prosopis cineraria agroforestry context. Additionally, agroforestry's conservational ethos shines through in research highlighting its role in nutrient cycling, erosion reduction, soil moisture conservation, and pest control.

Diversification, a core tenet of agroforestry, not only fortifies farming resilience against erratic weather patterns but also presents a gateway to amplifying farmers' incomes. Moreover, in a country like India, heavily reliant on imported wood products, the implementation of a National Agroforestry Policy could markedly enhance tree cover, allay concerns regarding tree product regulations, and open avenues for intercropping high-value crops. Economic analyses affirm the profitability of diverse agroforestry systems across varied agroclimatic regions, reflecting internal rates of return and benefit-cost ratios that underscore its economic viability and potential for sustainable growth. Agroforestry and natural farming share a complementary relationship, both embodying sustainable agricultural practices that harmonize with natural ecosystems. Natural farming emphasizes minimal intervention, organic techniques, and a holistic approach to cultivation, mirroring the principles echoed in agroforestry.

- **Ecosystem Harmony:** Both agroforestry and natural farming prioritize working in harmony with the environment. Agroforestry integrates trees with crops and livestock, creating diverse, interconnected systems that mimic natural ecosystems. Natural farming emphasizes using natural inputs, reducing reliance on external resources, and fostering self-sustaining ecosystems.
- **Biodiversity and Soil Health:** Agroforestry systems foster biodiversity by incorporating a mix of trees, crops, and sometimes animals. Similarly, natural farming focuses on enhancing soil health and biodiversity by avoiding synthetic chemicals, favoring compost, mulching, and crop rotation. Both practices emphasize preserving and enhancing soil fertility through natural means.
- **Sustainability and Resilience**: Both methods promote sustainability by reducing reliance on external inputs like synthetic fertilizers and pesticides. Agroforestry's diversified systems and natural farming's emphasis on biological cycles and soil health contribute to more resilient agricultural systems capable of withstanding environmental challenges.
- **Holistic Approach:** Natural farming often incorporates agroforestry elements by integrating trees into cropping systems or creating mixed plantations. This integration complements the principles of natural farming, emphasizing the synergy between different plant species, leading to improved productivity and ecosystem health.
- **Environmental Benefits:** Agroforestry and natural farming contribute positively to environmental conservation. Agroforestry reduces deforestation pressures by providing alternative wood sources, while natural farming reduces chemical runoff, protecting water sources and preserving biodiversity.

Meaning of Agroforestry

Simple language agroforestry is defined as planting of woody trees with agricultural crops. Many definitions of agroforestry are exist. Agroforestry is defined as a land use system which integrate trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. It is a dynamic, ecologically based, natural resource management system that, through integration of woody perennials on farms and in the agricultural landscape, diversifies and sustains production and builds social institutions. Agroforestry is a collective name for a land-use system and technology whereby woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence. In an agroforestry system, there are both ecological and economical interactions between the various components.

Agroforestry systems encompass both traditional and modern farming approaches where trees are intentionally integrated with crops and/or animal farming in agricultural landscapes. These systems operate in various conditions—both irrigated and rain-fed—and yield a diverse range of products like food, fuel, animal feed, timber, natural fertilizers, and fiber. They play a vital role in ensuring food security, nutrition, and ecological stability while supporting livelihoods, reducing poverty, and fostering resilient farming environments. Moreover, agroforestry offers numerous ecosystem benefits by storing carbon, preventing deforestation, preserving biodiversity, and conserving soil and water resources (Fig 1). When strategically implemented at a larger scale with a thoughtful mix of tree species, agroforestry helps agricultural lands withstand harsh weather conditions like floods, droughts, and the impacts of climate change.

Furthermore, agroforestry holds significant potential for creating employment opportunities, benefiting both rural and urban populations through various production, industrial, and value addition ventures. Presently, approximately 65% of the country's timber demand is met by trees grown on farms, showcasing the economic significance of agroforestry in generating employment and meeting resource needs.

Types of Agroforestry

The major Agroforestry systems are mentioned below:

- Agri-silviculture: Cultivating both forest trees and agricultural crops simultaneously or alternately on the same land.
- Silvi-pasture system: Managing trees for wood and fodder alongside raising domestic animals.
- Agri-silvi-pasture system: Combining both agri-silviculture and silvi-pasture approaches.
- Multipurpose forestry production system: Forests managed to yield diverse products like fruits, leaves, honey, and medicines, particularly suitable for hill tribes.
- Homegraden: Home gardens, prevalent in high rainfall areas of tropical South and Southeast Asia like Kerala and Tamil Nadu, integrate diverse trees, shrubs, vegetables, and animals within house compounds. With a land area of around 0.20 to 0.50 ha per homestead, these gardens sustainably produce food, incorporating multiple crops and livestock managed by family labor. Characterized by vertical layers, they feature herbs, vegetables, and various fruit trees in stratified arrangements. Species diversity is high, spanning woody plants like mango, guava, and coconut, alongside herbs like pumpkin, beans, and onions, creating a productive and sustainable land use system.

- Alley cropping: Alley cropping, or hedgerow intercropping, involves growing perennial trees or shrubs alongside arable crops. Trees are managed in rows, creating alleys where crops are planted. This method aims to improve soil quality, microclimate, and weed management, while also providing various tree products like fuelwood, food, medicine, and fodder for farmers. Trees like Gliricidia sepium, Leucaena, Calliandra calothyrsus, Erythrina subumbrans, and Cajanus cajan used in alley cropping.
- Shelterbelt: It is rows of trees and shrubs, deflect prevailing winds, protecting cultivated areas from erosion and drying effects. Their design, including varying heights and permeability, aims to maximize their influence and mitigate wind impact on crops.
- Windbreaks: It is a protective planting around a garden, a farm or a field to protect it against strong winds. It usually consists of 2-3 rows of trees or shrubs, spaced at 0.5 m to 2.5 m apart, depending on the species.
- Multipurpose Wood Lots: In this system special location-specific MPTs are grown mixed or separately planted for various purposes such as wood, fodder, soil protection, soil reclamation, etc.
- Aquaforestry: In this system various trees and shrubs preferred by fish are planted on the boundary and around fish ponds. Tree leaves are used as feed for fish. The main role of this system is fish production and bund stabilization around fish ponds

Benefits of Agroforestry

Agroforestry offers several benefits to farmers:

- Meeting Demands for Food, Fuelwood & Fodder:
  - Enhanced crop production via nitrogen fixation and improved soil nutrient access from tree roots
  - trees provide fruits, nuts, and substitutes, meeting human food needs, and offer fodder for rural areas
- Water Conservation:
  - Improved soil moisture retention in rainfed lands
  - Regulation of stream flow, reducing floods, and enhancing water availability
- Fuelwood and Energy:
  - Tree-based fuelwood for combustion and pyrolytic products like charcoal and oil
  - Production of ethanol and combustible saps/resins from trees
- Shelter and Construction:
  - Trees serve as building materials, shade providers, windbreaks, and live fences

- Used for shelter construction, protecting settlements, and providing fencing material

➢ Raw Material for Industries:

- Trees supply raw materials for industries like pulp and paper, tannins, essential oils, and medicinal ingredients

➢ Cash Benefits:

- Direct income from tree product sales and increased overall productivity
- Agroforestry often yields higher income per unit of land compared to monoculture

➢ Increased Yield and Diversified Production:

- Combined agriculture with trees boosts land productivity
- Leguminous trees fix nitrogen and contribute more nutrients to the soil than they take

➢ Diversified Products:

- Various trees, shrubs, herbs, and climbers yield abundant food resources, supporting rural and tribal populations

➢ Utilization of Wasteland and Degraded Land:

- Wasteland can be efficiently used for tree cultivation, improving soil conditions for agricultural production

➢ Employment Opportunities:

- Agroforestry systems create jobs through plantation, wood-based industries, and related sectors

➢ Carbon Sequestration and Climate Influence:

- Agroforestry helps capture carbon, contributing to climate change mitigation

➢ Reduced Deforestation Rate:

- Availability of fuelwood on farms lessens dependence on natural forests, curbing deforestation

➢ Improved Soil Health:

- Trees enhance soil properties, fostering a favorable environment for soil microbes and nutrient release

➢ Habitat for Wildlife:

- Agroforestry supports biodiversity, offering habitats and connectivity for wild species in multi-functional landscapes.

Agroforestry systems in India

Agroforestry has a long tradition in the Indian subcontinent. The socio-religious fabric of the people of the subcontinent is interwoven to a very great extent with raising, caring and

respecting trees. Agroforestry plays a pivotal role in sustaining resources and enhancing overall productivity, especially in rainfed areas within arid and semi-arid regions. There are abundant evidence showcasing that agroforestry systems generally outperform annual systems in terms of biomass productivity, soil health enhancement, conservation, nutrient cycling, microclimate improvement, and carbon storage. It significantly contributes to reducing vulnerability, enhancing resilience in farming systems, and shielding households from climate-related risks, ensuring livelihood security. Moreover, agroforestry has the potential to offer multiple benefits. In India, agroforestry is practiced on 13.75 million ha area under diversified types of agroforestry system.

Agroforestry for Soil Health Management

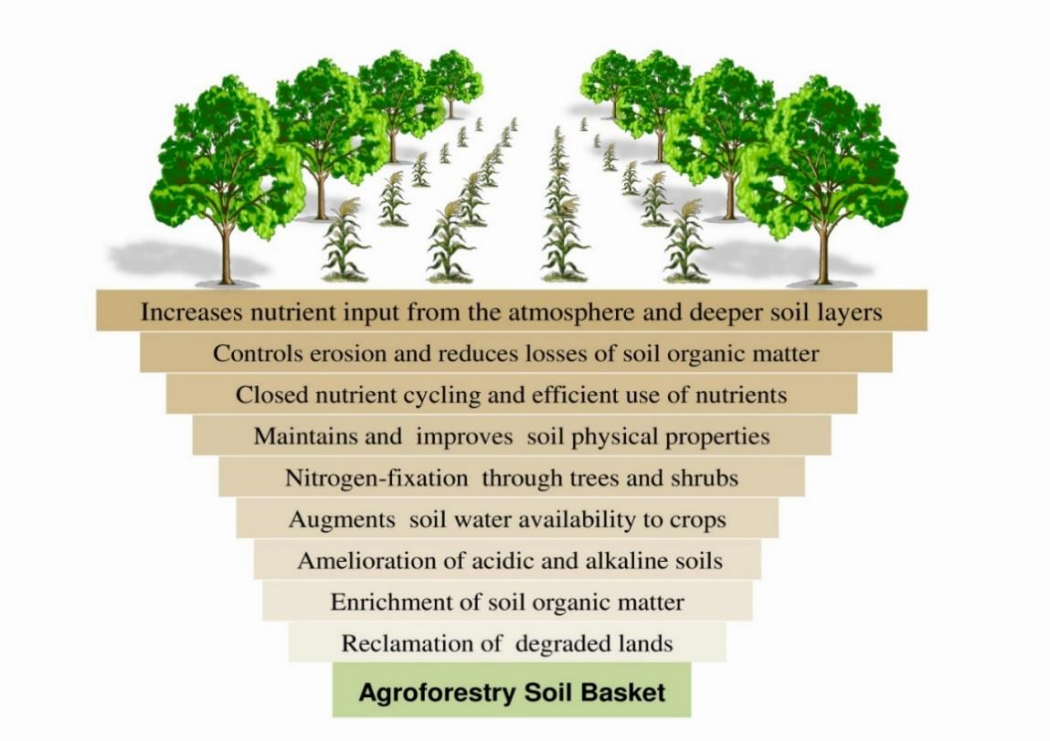


Fig.: Agroforestry for soil health improvement

The integration of trees within croplands plays a pivotal role in sustaining soil health. Tree litter and pruning biomass contribute to soil fertility by releasing nutrients through mineralization, enhancing soil organic matter through carbon fixation, and transferring nutrients via litter and root decay. These trees, especially leguminous species, act as nutrient pumps, accessing and redistributing nutrients from deeper layers of the soil while fostering the release of growth-promoting substances in the rhizosphere. Their roots function as a safety net, trapping and recycling nutrients that might otherwise be lost through leaching, aided by mycorrhizal systems associated with tree roots. Scientific studies highlight significant nutrient

contributions from leguminous trees in alley cropping systems, demonstrating nitrogen fixation and substantial additions of essential elements. Furthermore, the permanent tree cover offers protection against erosion and degradation by intercepting rainfall impact, impeding surface runoff, and promoting water infiltration, ultimately maintaining soil physical and biological properties (Fig 3). Agroforestry trees not only provide a habitat for diverse soil organisms but also contribute organic inputs through litter, prunings, and root turnover, fostering soil carbon storage, enhancing soil structure, and reducing greenhouse gas emissions.

Biological nitrogen-fixing (BNF) trees in agroforestry

Nitrogen Fixing Trees (NFTs) are special trees and shrubs that team up with specific soil bacteria. Together, they pull nitrogen from the air and use it to grow. Many types of bacteria can work with plant roots, helping them grow better. This nitrogen-fixing happens in two ways: one where the plants and bacteria closely work together, and the other where soil organisms independently fix nitrogen.

There are more than 600 known nitrogen-fixing species. Some plants, like legumes, interact with *Rhizobium bacteria*, while others, like certain non-legume species, partner with *Frankia*. Legumes, usually known for this partnership, can add around 40-200 kg of nitrogen per hectare per year. Apart from legumes, about 200 other plants in various families also collaborate with nitrogen-fixing organisms like Frankia. This process, called Biological Nitrogen Fixation (BNF), is crucial for keeping soils healthy in agricultural systems. Trees like *Leucaena leucocephala, Gliricidia sepium,* and *Calliandra calothyrsus* can add a lot of nitrogen to the soil, while others like *Acacia melanoxylon* and *A. holoserica* contribute less (Table 2). For instance, *Casuarina* tree roots can add up to 350 kg of nitrogen per hectare per year. In agroforestry, these nitrogen-fixing trees play a crucial role. They help sustain the system by providing nutrients, making the overall farming more sustainable. Tropical agroforestry systems particularly rely on these trees as natural fertilizers for their crops.

Agroforestry for Ecosystem Services

Agroforestry stands as a versatile land-use approach, renowned for its capacity to address numerous environmental, economic, and societal challenges. Embedded within the United Nations' sustainable development goals, agroforestry emerges as a significant solution across multiple domains, including food security, poverty reduction, biodiversity preservation, and climate change mitigation. While conventional agroforestry models have traditionally garnered attention, there's a growing realization of the importance of indigenous agroforestry systems that evolved without substantial intervention. Concepts like integrated farming

systems, urban, and peri-urban agroforestry have surfaced alongside multifunctional agroforestry, drawing attention for their diverse array of benefits encompassing timber, fodder, fruits, vegetables, medicinal plants, and more. Recognizing agroforestry as a producer of both tangible commodities and intangible environmental and cultural services, multifunctional agroforestry serves as a crucial pathway amid mounting global challenges (Table 3). Within this context, multifunctional agroforestry emerges as a promising avenue to ensure food security while fostering environmental sustainability.

Table: Ecosystem services provided by agroforestry

Types of ecosystem services	Different services
Provisional services	Food, Fiber, Fruits, Fodder, Biomass, Water, Oxygen, etc
Regulating services	Carbon sequestration Micro-climate amelioration Soil and water conservation Water and air purification
Cultural services	Aesthetic Recreational Ecotourism
Supporting services	Primary production (in relation to soil health) Nutrient cycling, water cycling Biodiversity conservation

Agroforestry for adaptation and mitigation of climate change

Agroforestry stands out as a prominent land use approach, addressing the dual challenges of climate change adaptation and mitigation. By integrating trees into agricultural systems, agroforestry fosters microclimate modifications, biodiversity conservation, and soil health improvements, offering a multifaceted solution to environmental and economic concerns.

- **Adaption strategies:** Adaptation strategies within agroforestry systems involve meticulous adjustments to mitigate the impacts of climatic changes. Trees play a pivotal role in microclimate improvements by lowering temperatures, reducing evapotranspiration, and enhancing moisture retention. This method significantly enhances on-farm resilience, buffering crops from the adverse effects of temperature fluctuations and precipitation variations. Mechanisms like shade trees and windbreaks act as shields against extreme

weather, maintaining suitable conditions for agricultural productivity, and easing the burdens faced by smallholder farmers amidst climate uncertainties. A famous example is shade trees like Grevellia robusta, Acacias, Albizia odoratissima, A. chinensis, A. lebbeck and Derris robusta planted in tea estates. Shade trees play a crucial role in plantations by regulating leaf temperatures to optimize photosynthesis and prevent sun damage. Additionally, they contribute significantly to soil moisture conservation. This balance of temperature control and moisture retention is fundamental for the healthy growth of plantation crops.

- **Mitigation strategies:** Mitigation efforts in agroforestry primarily focus on carbon sequestration and ecosystem sustainability. Capacity of Agroforestry to store carbon through tree plantations showcases its immense potential in reducing atmospheric carbon levels. Different agroforestry systems exhibit varying levels of carbon sequestration, contributing significantly to climate change mitigation efforts. With its ability to enhance soil fertility, local climate conditions, and forest conservation, agroforestry stands as a crucial ally in addressing global greenhouse gas concentrations while ensuring local adaptation and multifunctional benefits. The carbon sequestration potential of tropical agroforestry system in recent studies is estimated between 12 and 228 Mg ha^{-1} with a mean value of 95 Mg ha^{-1}. Agroforestry enhances the uptake of CO_2 or reduce its emission and has the potential to remove a significant amount of CO_2 from the atmosphere if the trees are harvested, accompanied by replanting of same and/or other areas, and sequestered carbon is locked through non-destructive use of such wood (Figure 4).

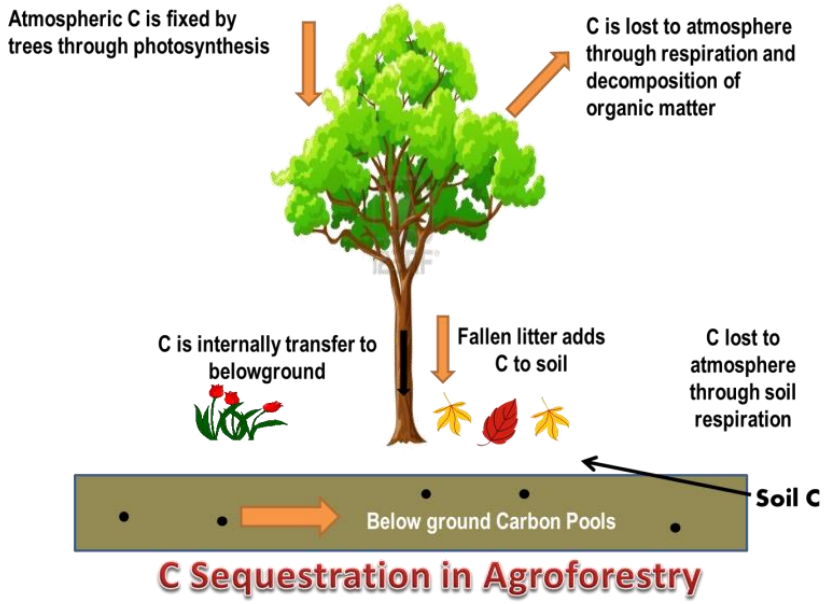


Figure 4. Carbon sequestration through agroforestry systems

Suitable tree species for agroforestry

Selection of suitable tree species in agroforestry is one of the important consideration and challenging task for farmers. It also varies with desired output of systems. In the past tangible benefits has always outweighed the intangible benefits in selection of trees in agroforestry. In this era of climate change and land degradation, ecosystem services such as soil health and carbon sequestration has been a prominent criterion in selecting trees in agroforestry systems. Some of the important characteristics of trees suitable for agroforestry has been mentioned below.

Characteristics of a good soil improving tree*:*

- Tree species should have their multiple uses
- Tree species selected should not interfere with soil moisture & agricultural crops
- Tree species should have high yield potential
- Tree species should not compete for plant nutrients
- Tree species should not compete for sunlight
- Tree species should have high survival rate, fast growing habit and easy establishment
- Tree species should have wider adaptability
- Tree species should have high palatability as a fodder
- Tree species should have shelter conferring and soil stabilization attributes
- Tree species should have capability to withstand management practices such as lopping, pruning and coppicing
- Tree species should have nutrient cycling and nitrogen fixation attributes
- Tree species should be free from chemical exudations and pest attacks

Conclusion

In this comprehensive exploration, the convergence of agroforestry (AF) and natural farming (NF) emerges as a compelling strategy rooted in regional and national contexts to combat the challenges posed by climate change. By intertwining sustainable AF systems with the principles of NF, a harmonious symbiosis arises, offering continuous inputs like jeevamrut and beejamrut, leveraging plant protection formulations, and fostering biomass mulching through nitrogen-fixing trees. This integration not only aids in mitigating methane emissions from livestock but also accentuates the resilience of farming practices. Emphasizing indigenous trees and livestock integration while blending traditional and improved AF methods emerges as a cornerstone for enhancing NF practices.

However, scaling this collaboration faces challenges such as securing sufficient livestock and trees, necessitating scientific validation, improved germplasm, and production techniques. Amidst global threats like climate change and food insecurity, the amalgamation of AF and NF embodies a transformative path towards sustainable economies of scale, albeit requiring concerted efforts in research, knowledge dissemination, policy support, and technical advancements. This synergy of agroforestry and natural farming signifies not just a means of agricultural advancement but a blueprint for cultivating resilience, sustainability, and holistic environmental stewardship in farming communities worldwide.

Integration of Livestock Systems

10. INTEGRATION OF LIVESTOCK IN NATURAL FARMING – PERSPECTIVE, PRINCIPLES AND PRACTICES

"Integrating animal husbandry into crop producing farms is one of the principles of Natural Farming." Many farmers are practicing and adopting natural farming on smaller and larger scales in holistic and split modes in different states of India (Sharma et al., 2023). The NITI Ayog has documented a compendium of success stories of natural farming by 110 farmers in India indicating the importance, methods used, and impact on yield and profit (NITI Aayog, 2022). Farmers in India have successfully pioneered natural farming models, emulating natural ecosystems through the integration of crops, livestock, and local ecology. They emphasize the elimination of synthetic external inputs, such as fertilizers and pesticides, in favor of promoting natural formulations derived from on-farm resources like cow dung, cow urine, pulse flour, and botanical extracts. These innovative approaches foster synergistic effects within integrated farming systems, optimizing the utilization of different components. The adoption of eco-friendly practices is a key aspect of their methods, including reduced tillage, trenching, cover crops, crop rotations, crop residue mulching, intercropping systems, minimal irrigation, and the use of coated seeds. Additionally, farmers actively promote the activation of soil microorganisms to enhance soil fertility, leading to a range of ecosystem services. These services include nutrient cycling, conservation of topsoil, increased water retention, biological nitrogen fixation, natural regulation of pests and diseases, and biodiversity conservation. Ultimately, these practices contribute significantly to the sustainability of agricultural ecosystems.

What do we mean by Livestock? What image is formed when we use the term?

Livestock is commonly defined as domesticated animals raised in an agricultural setting to produce labor and commodities such as meat, eggs, milk, fur, leather, wool, etc.The term is used interchangeably for animals bred for consumption, and farm ruminants such as Cattle and Goats.

What is Animal Husbandry then?

Animal husbandry is the branch of agriculture concerned with animals that are raised for meat, fibre, milk, or other products. It includes day-to-day care, selective breeding, and raising of livestock.

What is the need for the integration of animals into the farms?

Integrating animals into a farm helps create a closed or semi-closed system where energy and nutrients are recycled as shown in Figure 1. Animals can convert non-edible biomass (e.g., grass, straw, kitchen waste) into food and other services while increasing soil fertility with their manure.

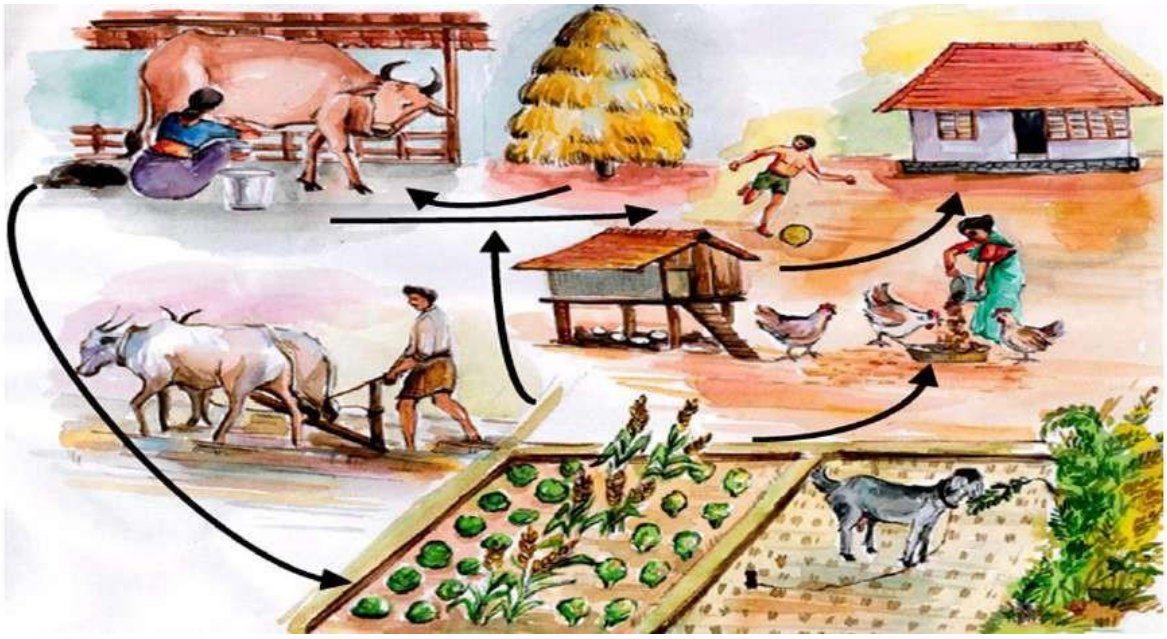


Figure 1: Animals integrated into the farm, showing the flow of fodder, dung, services, and products.

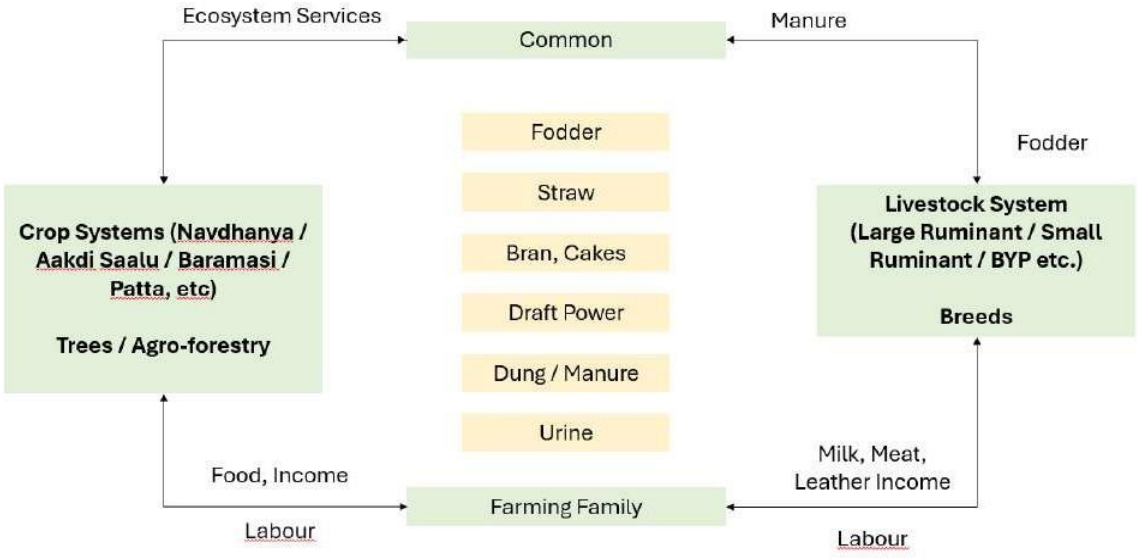


Figure 2: Interlinkage between Crop and Livestock production system

Let us understand it in detail using Figure 2 which showcases the interlinkage between the multi-cropping system and livestock which are as follows:

1. Livestock provides manure in different forms to the land which increases soil microbial activity and generates soil fertility.
2. Recycling of by-products such as straw acts as fodder for livestock & kitchen waste goesinto the kitchen garden/ Compost.
3. Raw material generated from livestock like cow urine is used in the preparation of herbal concoctions/ bio-pesticides which are used to control pests & diseases in crops.
4. Livestock serves as a draught power for tillage and transport.
5. Multi-cropping systems generate diverse fodder that is nutritious for the farm animals.
6. Yields such as milk or eggs can be used for sale or self-consumption.
7. Open grazing of Livestock in forests manages weeds & enhances soilfertility by rejuvenating the common land.

The use of animals in natural farming can play several important roles, contributing to the overall health and fertility of the farm ecosystem. Here are some ways animals are employed in natural farming:

1. **Manure Production**: Animals such as cows, goats, poultry, and pigs contribute to the farm by producing manure. This natural fertilizer is rich in organic matter and nutrients, enhancing soil fertility and structure. Poultry produces manure that is high in nitrogen and other essential nutrients. This manure can be used to fertilize crops and improve soil fertility. Integrating poultry into a rotational system allows them to distribute their manure effectively.

2. **Composting**: Animals, especially poultry and pigs, can be utilized in composting systems. They help turn and mix organic materials, accelerating the decomposition process and producing nutrient-rich compost that can be used to improve soil quality.

3. **Weed and Pest Control**: Certain animals, like ducks and poultry, can help control weed growth and insect pests. For example, ducks are known for eating insects and larvae in paddy fields, contributing to natural pest management. Poultry, through their foraging behavior, can assist in weed management. They consume young weeds, preventing them from maturing and competing with crops for resources. Poultry birds are natural foragers and can help control insects and pests in the farming environment. They scratch the soil and consume insects, larvae, and weed seeds, contributing to a reduction in pest populations.

4. **Ploughing and Tilling**: Draft animals, such as oxen or horses, can be used for plowing and tilling fields, reducing the reliance on fossil fuel-powered machinery. This traditional method is energy-efficient and has lower environmental impacts.

5. **Diversity and Rotation**: Integrating animals into crop rotations can enhance the diversity of the farming system. For instance, integrating livestock into a crop rotation helps break pest and disease cycles while improving soil health through nutrient cycling.

6. **Milk and Meat Production**: Livestock on a natural farm may be raised for milk, meat, and other products. Animals are typically raised in more humane conditions, with an emphasis on natural diets and fewer antibiotics or synthetic growth hormones.

7. **Biodiversity Enhancement**: Grazing animals on pasture can contribute to the maintenance or restoration of natural habitats. Proper rotational grazing practices can enhance biodiversity by mimicking natural processes and preventing overgrazing. Integrating poultry into a diversified farming system contributes to overall biodiversity. It can create a more balanced ecosystem by incorporating different species and their interactions.

Integration with Perennial Crops: Animals can be integrated into agroforestry systems or other perennial cropping systems. For example, agroforestry systems might include poultry foraging in orchards, pest controlling and fertilization services.

Waste Recycling: Animals can help recycle agricultural and kitchen waste. Pigs and Poultry, for instance, can be fed food scraps and agricultural waste, reducing the need for external feed inputs and contributing to a closed-loop system.

It's important to note that effective natural farming involves holistic management practices, and the role of animals should be balanced to ensure the well-being of both the animals and the overall farm ecosystem. Ethical and sustainable animal husbandry practices are essential in natural farming systems.

In Indian conditions, the dung and urine of desi / indigenous cows perform best as bio-formulations. The reason behind this is they eat a lot of diverse vegetation which enhances the number of microbes in the cow dung and cow urine. However, due to several years of cross-breeding programs, indigenous cattle breeds are being diluted. National Bureau of Animal Genetic Resources has identified, characterized, and registered nearly 50 cattle breeds in the country from different agro-climatic zones.

However, in the absence of indigenous cows, buffalo and other animals can also be used for natural farming.

Role of Bullock in Natural Farming

With the increased use of heavy farm machinery in the mono cropping system, the use of bullocks has been reduced in Indian agriculture. However, still more than 40% of the energy used in agriculture contributes to draught animal power. They are mainly kept for milk. Raw materials like dung and urine can still be used for the preparation of concoctions such as *jeevamrita, beejamrita,* and others that are useful for Natural Farming. Buffalo also helps in promoting a diverse mix-cropping/ multi-cropping system which is one of the important principles of natural farming. Bullocks can be employed in managing crop residues in the field. They can help trample and incorporate crop residues into the soil, enhancing organic matter content and soil fertility. The dung produced by bullocks is a valuable source of organic fertilizer. When allowed to mix with straw or other bedding material, it can be composted to create nutrient-rich compost to improve soil fertility.

A lot of such evidences are recorded through case studies documented by RRA Network and WASSAN under the project TIGRESS (Transforming India's Green Revolution by Research and Empowerment for Sustainable Food Supply) carried out in 14 agroecology zones in 10 states found that traditional mix-cropping followed by the farmers use Bullocks. Some of them are widely known as *Aakdi Saalu* in Karnataka, *Navadhanya* in Andhra Pradesh, *Sangdi Kheti* in the Tribal region of Rajasthan, or *Patta Padhhati* in Vidarbha Region of Maharashtra.

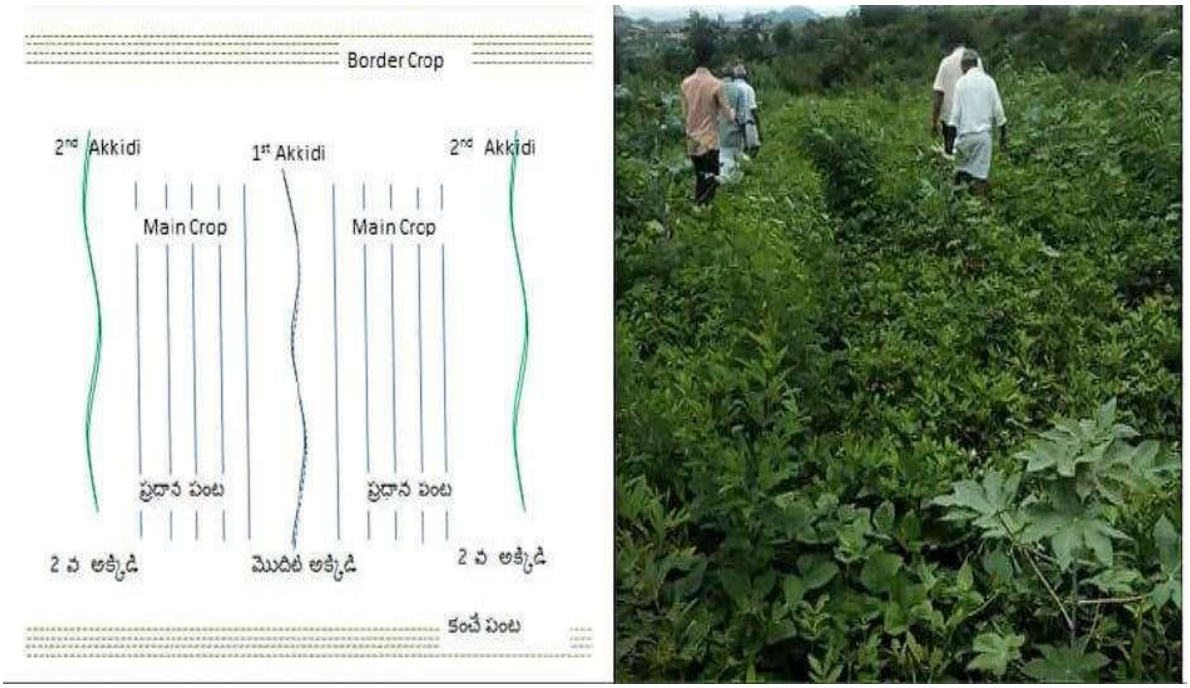


Figure 3: A Navadhanya field in Andhra Pradesh and its mix-cropping design

Big ruminants like bullocks also help in providing mobile hybrid energy solutions for effective and efficient use of water. Some of these technologies are Mobile Solar Pumps toprovide critical irrigation to multiple farms.

Intensive Ecological Farm with Desi Poultry

This is yet another enterprise model of multilayer farming using Desi Poultry tried in backyard land integrated with the production of desi/ indigenous poultry.

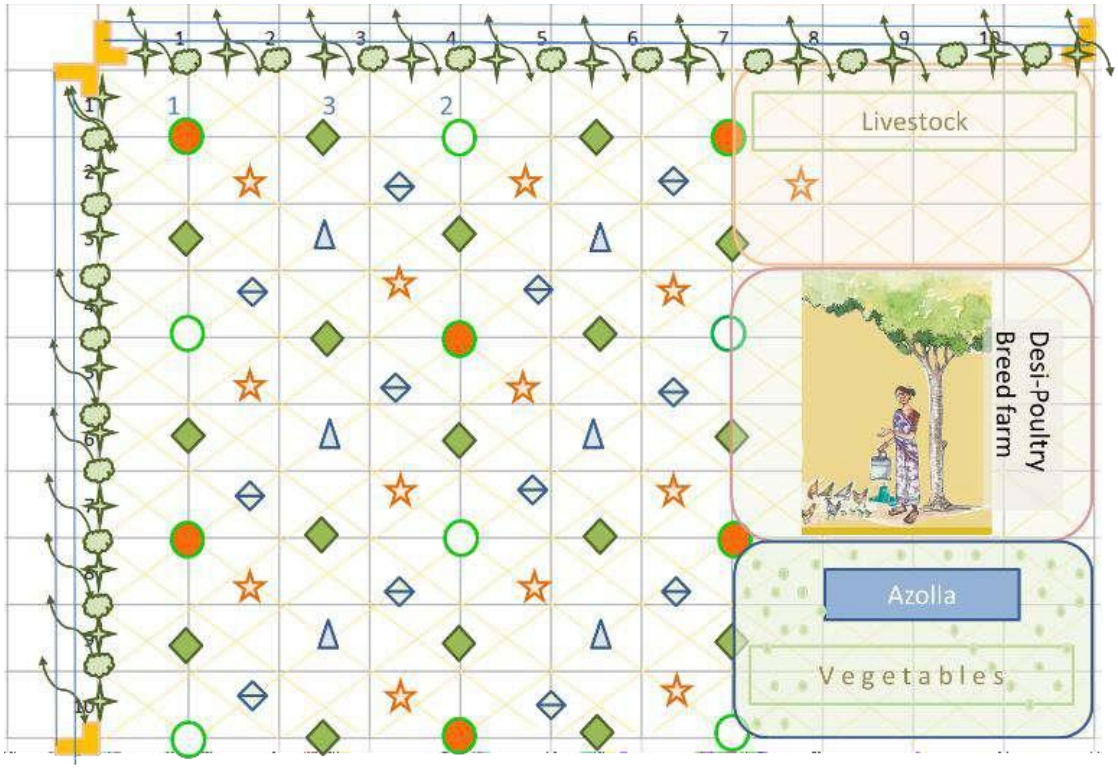


Figure 4: Design of the integrated model of desi poultry

The 0.5 ac of land in Figure 4 shows the design of multi-layer farming with Desi Poultry whereby grains, vegetables, and fruits are grown by adding composts made of poultry litter and without using any chemical pesticides and fertilizers. Further, poultry serves as a natural predator for the insects that attack crops. The fodder requirement of desi poultry is fulfilled through a foraging system (relying on food provided by nature by gathering plants and small animals, birds, and insects; scavenging animals killed by other predators; and hunting) & green fodder like Azola without having industrial feed. The entire land is fenced using wire covered with dark colored sarees to protect it from wild animals.

Figure 5: Benefits of Integrated model of multi-layer farming with Desi Poultry

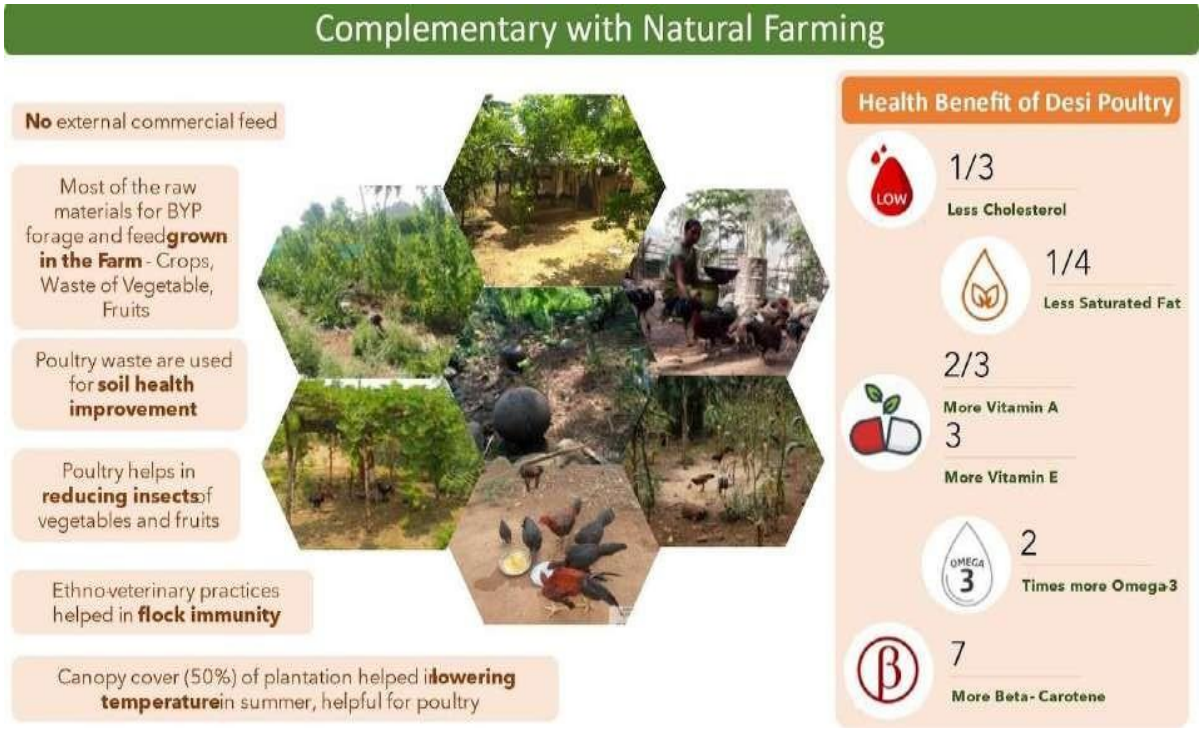


Figure 6: Health benefits of Desi Poultry drawn up from this model

Scope of fish in rice cropping systems

Ayyappan et al. (2004) reported that good in-situ synergism exists between the fish and rice crop, improving the productivity of each other. Rice yields improved by 35% as fish control a wide variety of insect pests and weeds. Channabasavanna and Biradar (2007) reported that Rice-fish-poultry system could be efficiently adopted under irrigation conditions which enhances overall productivity and maintains sustainability. They also reported that the Poultry droppings increased the biological productivity of the pond (plankton production) and consequently enhanced the fish yield which increases the water productivity by producing more yield with less amount of water.

Key features of the intensive ecological farms are as follows

- Can be tried in half an acre/ 0.5 ac farm.
- Vegetable crops can be grown.
- 5-layer intensive fruit and other multipurpose boundary plantation trees and grass.
- About 50 hen units can be placed (foraging system for food).
- 3 to 4 ram lambs (grazing).
- 2 Dairy animals.
- Low irrigation through drips.
- Proper fencing for protection.
- A night shelter for poultry.
- Investment of about Rs.2.00 lakhs over the period is required.
- Returns start after 6 months.
- A Reach of about Rs.0.75 to Rs.1.00 lakh by 2nd year.
- Pays back in 4 year’s time.

11. FODDER & FEED MANAGEMENT

What is fodder and forage?

Fodders crops are cultivated plant species that are utilized as livestock feed. Fodder refers mostly to the crops which are harvested and used for stall feeding.

Forage can be defined as the vegetative matter, fresh or preserved, utilized as feed for animals. It includes grasses, legumes, crucifers and other crops cultivated and used in the form of hay, pasture, fodder and silage.

What is the present scenario of fodder in the country?

Based on the recent data of 2022, India is facing a net shortfall of 35.6% green fodder, 10.5% dry crop leftovers, and 44% concentrate feed ingredients. The option for increasing land area under fodder cultivation is very limited. Hence, it is a big challenge to utilize the available meagre land wisely with its fullest potential to produce the fodders for the animals.

How the deficit of fodder can be achieved?

Few of the possible ways includes adopting suitable multi-cropping systems, incorporation of fodder crops in food and other cash crop-based cropping systems on rotational basis, production of fodder on degraded lands by adopting fodder-based agro forestry systems and exploring other options of green fodder like azolla. The cropping system with forage crops provides a potential alternative to overcome the fodder problem as it utilizes the resources more efficiently. Some of the successful models are as follows:

1. Intensive Ecological Farm with Desi Poultry: The model has been explained in details in the Livestock session under Image 1.4. This was first piloted by RRA Network in 7 states which was influenced from the training of Namakkal KVK in Tamil Nadu. It was further scaled up by the Department of Animal Husbandry, Govt of Andhra Pradesh in the tribal areas.

2. Regeneration of Commons & Fallows for Fodder Security: Since Livestock is integral part of natural farming, it is important to sustain livestock in the village in order to transform a village into natural farming village. Though commons are shrinking, it is high time to protect, conserve and regenerate commons.

Beside commons, current fallows can also contribute towards fodder security for the animals in the village. Another such example is from the drought experiencing Anantapur district of Andhra Pradesh. WASSAN worked with communities in Ayyavaripally village, a dairy dependent village which became fodder surplus in 2 years reviving all the fallow lands in the village; moving from Rs.17 lakhs deficit to meeting all its requirements.

This was carried out by villages communities through

1. Mapping of Fallow lands.
2. Estimating Fodder deficits (fodder budgets).
3. Tie-up between Dairy farmers with fodder deficits with fallow landowners.
4. Promoting fodder crops like Jowar, Bajra, Field beans, Cowpea, Maize & Horse gram in the fallow lands during the rainy season (Kharif) using Pre-Monsoon dry sowing (PMDS). (In the rainfed and unirrigated region, the beejamritha treated seeds are broadcasted in the field before the onset of monsoon. Beejamritha helps in combating unpredicted and less rain for Kharif crop and also protects seeds from being eaten by birds. The seeds germinate whenever first rain happens for which farmer need not wait. It helps in avoiding repeat sowing due to monsoon failure/delay.) The fodder crop combination is shown in Table 1.

Integrating fodder crops in *Navdhanya* multi-cropping system, Andhra Pradesh.

CROP COMBINATION			
Sl.No	**Type of seed**	**Units**	**Seed per Acre**
1	Jowar	Kgs	3

2	Bajra	Kgs	3
3	Horsegram	Kgs	4
4	Cowpea	Kgs	2
5	Field beans	Kgs	2
6	Maize	Kgs	4
7	Ragi	Kgs	1
8	Stylosanthes hamata	Kgs	1
	Total		**20**

Table 1 Fodder crop combination in fallow land.

Penning of animals on agricultural fields

In several places, particularly in drylands, penning of animal on agricultural field is a traditional practice followed by farmers. Penning with migratory herds of sheep, cow, camel is practiced which is the low-cost method of improving soil health. Penning reduces lots of labor of farmers family and high labor intensity is one of the bottlenecks for conversion towards natural farming.

A study carried out by CRIDA highlights farmers adopted penning achieved higher yield than those who didn't. Similarly, a recent study carried out by Centre for Pastoralism (CFP), Watershed Support Services and Activities Network (WASSAN) and Centre for Peoples Collective (CPC) found that in deccan plateau farmers who invites pastoralist to pen his animals for 7 - 10 days have drastically reduced usage of chemical fertilizers. Therefore, other species of animals not only desi cow contributes to promotion of natural farming.

Penning of animals in agricultural field in Gujarat.

Open Grazing Vs Stall feeding to animals

Keeping animals means providing fodder throughout the year. Either it can be produced on the farm using multi-cropping system or in fallows or grazing in an agricultural land or grass or tree crops used for cutting.

While grazing requires less labour than stall feeding, land & appropriate measures are taken to monitor the animal to keep it away from other crops. It is usually the most favorable option concerning health & welfare of the animal. Interestingly, studies in Gujarat & Rajasthan, have proven that pastoral communities producing milk mostly relay on grazing of their animals.

Shed keeping however has an advantage that the dung can be easily collected, stored, or composted and applied to the crops. Whether grazing or stall feeding is the most suitable option, mainly depend on the agro-climatic conditions, the cropping system, and the availability of land. A combination of stall feeding and grazing in a fenced area may be an ideal combination of high productivity and animal friendly husbandry**.** In extensive grass lands of semi-arid areas, however, grazing may be the only suitable option.

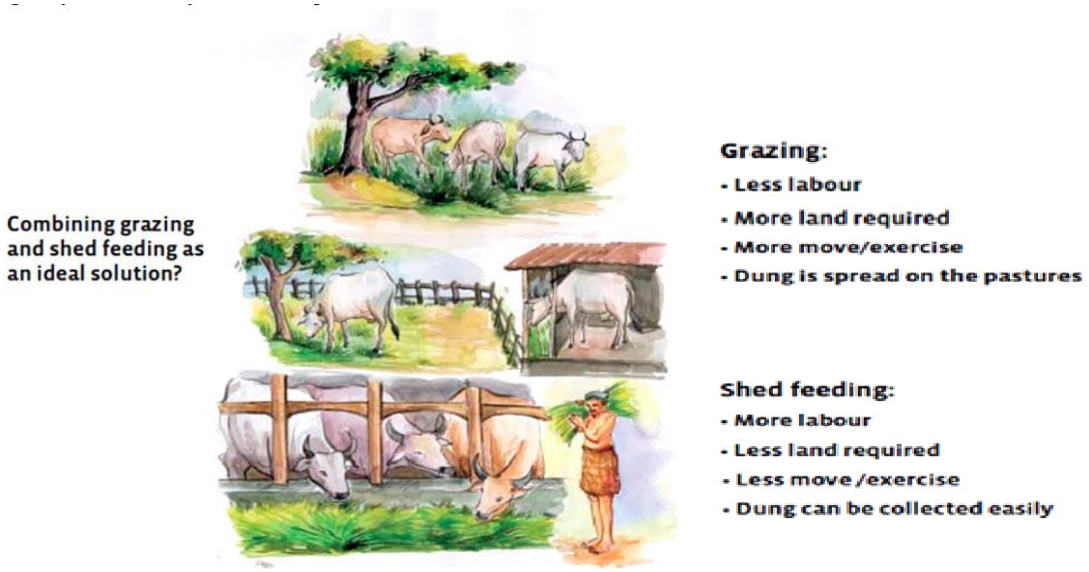


Figure : The pros and cons of Grazing and stall feeding, and the combination of both as a promising option**.**

Alternative source of fodder production, Azolla: Azolla is a free- floating, fast growing aquatic-fern. Its nutritional value is well recognized, indicating that it is a good source of protein, practically all the amino acids for animals as well as micro nutrients like calcium, magnesium, potassium and vitamins. It is a unique supplement for variety of animals including ruminants, chicken, pigs, and fish. It holds the promise of providing a sustainable feed for livestock & can be easily digested. Azolla can be used to replace 15-20% of commercial feed.

Key Learning:

Natural farming strategy: Integration of Livestock with multi-cropping system	
Requirement	**Strategy**
• Enhance biological activity in Soil	Practice multi-cropping system of diverse crops, deep and shallow rooted.
• Input support to enhance microbial activity	Integrate farm animal suitable for the region. Optimum utilization of the available resources in preparation of stimulants.
• Meet the requirement of fodder for livestock	Adoption of traditional practices like peening or grazing or foraging. Fodder production in fallows or multi- cropping system or Azolla.
• Recycling of nutrients	Integrate farm system suitable for the region.

Seed & Planting Material

12. SEED SYSTEM FOR NATURAL FARMING

The seed system is a critical component of natural farming and seed material is crucial for maintaining the ecological balance. Seed systems for natural farming are based on the principles of resilience, biodiversity of crops, sustainability, and farmer empowerment. The types of seed materials used in natural farming can vary but generally fall into the following,

- **Resilience**: Seed systems are designed to be resilient to climate change, including biotic and abiotic stress. This is achieved by using a variety of seed sources, including farmer-saved seeds, community-based seed banks, and OP varieties from public sector Institutions.
- **Sustainability**: This is achieved by using seed varieties that are adapted to local conditions and responsive to natural farming.
- **Biodiversity of crops**: Natural farming seed systems emphasize diversity. Diversity helps to ensure that farmers have access to the seeds they need to adapt to changing conditions and pests.
- **Adaptation**: Natural farming seed systems are adapted to local conditions. This means using seed varieties that are suited to the climate, soil, and resistant to pests. Adaptation helps to ensure that farmers get the best possible yields from their crops.

Some of the key features of seed systems for natural farming:

Seed Sovereignty: Natural farming emphasizes the importance of seed sovereignty, allowing farmers to have control over their own seeds. Using locally adapted seeds empowers farmers to save, exchange, and replant seeds without dependence on external sources.

No Chemical Treatment: Seeds in natural farming systems are not treated with synthetic chemicals or coatings. This aligns with the overall goal of avoiding synthetic inputs.

Open-pollinated seeds are seeds that are pollinated naturally, without human intervention. Pollination occurs through various natural mechanisms, such as wind, insects, birds, or other natural agents. The key characteristic of open-pollinated plants is that they can produce seeds that will, in turn, grow into plants with traits similar to those of the parent plant.

Heirloom Varieties: Many heirloom varieties are open-pollinated. Heirlooms are traditional plant varieties that have been passed down through families or communities. They often have historical significance and unique characteristics.

Reduced Dependency on External Inputs: Locally adapted seeds often require fewer external inputs, such as synthetic fertilizers and pesticides. This reduces the economic and environmental costs associated with agricultural production.

Non-genetically modified organism (GMO) seeds are those that have not been genetically engineered in a laboratory. Natural farming practices typically favour non-GMO seeds to support biodiversity and avoid potential environmental and health concerns associated with GMOs.

Regenerative Agriculture: Incorporate regenerative agriculture practices to improve soil health and overall ecosystem resilience, contributing to the success of the seed system.

A well-designed seed system for natural farming integrates these elements to create a resilient, sustainable, and community-centred approach to agriculture.

Benefits of using seed systems for natural farming:

Improved soil health: Natural farming seed systems can help to improve soil health by using seed varieties that are adapted to low-input farming practices. Healthy soils, in turn, support better seed germination, nutrient uptake, and overall plant growth.

Reduced environmental impact: Natural farming seed systems can help to reduce the environmental impact of agriculture by using seed varieties that do not require high inputs of fertilizers or pesticides. In turn, reducing pollution and preserving ecosystems.

Increased farmer income: Natural farming seed systems can help to increase farmer income by providing farmers with access to seeds and by helping them to produce more food.

Sustainable Agriculture: Natural farming focuses on organic and sustainable agricultural practices. Using seed systems aligned with these principles reduces the reliance on synthetic chemicals and fosters environmentally friendly farming methods.

Self-Sufficiency: Encouraging farmers to save seeds from their own crops promotes self-sufficiency. Farmers become less dependent on external seed sources, contributing to food security and economic stability within communities.

Cost Reduction: Seed-saving practices reduce the need for purchasing seeds every planting season. This can result in cost savings for farmers, especially in comparison to the recurring expense of buying hybrid or genetically modified seeds.

Community Empowerment: Seed systems often involve community-based initiatives such as seed banks and exchanges. These activities empower local communities by fostering collaboration, knowledge sharing, and collective decision-making.

Preservation of Traditional Knowledge: Seed systems in natural farming often incorporate traditional and indigenous knowledge. This helps preserve cultural practices and agricultural wisdom that have been developed over generations.

Quality of Seed source:

Seed source: Good quality seeds should be obtained from a reputable source. Traditional cultivars can be obtained from custodian farmers, seed banks, FPOs, etc.

The source should also be able to provide you with information about Value in Cultivation and Use (VCU) such as suitable soils, season, resistant/ susceptible to pests/ diseases; and its uses. (VCU Systematic documentation of plant characteristics and its expression under specific agronomic condition along with its uses is defined as Value for Cultivation and Use.)

Classification of seeds

Traditional cultivars: Heirloom varieties are a type of open-pollinated crops that have been passed down through generations of farmers. They are often prized for their unique flavor, nutritional value, and adaptability to local conditions.

OP varieties: Open-pollinated: Heirloom varieties are open-pollinated, which means that they are pollinated by natural means, such as wind, insects, or birds. This type of pollination allows for more genetic diversity in plants, which can lead to a number of benefits, such as increased resistance to pests and diseases, improved adaptation to local conditions, and increased flavor and nutrition.

Hybrids: Crossing two different types of the same plant creates hybrids. This results in a plant with the desired traits of both parents. Hybrids cannot re sued as they get segregated in F2 generation.

Hybrid seeds are generally not a common feature in natural farming practices. Natural farming emphasizes working in harmony with natural processes, avoiding synthetic inputs, and promoting biodiversity. Hybrid seeds are produced by crossing two genetically distinct parent plants to achieve specific traits, such as increased yield or resistance to pests. Heirloom seeds are non-hybrids, meaning they are not the result of crossbreeding different species or varieties. This non-hybrid nature allows for the stability of traits in successive generations.

While natural farming tends to avoid hybrids, it is important to note that there may be variations in the interpretation and implementation of natural farming practices across different regions and practitioners. Some farmers may choose not to use hybrids strictly based on the principles outlined above, while others may make individual decisions based on local conditions and circumstances. Overall, the emphasis in natural farming is on practices that are ecologically sound, economically viable, and socially responsible.

Genetically Modified crops: Inserting a gene from another organism into the plant's DNA creates genetically Modified crops.

Non-GMO seeds are an important choice for farmers and gardeners who prioritize traditional breeding methods, seed diversity, and the avoidance of genetically engineered crops. These seeds contribute to the broader movement for sustainable and natural farming practices and also some consumers prefer products made from non-GMO crops due to concerns about potential health and environmental impacts associated with genetic engineering. Non-GMO labeling is common on food products to meet consumer demand for transparency.

Perennial Crops: In some natural farming systems, there is a focus on perennial crops and perennial seed varieties, which can reduce the need for annual replanting and soil disturbance.

Examples of perennial crops commonly integrated into natural farming systems include fruit trees, nut trees, perennial herbs, and woody shrubs. The specific choice of crops depends on local climate, soil conditions, and the goals of the farming system. Perennial crops are often part of a diversified and resilient agroecosystem in natural farming.

Except Hybrids and GM crops, Traditional cultivars and OP varieties are suitable under Natural farming.

Basic Principles of Producing Quality Seeds:

Open Pollinated varieties:

- **Production plan**
  - ✓ Need assessment: The first step is to assess the need by taking in to consideration demand, value for cultivation and use.
  - ✓ Demand for a particular crop variety: It is also important to consider the demand for a particular crop variety.

- **Site selection:** Seed multiplication plot/ site should be in the same climatic area for which the variety has been developed. Dry humid climate with moderate humidity and sufficient moisture during the critical stage is ideal for seed production.

- **Credible source:** The sources can be formal and informal.
  - ✓ Formal sources such as State Agriculture Universities, ICAR –research station, NBPGR, International Institutions such as ICRISAT, IRRI, etc.
  - ✓ Informal Sources:
    - Custodian farmers
    - Community Seed banks
    - NGOs.
    - Seed Networks, etc.

- **Seed procurement** is an important part of seed production. Breeder/ Foundation seeds should be procured in advance from known sources such as State Agricultural Universities, ICAR institutions, and farmers' breeders. To obtain foundation/ breeder seeds from agricultural universities, it is mandatory to place a seed indent one year before the seed requirement.

- **Land selection** for seed multiplication/In situ conservation. The seed production plot or site should be in the same climate as the variety was developed for. Heavy rains, high temperatures, and lack of soil moisture can all lead to poor quality seed. A dry climate with moderate humidity and rainfall during the growing season is ideal for seed production.

  The selected plot for seed production should be free of volunteer and weed plants. Crop rotation can be used to avoid volunteer plants. The field should also be free of soil-borne pathogens and insect pests, as well as salinity and alkalinity.

- **The sowing method, spacing, and seed rate vary depending on the crop**. To get higher yields and better seed quality, it is important to keep the soil fertile and the moisture level in the soil at a desirable level during the crop growth period. Irrigation is necessary at the seed development stage in many cereal crops to obtain good quality seed. Soil fertility management, Pest management and Water management are similar to crop production practices under Natural Farming.

- **Seed quality management practices**
  - ✓ Isolation: Good quality seeds should be produced in isolation from other varieties of the same crop. This is to prevent cross-pollination, which can lead to contamination of the seed. The isolation distance will vary depending the crop. Self-pollinated crops required less isolation distance then cross pollinated crops.

- ✓ Rouging: is the process of removing unwanted plants from a crop. This is done to maintain the genetic purity of the seed. Unwanted plants can include plants that are not of the desired variety, plants that are diseased, or plants that are damaged.

- **Harvesting:** Moisture content is an important factor to consider in deciding when to harvest seeds. In general, Indian farmers and seed producers decide when to harvest by checking the morphology of the crop. For example, in tomatoes, the first picking of fruits usually has the highest germination percentage. In okra, pods collected from the 3rd to 6th nodes typically have the best seed quality.

- **Processing:** Good quality seeds should be processed to remove impurities, half-filled seeds, and other defects. This is done to ensure that the seed is of a high standard, ensure physical purity of the seeds including free from weed seeds, admixture, inert matter, etc.

Importance of traditional cultivars for Natural Farming

Traditional cultivars are crop varieties that have been developed and grown over many generations by farmers, are often well adapted to local conditions and can be more resistant to pests and diseases. The revival of traditional cultivars is an important part of natural farming as these cultivars are well-suited for natural farming because they are often more resilient and require less inputs than modern varieties.

Many local and indigenous seeds have cultural significance, often tied to traditional agricultural practices, folklore, and community heritage. Preserving and using these seeds can help maintain cultural identity.

Local and indigenous seeds, with their adaptability to specific local conditions, can play a role in climate change adaptation by providing crops that are resilient to changing climatic patterns.

When practicing sustainable and regenerative agriculture, including natural farming, farmers often prioritize the use of local and indigenous seeds as part of a holistic approach to ecosystem health and food security. These seeds contribute to the conservation of agricultural biodiversity and the preservation of traditional farming knowledge.

The key processes for preparation of SOPs for seed system of landraces are,

- ✓ Standardizing characters with minimal descriptors for landrace documentation.
- ✓ Evaluation of landraces for yield, pest resistance, nutritional value, climate resilience and no chemical inputs to release in those areas.
- ✓ Preparing guidelines for certification of seed standards of landraces.

- ✓ Preparing package and practices for seed production of landraces.
- ✓ Release of landraces by apex committee under Agriculture Production Commissioner (APC) cum Additional Chief Secretary (ACS)/secretary Department of Agriculture & Farmers'
- ✓ Empowerment (DAFE) which is facilitated by Central Variety Release Committee (CVRC) at national level.
- ✓ For seed production and certification, the exclusive rights should not be given to an individual.
- ✓ All the public infrastructure institute will be utilized for technical support on the production programs and maintenance breeding.
- ✓ Package of practices will be developed in association with experts NGOs (MSSRF, SAMBHAV, WASSAN, RRA network etc.) and FPOs that has traditional knowledge.
- ✓ All the data related to landraces and operations will be managed through an open-source digital platform.
- ✓ Landraces Seed Centers at block level by FPOs to get registered to enhance quality seed supply at community level.
- ✓ Paras Seed Certifiers at village level will be trained by different public institutions and universities to support certification of seed production of landraces at local level.

Role of Seed Banks in Natural Farming System:

Seed banks in natural farming often focus on preserving indigenous, heirloom, and traditional seed varieties. These seeds are adapted to local climates, soil conditions, and ecosystems, making them valuable for sustainable and natural agricultural practices.

Conservation of Biodiversity: Seed banks contribute to the conservation of agricultural biodiversity by storing a diverse range of seed varieties. This biodiversity is essential for the resilience of crops and ecosystems.

Community-Based Seed Banks: Some natural farming initiatives involve community-based seed banks where local communities actively participate in seed conservation. These seed banks may serve as communal resources for farmers practicing natural farming in the region.
Education and Outreach: Seed banks in natural farming often engage in educational and outreach activities to raise awareness about the importance of seed diversity, the value of traditional seeds, and the benefits of natural farming practices.

Promotion of Non-GMO Seeds: Natural farming principles often advocate for the use of non-GMO seeds. Seed banks may focus on collecting, storing, and distributing such seeds to support farmers committed to natural and sustainable farming methods.

Seed Exchange Programs: Some seed banks facilitate seed exchange programs, allowing farmers to share and trade seeds with one another. This practice promotes genetic diversity and strengthens community ties.

Resilience to Climate Change: Seeds stored in seed banks, particularly those adapted to local conditions, can serve as a valuable resource for farmers seeking resilient crops in the face of changing climate patterns.

Documentation of Traditional Knowledge: Seed banks often document traditional knowledge associated with specific seed varieties. This documentation may include information about planting techniques, cultural significance, and historical uses of the seeds.

Partnerships with Farmers and NGOs:

Seed banks may form partnerships with local farmers, non-governmental organizations (NGOs), and research institutions to collaborate on seed conservation efforts and promote sustainable farming practices.

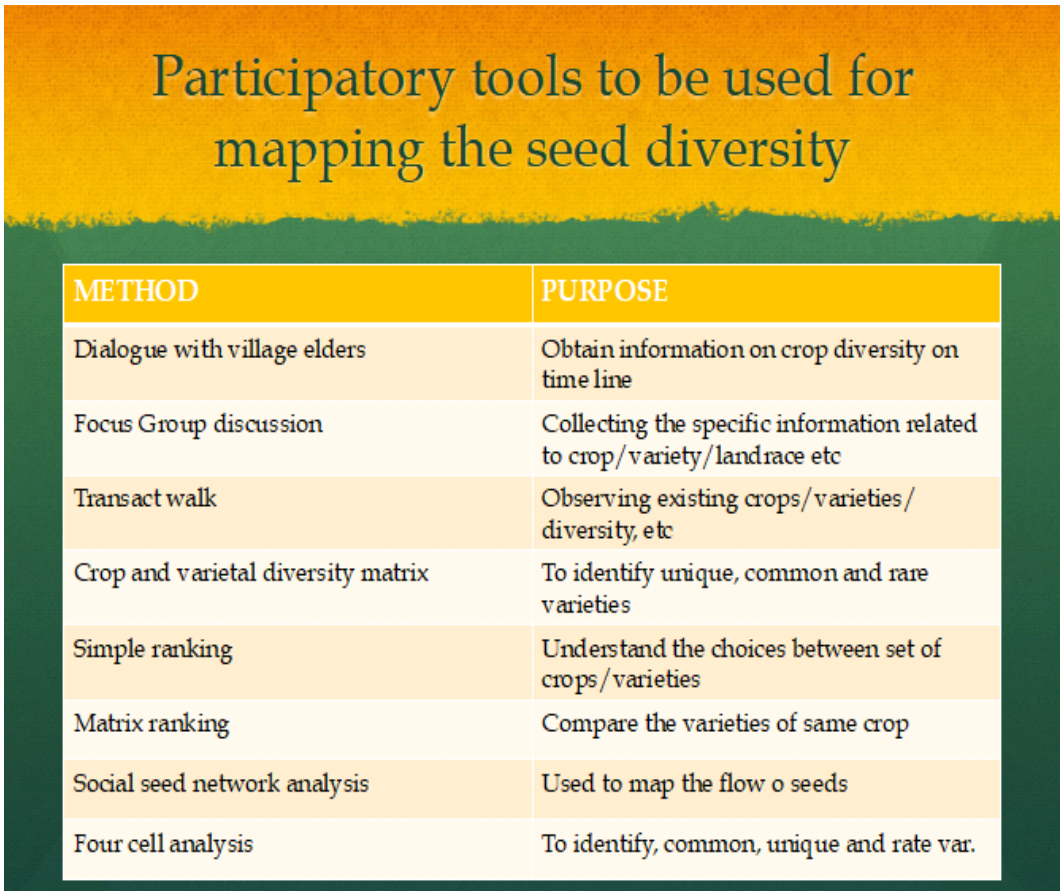
Seed Quality Control: Seed banks typically implement quality control measures to ensure the viability and purity of stored seeds. This includes regular monitoring, testing, and regeneration of seeds as needed.

Legal and Ethical Considerations: Seed banks may navigate legal and ethical considerations related to intellectual property rights, ensuring that seeds are stored and distributed in compliance with relevant laws and ethical principles.

Seed banks in the context of natural farming contribute to the overall sustainability of agriculture by safeguarding the diversity of plant genetic resources and supporting farmers who embrace eco-friendly and regenerative farming practices.

PRA Tools for mapping status of traditional cultivars.

Mapping- 4 cell analysis.



METHOD	PURPOSE
Dialogue with village elders	Obtain information on crop diversity on time line
Focus Group discussion	Collecting the specific information related to crop/variety/landrace etc
Transact walk	Observing existing crops/varieties/ diversity, etc
Crop and varietal diversity matrix	To identify unique, common and rare varieties
Simple ranking	Understand the choices between set of crops/varieties
Matrix ranking	Compare the varieties of same crop
Social seed network analysis	Used to map the flow o seeds
Four cell analysis	To identify, common, unique and rate var.

FOUR CELL ANALYSIS

When to use the tool

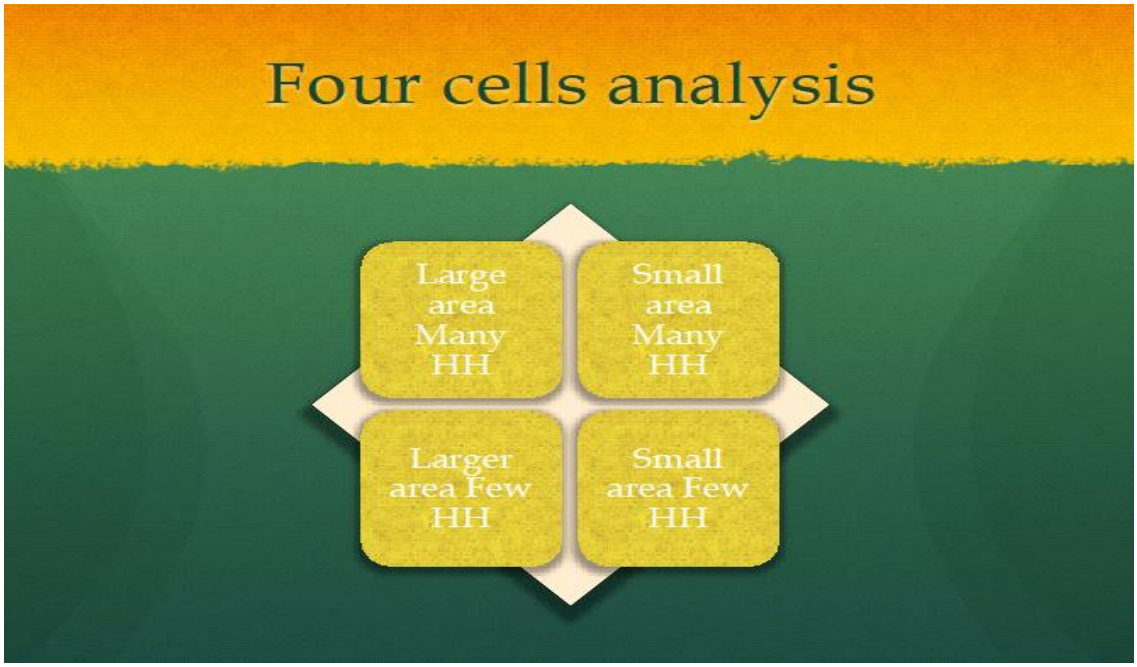
- The tool helps in identifying unique, common and rare varieties or crop species cultivated in a community
- It documents the reasons why crop species or varieties are in a dynamic stage within a community
- It further facilitates the identification of the interventions for the conservation of a crop species or variety within a specific community.

Materials: Four cell analyses can be done on the ground with real samples of the varieties/ crops, or on a large piece of paper with cards

Methodology

Step 1: Invite farmers and ask them to bring samples of each variety that they are growing.

Step 2: Make a large cross on the ground and distinguish the four categories



Step 3: The meaning of the four squares are visualized by drawing different numbers of houses and large or small fields

Step 4: The following questions are asked to the participants to get information on varieties crop species (name, specific traits, origin)

- What varieties/ crops are cultivated in **large areas** by **many** households?
- What varieties/ crops are cultivated in **large areas** by **few** households?
- What varieties/ crops are cultivated in **small areas by many** households?
- What varieties/ crops are cultivated in **small areas by few** households

Step 5: The participating group discusses the result, with special focus on the varieties to be grown in small areas and held by few households; these are the threatened varieties. The group discusses actions to increase cultivation.

The four-cell analysis method can be used to identify rare cultivars that have the potential to be revived based on the VCU of the cultivars. It takes into account factors such as the taste, nutritional value, and adaptability of the cultivar.

The identified cultivars can be conserved. It can be in situ conservation or Ex-situ conservation.

- In situ conservation is the preservation of plant genetic resources in their natural habitat. This can be done through a variety of methods, such as establishing protected areas, managing traditional farming practices, and supporting local seed banks.

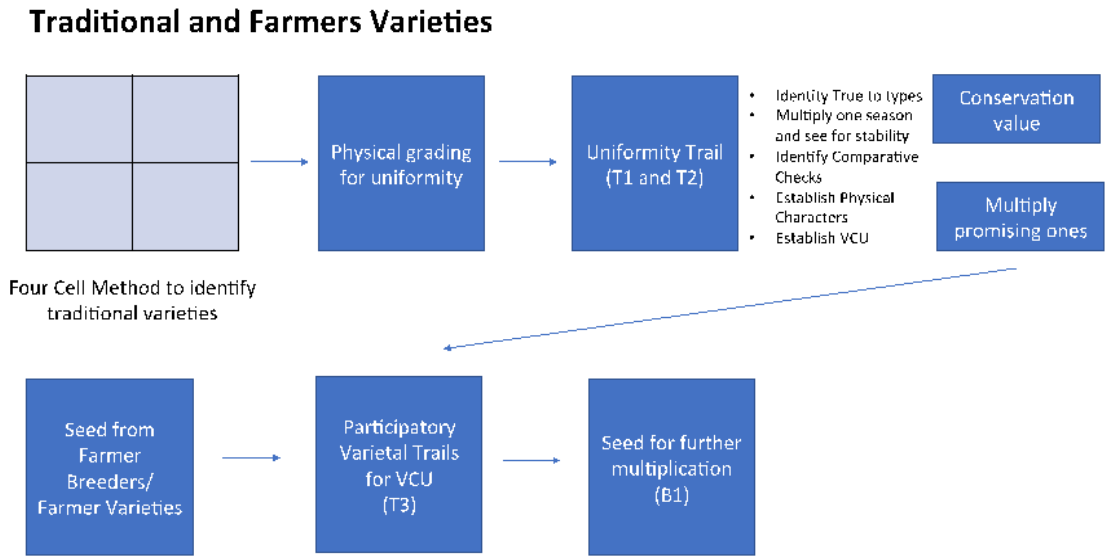
- Ex situ conservation is the preservation of plant genetic resources outside of their natural habitat. This is typically done in seed banks, which are facilities that store seeds under controlled conditions.

Some of the method of multiplication of traditional cultivars are

Cultivar Evaluation Trials.

Cultivar evaluation trials are conducted to compare the performance of different crop varieties under a specific set of conditions. The goal of these trials is to identify the varieties that are best suited for a particular environment and use.

The best-performing crop varieties can be evaluated by farmers based on their preferred traits, and then multiplied and supplied to farmers through community-based organizations (CBOs) or farmer producer organizations (FPOs).



Crop Production System

13. CROP PRODUCTION TECHNOLOGIES

Natural farming practices are often based on principles rather than specific technologies, there are several methods and approaches associated with this agricultural philosophy. However, it's important to note that the field of natural farming is diverse, and practices can vary based on regional and cultural contexts. Here are some key crop production technologies and practices commonly associated with natural farming.

Zero or Minimum Tillage: Natural farming often promotes minimal tillage or no-till practices. Reduced soil disturbance helps preserve soil structure, minimize erosion, and support beneficial soil organisms.

Cover Cropping: Planting cover crops, such as legumes and grasses, helps protect and improve soil health. Cover crops contribute to weed suppression, nutrient cycling, and the enhancement of soil organic matter.

Crop Rotation: Crop rotation is employed to break pest and disease cycles and improve soil fertility. Rotating different crops through the same field helps maintain a balanced and resilient agroecosystem.

Agroforestry: Agroforestry integrates trees and shrubs into agricultural landscapes. This practice enhances biodiversity, provides shade, conserves water, and contributes to carbon sequestration.

Natural Fertilizers: Instead of synthetic fertilizers, natural farming utilizes organic fertilizers such as compost, manure, and cover crop residues. These materials contribute to soil fertility, improve structure, and promote beneficial microbial activity.

Effective Microorganisms (EM) Technology: Effective Microorganisms (EM) technology involves the use of beneficial microorganisms to enhance soil fertility and plant health. EM solutions, typically composed of various beneficial bacteria and yeast, are applied to the soil and plants.

Mulching: Mulching with organic materials such as straw or cover crop residues helps conserve soil moisture, suppress weeds, and regulate soil temperature. Mulching also contributes to the improvement of soil structure.

Biological Pest Control: Natural farming encourages the use of biological pest control methods, such as the introduction of beneficial insects, crop diversification, and the promotion of predator-prey relationships to manage pests without synthetic pesticides.

Companion Planting: Companion planting involves growing different crops together to enhance each other's growth and deter pests. This practice promotes biodiversity and reduces the risk of pest and disease outbreaks.

Seed Ball Technology: Seed ball technology involves encapsulating seeds in a mixture of clay, compost, and sometimes other materials. These seed balls can be scattered over fields, promoting natural seed dispersal and germination.

Natural Pesticides and Fungicides: Natural farming utilizes plant-based extracts, such as neem oil, garlic, and chili, as well as fermented plant extracts, to create natural pesticides and fungicides for pest management.

Water Conservation Technologies: Techniques such as rainwater harvesting, drip irrigation, and water-efficient practices help conserve water resources and improve the efficiency of water use in natural farming.

Polyculture and Diversification: Instead of monoculture, natural farming often involves planting a variety of crops together. Polyculture and diversification enhance resilience, reduce the risk of crop failure, and promote ecological balance.

These technologies collectively contribute to the principles of natural farming, emphasizing sustainable and regenerative practices that prioritize soil health, biodiversity, and the overall well-being of the agroecosystem. The specific application of these technologies may vary based on local conditions and the goals of individual farmers practicing natural farming.

Crop production technologies involves,

Land preparation

The goal of land preparation is to create the ideal soil environment that will facilitate the development of growing plants. Tillage refers to the mechanical manipulation of the soil using tools and implements in order to improve soil conditions for better seed germination and subsequent crop growth. Conservation tillage is a unique type of soil cultivation used in natural farming systems. It involves leaving crop residue from the previous year on fields before and

after the next crop is planted, which has the added benefit of reducing soil erosion and runoff as well as carbon sequestration.

Major advantages of conservation tillage include

- Enhances soil water infiltration, minimizing nitrate and water runoff as well as erosion.
- Enhances soil surface stability against wind erosion and the discharge of dust and other airborne particles.
- Less nutrient leaching since there is more soil organic matter to supply binding sites.
- Reduces evaporation and boosts soil moisture retention, increasing harvests in years of drought.
- Reduces the vehicle traffic in the field level, which lowers the cost of fossil fuel and lowers the emissions of carbon into the atmosphere.
- Due to higher soil organic matter levels that result in less leaching, higher infiltration rates with more surface residue result in less runoff moisture retention capacity.

Crop and variety selection

The selection of crop and varieties plays an important role in crop production and it is consider as non-monetary inputs. The selection of crop and variety should be based on the available resources and must withstand under the biotic and abiotic stress.

A) Seasonality Based

- Crops grown in the Kharif season include rice, maize, sorghum, bajra, ragi, and small millets.
- Crops grown during the Rabi season include wheat, barley, oats, chickpeas, sorghum, potatoes, rapeseed, and mustard.
- Crops grown throughout the summer include sesame, black gram, and green gram.

B) Considering Rainfall

- 10-20 cm/month for at least 3 months - bajra, tiny millets
- 30 cm/month for at least 3 months - rice
- 20–30 cm/month for at least 3 months- maize/black gramme
- Monthly rainfall of 5 to 10 cm favours grass
- Less than 5 cm is unsuitable for crop production.

C) Depending on the length of the growing season

- 20 weeks - Single crop

- 20–30 weeks - Single crop plus Inter crop
- 30 weeks - Sequential planting of two crops

Treatment of seeds

In natural farming, seed treatment involves using natural and non-synthetic methods to enhance seed quality, promote germination, and protect seeds from diseases and pests. The focus is on avoiding the use of chemical treatments and instead utilizing environmentally friendly approaches. Here are some common seed treatment practices in natural farming:

Seed priming involves pre-soaking seeds in water to initiate the early stages of germination. This can enhance uniform germination, reduce the time it takes for seeds to sprout, and improve seedling vigor. Priming is often done with plain water or natural solutions such as aloe vera or herbal extracts.

Microbial Inoculants Seed Coating: Instead of synthetic pesticides, natural farming may involve coating seeds with bio-pesticides derived from plant extracts or microbial sources. These coatings can help protect seeds from soil-borne pathogens and pests.

Beejamritham seed treatment

Beejamrita, an organic liquid manure, is used to treat the seeds of several crops. It is a potent treatment that guards the seed from numerous bacterial and fungal illnesses. Before sowing/ planting, seeds, plants, seedlings, or any other planting material can be treated with Beejamrutha. It is beneficial in preventing fungus growth on young roots. It is the second pillar of natural farming with. It is made via a fermentation method using components found on the farm itself.

Procedure: Gather the seeds in a cotton cloth. Before applying the solution to the seeds, stir the solution once more in a circular motion. Place the bundle of seeds there after dipping it in the Beejamrita solution until it is completely submerged. After that, take the seed bundle out and let it dry in a shaded place. Avoid rain and harsh sunlight on it.

The seed treatment is done for the following purposes:

- To ward off or fend off birds and vermin
- To provide nutrients to plants
- To provide resistance against pathogens
- To end the dormancy of seeds
- To promote tolerance for drought
- To promote early emergence and a greater germination percentage

Sowing

It is the act of putting plant propagules (such as seeds, seedlings, cuttings, rhizomes, clones, tubers, etc.) in the ground to become plants.

Methods of Sowing

- **Broadcasting** - Broadcasting is the act of scattering or distributing seeds on the ground. The simple, rapid, and inexpensive way of seeding is broadcasting. Uneven distribution, incorrect seed placement, less soil cover, and compaction are problems with broadcasting. Germination, seedling vigor, and establishment are not uniform due to the fact that all of the seeds are not sown in the same density and depth. It works well for crops with small, closely spaced seeds.
- **Dibbling:** Using a planter, a dibbler, or frequently by hand, seeds are inserted into a hole or pit that has been dug at a specific depth (2-3cm) and with a predetermined spacing. Compared to broadcasting, dibbling is more time-consuming, expensive, and labor-intensive. But this method reduces the seed rate and also ensures the good germination and also vigorous seedling growth.
- **Sowing behind the country plough** is an activity in which a person working behind a plough sows seeds into the furrow either constantly or at the necessary intervals. The soil sealing the furrow prevents the seeds in the prior furrow from germinating when the plough cuts the next adjacent furrow. The depth of the plough furrow can be changed to alter the depth of sowing.
- **Drilling**: This technique involves placing seeds at a precise depth before compacting the soil around them. Seed drills are used for this purpose. Rows of seeds are constantly drilled or drilled at regular intervals. Although it takes more effort, money, and time, it keeps the population density per unit area constant.
- **Planting** – It entails firmly burying seeds or seed material in the ground.

CROP GEOMETRY

In a crop field, it refers to the way that plants are distributed throughout the surface or the form of the space that each plant has access to. Seeds should be planted with the right space. If the plant density per unit area increases, the yield per plant steadily declines.

SYSTEM OF ROOT INTENSIFICATION

It started in 1980s as System of Rice Intensification in Medagaskar. It spread to India and more than 70 other countries. In India it started in 2000-2001 through ex-scientists, various

Civil Society Organizations and State Rural Livelihood Missions under NRLM, MORD. The principles were successfully demonstrated in various crops. Principles of System of Root Intensification are as follows:

- Young age seedlings
- Use of organic manures and fertilizers/plant protection measures
- Use of weeders for aerating soil and incorporating weeders
- Alternate Wetting and Drying
- Proper spacing of seedlings
- Priming and Treatment of seeds/seedlings

INTERCROPPING

Intercropping is the simultaneous cultivation of two or more different crops on the same plot of land at the same time. The principal crop is appropriately mixed with the additional plant density of the related crop, which must be in a distinct row arrangement and have its recommended maximum plant population. The goal is to increase crop production per unit area by raising plant population pressure and intensifying cropping in both the temporal and spatial dimensions. Compared to solo cropping, it uses growth resources more effectively. Both legumes and non-legumes are typically grown. The benefits of intercropping are as follows:

- Increased revenue from the companion crop
- Companion crops may provide subsistence income if the main crop is harmed by unfavourable conditions like drought, flood, epidemics, etc.
- By fixing nitrogen, legumes cultivated as companion crops always help the main crop and also draw moisture from deeper soil layers.
- Effective labour utilisation by increasing the number of man days available for employment
- Quick-growing companion crops always reduce the damaging weeds thriving in the intervals between the main crops
- More effective use of the nutrients, water, light, and space needed for growth
- A decrease in the frequency of disease and insect attacks
- A decrease in erosion losses.
- Generates money just prior to the long-duration main crop's harvest.

Intercropping can produce successful results if an appropriate companion crop is chosen to grow alongside the primary crop. Knowing the prerequisites of the companion crops, such

as soil and water requirement, competition for space, sunshine, and air, crop duration, yielding potential, time of sowing and harvesting, is crucial before putting any intercrop with the main crops, such as sugarcane, maize, sorghum, or bajra. On the basis of the aforementioned knowledge, some appropriate combinations are:

Principal Crop	Intercrop
Sugarcane	Wheat, cowpea, soybean, moong, sunflower
Sorghum	Cowpea, soybean, moong, urd, arhar
Maize	Cowpea, soybean, urd, arhar, castor
Bajra	Cowpea, soybean, urd, arhar, castor
Cotton	Soybean, groundnut
Potato	Wheat, radish

CROP ROTATION

Crop rotation is a traditional agricultural practice that involves growing different crops in a planned sequence on the same piece of land over several seasons. This practice is designed to improve soil health, reduce pest and disease pressure, optimize nutrient use, and enhance overall crop productivity. In the context of natural farming, crop rotation is a key strategy for regenerative agriculture.

Natural farming emphasizes the importance of biodiversity. Crop rotation involves planting a variety of crops with different growth habits, nutrient requirements and susceptibility to pests and diseases. This diversity helps break pest and disease cycles and promotes a balanced ecosystem.

Crop rotation allows for the efficient use of nutrients in the soil. For example, leguminous crops in the rotation can fix nitrogen, benefiting subsequent crops that require this essential nutrient.

General recommendation for practicing crop rotation

- Plant a crop that requires lots of nitrogen after a crop of legumes.
- After a legume, in the second or third year, plant less nitrogen-demanding crops.
- Plant annual crops for a single season in a specific site.
- Avoid planting a crop after a closely related species.
- Make use of crop successions that encourage healthier crops.
- Use crop rotations to keep weeds under control.

- As part of the rotation, try to cultivate a crop with deep roots.
- Plant some crops that will produce a lot of residue.

WEED MANAGEMENT

Weeds are unwanted and unattractive plants that negatively impact human welfare by interfering with the use of land and water resources. They may alternatively be called "plants in the wrong place." Weeds constitute a significant challenge in non-cropped areas such industrial sites, road/rail lines, air fields, landscape plantings, water tanks and water ways, etc. because they compete with the desirable and helpful plants in crop lands, woods, aquatic systems, etc.

Weed control measures include weed prevention, eradication, and control through controlled use, invasion restriction, growth suppression, seed prevention, and total elimination. So, one part of weed management is weed control. (This is discussed in detail in a separate session.)

BIOLOGICAL CONTROL

Biocontrol is the employment of living creatures to reduce a pest population's abundance, which makes it less harmful than it would otherwise be. Biological control refers to the use of live organisms or bioagents, such as insects, pathogens, herbivorous fish, snails, or even competitive plants, to manage weeds. Encourage natural predators, such as ladybugs, lacewings and predatory beetles, to control pest populations in natural farming and use botanical extracts, like neem oil or garlic spray, as natural pesticides to control pests were followed. Encouraging the beneficial microbial populations, such as beneficial bacteria and fungi, to enhance soil health and suppress soil-borne diseases.

IRRIGATION MANAGEMENT

Irrigation is the artificial application of water intended to make up for the insufficient soil moisture that does not fully fulfil the needs of growing crops. To increase the production of agricultural and horticultural crops, irrigation is simply the practice of supplemental natural precipitation. The art and science of irrigation management involves applying water from a source to an agricultural field.

There are three different irrigation techniques: Surface irrigation, subsurface irrigation, and pressurized irrigation (drip and sprinkler irrigation).

Surface irrigation

The phrase "surface irrigation" describes water delivery methods that use an overland, gravity-fed water flow to water crops. It includes various methods of irrigation like flooding, check basin method, ring basin method and border strip method etc.

Subsurface irrigation

Through a system of subsurface perforated or open jointed pipes, water is supplied underneath the surface of the land. These pipelines allow water to flow under pressure, and the water exits through open joints. To ensure that they do not interfere with the crop, pipes should not be any shallower than 40 cm. Losses from evaporation are decreased. The procedure is costly due to the high cost of the installation and the pipes. To prevent the perforation from being clogged, the water utilized should be of high quality.

Pressurized irrigation

Both drip irrigation and sprinkler irrigation are pressurized irrigation techniques that apply water through a network of tubes using pressure devices. Pressurized irrigation systems use a network of pipes to pressurize water that is then carefully applied to the plants under pressure. Surface irrigation methods are less efficient in applying irrigation water to crops than pressurized irrigation systems. This method offers better agricultural distribution, better time control, less land wastage for irrigation layout, less labour demand, and better use of scarce water resources.

Mulching in irrigation management

Mulching is a widespread practice that involves spreading materials such as crop residues, agricultural leftovers, livestock manure, etc. over the soil surface in the field before or shortly after planting. Mulching is primarily used to reduce evaporation or water erosion, raise soil temperature, increase the capacity of the soil to hold water, and control weeds. Mulching encourages plant growth, increases crop yields, reduces water losses and also controls weeds. Mulch to the soil surface to conserve moisture, suppress weed growth and regulate soil temperature.

Nutrient Management

A common framework for approaching nutrient management is known as the “Four R’s”:

- Right amount - the proper rate of application
- Right source - applying the proper type
- Right placement - using the appropriate method for application
- Right timing - applying at the correct time in the lifecycle of the system

Crop rotation, cover crops, decreased tillage, and the use of compost are some of the techniques used in organic agriculture systems to increase soil fertility. Less carbon is lost to the atmosphere due to reduced tillage, which results in more soil organic carbon. This prevents soil from becoming inverted and exposed to air. A few industrial fertilisers, including de-oiled cakes, bone meal, biofertilizers, and a variety of mineral powders, including rock phosphate and green sand, a potassium-rich type of potash that occurs naturally. Lime and sulphur are examples of natural pH supplements that can be used when the pH has to be changed.

Jeevamrutha

It is an inexpensive, fermented, microbial preparation that enhances soil mineralization while enriching the soil and promoting the proliferation of microorganisms. It is one of the major inputs in the natural farming. It also provides resistance to pests and diseases, encourages the activity of beneficial organisms, and increases the amount of organic carbon in the soil.

Composting

Composting involves the decomposition of organic materials to create nutrient-rich compost, which can be used to improve soil fertility, structure, and overall health. In natural farming, the emphasis is on working with nature and promoting biodiversity while minimizing the use of synthetic inputs.

Composting is a natural process in natural farming and its aim is to balanced carbon-to-nitrogen ratio, facilitating the decomposition process and also encourage microbial activity by providing aeration and maintaining proper moisture levels. Turning the compost regularly helps oxygenate the pile and promote the growth of beneficial microorganisms.

Earthworms and other decomposers play a crucial role in breaking down organic matter, so their presence is generally encouraged in natural farming.

Green Manuring

Green manuring is the process of growing leguminous and other plants in the field, and incorporating into the soil when they reach the 50% flowering stage. *Crotalaria juncea, Sesbania bispinosa, Phaseoulus trilobus, and Sesbania rostrata* are the most significant green manure crops. In natural farming, green manuring is often employed as a way to enrich the soil with organic matter, nitrogen, and other essential nutrients.

Greenleaf manuring

Green leaf manuring is the application of green leaves and twigs of trees, shrubs, and plants that have been collected from elsewhere. The primary sources of green leaf manure are forest tree leaves. Another source of green leaf manure is vegetation that grows in wasteland, field bunds, etc. Neem, mahua, wild indigo, Glyricidia, Karanji (*Pongamia glabra*), calotropis, *Sesbania grandiflora*, subabul, and other shrubs are significant plant species suitable for producing green leaf manure.

Plant protection Measures

Pest and disease management in natural farming relies on ecological principles and sustainable practices to minimize the use of synthetic chemicals. The goal is to create a balanced and resilient ecosystem that can naturally regulate pests and diseases.

This is discussed in detail in next chapters.

Harvesting and processing

Harvesting should be done based on the duration of the crop, maturity symptoms. Typically, the grain is harvested 10 to 15 days after it reaches physiological maturity. The grain has a certain moisture content and unique physical features as it reaches maturity. The length of the growing cycles, which varies depending on the crop and variety, and the level of grain maturity are used to identify the best time to harvest.

The grain should be harvested when its moisture level is between 15% and 20%. Clearly, the risk of losses from moulds, insects and germination increases with the grain's moisture content at harvest. The risk of losses owing to grain breaking or from attacks by birds, rats and other pests, however, increases the longer the grain is left in the field (for further drying of the product).

The harvested crop parts are dried, threshed, and the grains are segregated for storage after the crops are harvested. To boost the income, the right processing techniques are used based on the crop's characteristics.

Harvesting and processing in natural farming are crucial steps that need careful attention to maintain the principles of this approach. Here are some key aspects of harvesting and processing in natural farming:

Natural farmers often rely on keen observation of natural cycles and indicators to determine the optimal time for harvesting. This may include the stage of maturity of the crop, weather conditions, and other environmental factors. Whenever possible, natural farmers prefer

hand harvesting over mechanized methods to minimize damage to plants and soil structure. Natural farming often involves growing a variety of crops together, promoting biodiversity. Harvesting practices should consider the mixed nature of the crops and their respective maturity times.

Traditional methods of processing, such as fermentation and natural preservation techniques, may be preferred over modern industrial methods. Natural farmers often engage in seed saving to preserve heirloom varieties and maintain genetic diversity. This involves collecting seeds from the healthiest and most robust plants for future planting.

14. WEED MANAGEMENT IN NATURAL FARMING

Weed management in natural farming focuses on sustainable method to control weeds without relying on synthetic chemicals. Natural farming emphasizes working with natural processes to maintain a balanced and healthy ecosystem.

Need of Weed Management in Natural Farming

Weeds are essential and are used as living or dead mulch layers in natural farming. However, Weeds are the most important biotic constraints to increase agricultural productivity and farmers' income in both developing and developed countries. It is also a major constraint to increase agricultural productivity and farmers' income, particularly in developing countries like India. In general, weeds cause the highest potential yield loss to crops along with pathogens (fungi, bacteria, etc.) and animal pests (insects, rodents, nematodes, mites, birds, etc.). In India, reduction in crop yield was estimated as 31.5% (22.7% in winter and 36.5% in summer and rainy seasons) by weeds. Actual economic losses were high in the case of rice (USD 4420 million) followed by wheat (USD 3376 million) and soybean (USD 1559 million). Thus, annual total actual economic loss of about USD 11 billion was estimated due to weeds alone in 10 major crops of India viz. groundnut (35.8%), soybean (31.4%), greengram (30.8%), pearlmillet (27.6%), maize (25.3%), sorghum (25.1%), sesame (23.7%), mustard (21.4%), direct-seeded rice (21.4%), wheat (18.6%) and transplanted rice (13.8%). Yield losses in crops due to weeds depend on several factors such as weed emergence time, weed density, type of weeds and crops, etc. Left uncontrolled, weeds can result in 100% yield loss. Weeds compete with crops for sunlight, water, nutrients and space. In addition, they harbor insects and pathogens, which attack crop plants. Furthermore, they destroy native habitats, threatening native plants and animals.

Weeding is completely restricted in natural farming; therefore, yield and economic losses are higher in natural farming when compared to modern agriculture. Hence it is essential to follow suitable weed management practices without affecting the concepts of natural farming to boost the crop productivity.

Methods of Weed Management

To achieve higher yield and income by managing weeds in natural farming, some of the suitable weed management practices are discussed below. However, none of the single method is effective for all weeds and to manage weeds effectively and sustainably in the long run, it is essential to integrate possible weed management practices for natural farming.

1. Use of Weed Free Seeds

Use clean seed that is free from weed seeds for sowing purpose. Inspect seed, necessary stocks for the presence of weed seeds, tubers, rhizomes, weed seedlings etc. The cropped area, bunds, irrigation channels etc. should be kept clean or free of weeds. Keep threshing yard and manure pits free from weeds.

2. Selection of Variety

Careful selection of crop varieties is essential to limit weeds problems and to satisfy market needs. Any crop variety that is able to quickly shade the soil between the rows is able to grow more rapidly than the weeds will have an advantage.

3. Crop Rotation

Crop rotation involves alternating different crops in a systematic sequence on the same land. It is an important strategy for developing a sound long term weed control program. Weeds tend to thrive with crops of similar growth requirements as their own and cultural practices designed to contribute to the crop may also benefit the growth and development of weeds. Monoculture, that is growing the same crop in the same field year after year, results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, etc). Rotate crops regularly to disrupt the life cycle of specific weeds and prevent them from establishing persistent populations.

Within a rotation, crop choice will determine both the current and the potential future weed problems that a grower will face. Traditionally, potato (*Solanum tuberosum* L.) is included in the rotation to reduce weed problems before a less competitive crop was grown. For an organic grower, crop choice is complicated further by the need to consider soil fertility levels within the cropping sequence and to include fertility building periods in the rotation. Variations in crop and weed responses to soil nutrient levels can also play an important part in weed management. The inclusion of a fallow period in rotation will reduce perennial weeds. It is best to alternate legumes with grasses, spring planted crops with fall planted crops, row crops with close planted crops and heavy feeders with light feeders.

4. Planting Patterns

Crop population, spatial arrangement, and the choice of cultivar (variety) can affect weed growth. For example, studies have shown that narrow row widths and a higher seeding

density will reduce the biomass of later-emerging weeds by reducing the amount of light available for weeds located below the crop canopy. Similarly, fast growing cultivars can have a competitive edge over the weeds.

5. Intercropping

Intercropping involves growing a smother crop between rows of the main crop. Intercrops are able to suppress weeds and minimize soil erosion. When legumes are included as intercrop, it fixes atmospheric nitrogen in the soil and enhances soil fertility. However, the use of intercropping as a strategy for weed control should be approached carefully. The intercrops can greatly reduce the yields of the main crop if competition for water or nutrients occurs.

6. Cover Crops

Rapid development and dense ground covering by the crop will suppress weeds. The inclusion of cover crops such as rye, red, clover, buckwheat and oilseed radish or over wintering crops like winter wheat or forages in the cropping system can suppress weed growth. Highly competitive crops may be grown as short duration 'smother' crops within the rotation. Additionally, cover crop residues on the soil surface will suppress weeds by shading and cooling the soil. When choosing a cover crop, consideration should always be given to how the cover crop will affect the succeeding crop. In addition, decomposing cover crop residues may release allelochemicals that inhibit the germination and development of weed seeds.

7. Mulching

Mulching or covering the soil surface can prevent weed seed germination by blocking light transmission preventing seed germination. Mulches physically suppress weed seeds emergence. There are many forms of mulches available. The following two are suitable for natural farming.

a. Living mulch: Living mulch is usually a plant species that grows densely and low to the ground such as clover. Living mulches can be planted before or after a crop is established. It is important to kill ad till in, or manage living mulch so that it does not compete with the actual crop. A living mulch of Portulaca oleracea from broadcast before transplanting broccoli suppressed weeds without affecting crop yield. Often, the primary purpose of living mulch is to improve soil structure, aid fertility or reduce pest problems and weed suppression may be merely an added benefit.

b. Organic mulches: Materials such as straw, bark, and composted material can provide effective weed control. Producing the material on the farm is recommended since the cost of purchased mulches can be prohibitive, depending on the amount needed to suppress weed emergence. An effective but labor-intensive system uses newspaper and straw. Two layers of newspaper are placed on the ground, followed by a layer of hay. It is important to make sure the hay does not contain any weeds seeds. Organic mulches have the advantage of being biodegradable. Cut rye grass mulch spread between planted rows of tomatoes and peppers was more economic than cultivation. Fresh bark of conifers and oak as well as rapeseed straw gave good control of weeds when they were laid as mulches under the trees in apples orchards.

8. Field Scouting

It involves the systematic collection of weed and crop data from the field (weed distribution, growth stage, population, crop stage etc.). The information is used, in the short term, to make immediate weed management decisions to reduce or avoid economic crop loss. In the long term, field scouting is important in evaluating the success or failure of weed management programs and for making sound decisions in the future.

9. Water Management

Water management is a crucial aspect of natural farming, and it can play a significant role in weed control. Proper water management helps create conditions that are less favorable for weed growth while supporting the needs of cultivated crops.

Buried drip irrigation minimizes weed growth in natural farming. Drip tape buried below the surface of the planting bed can provide moisture to the crop and minimize the amount of moisture that is available to weeds closer to the surface. If properly managed, this technique can provide significant weed control during dry period.

10. Allelopathy

Allelopathy is the direct or indirect chemical effect of one plant on the germination, growth or development of neighboring plants. It is now commonly regarded as component of biological control. Species of both crops and weeds exhibit this ability. Allelopathic crops include barley, rye, annual ryegrass, buckwheat, oats, sorghum, sudan sorghum hybrids, alfalfa, wheat, red clover, and sunflower. Vegetables, such as horseradish, carrot and radish, release particularly powerful allelopathic chemicals from their roots. Suggestions have been made that allelochemicals and other natural products or their derivatives could form the basis of bio

herbicides. However, it is unclear whether the application of natural weed killing chemicals would be acceptable to the organic standard authorities.

It's important to note that while allelopathy can be a useful tool in natural farming, careful planning and observation are essential. Some allelopathic compounds can have detrimental effects on desired crops if not used judiciously. Additionally, the allelopathic potential of plants can vary, and not all allelopathic crops may be effective against the same set of weed species.

Integrating allelopathic methods into a comprehensive weed management strategy, along with other natural farming practices, can contribute to a more sustainable and holistic approach to farming.

Cultural weed control

To create favourable conditions for the crop, a variety of cultural practices including tillage, planting, fertiliser application, irrigation, etc., are used. If carried out appropriately, these methods aid in weed control. While cultural approaches cannot completely eradicate weeds, they can help to reduce their population. As a result, they ought to be employed in addition to other strategies. Tillage, fertiliser application, and irrigation are crucial in cultural practices. In addition, factors including variety choice, sowing method, cropping strategy, farm hygiene, etc., can all help reduce weed growth.

Field preparation

Weeds must be kept out of the field. Weeds shouldn't be permitted to flower. This aids in reducing the growth of the weed seed population.

Seasonal tillage

One of the most successful cultural practices to slow the spread of perennial weeds in crop cultivation is the use of summer or off-season tillage.

Optimal plant population maintenance

Lack of sufficient plant population makes weed infestations more likely and later more challenging to eradicate. To achieve a proper and uniform crop stand that can compete with weeds, practices including proper seed selection, appropriate sowing technique, adequate seed rate, protection of seed from soil transmitted pests and diseases, etc., are crucial.

Crop Rotation

If the same crop is planted year after year, the likelihood of a certain weed species or set of species emerging is higher. Crop rotation often eliminates or at least significantly reduces

problematic weed issues. By integrating low land rice in crop rotation, noxious weeds like *Cyperus rotundus* can be efficiently controlled.

Companion Planting: Planting certain crops together can help deter weeds. For example, using cover crops or companion plants that have allelopathic properties may suppress weed growth. Companion planting can also attract beneficial insects that contribute to natural pest control.

Polyculture: Growing multiple crops in the same area can create a diverse and resilient ecosystem that makes it more challenging for weeds to dominate. Polyculture systems enhance biodiversity, improve soil health, and contribute to a more balanced agroecosystem.

Intercropping

The ability to use crops as weed control techniques is made possible by the fact that intercropping suppresses weeds more effectively than solitary cropping. Numerous short-lived pulses, such as moong and soybean, effectively smother weeds without affecting main crop's yield.

Mulching

Mulch is a substance that is kept on top of the soil surface as a protective layer. Mulching inhibits top growth by blocking light from a plant's photosynthetic areas, which has a suffocating impact on weed control. It is extremely powerful against some perennial weeds, such as *Cynodon dactylon*, as well as annual weeds.

Stale seedbed

When the first one or two flushes of weeds are eliminated before planting a crop, the seedbed is said to be "stale." This is accomplished by soaking a field that has been properly prepared with irrigation or rain and letting the weed seeds develop. A non-residual pesticide like paraquat or shallow tillage can be employed at this point to eradicate the profusion of early weed plants.

Blind tillage

Blind tillage is the term for soil preparation done after a crop is sown but before the crop plants actually start to grow. When emergence of crop seedlings is hampered by soil crust created on receipt of rain or irrigation soon after sowing, it is frequently used to reduce weed intensity in drill sowing crops.

Weeds are major threat for crop production and challenge for successful natural farming. Adopting of effective weed management practices will enhance the crop productivity

and income of the farmers involved in natural farming. In addition to the growing concern for protection of environment, maintain biodiversity and protection of human and animal health, integrated weed management approaches are needed and more of research efforts are required to develop low cost and environment friendly weed management practices without altering the core concept of natural farming.

Cultural weed control in natural farming involves a combination of practices tailored to the specific conditions and crops grown on a particular farm. Regular observation, adaptation, and a holistic understanding of the agroecosystem are key components of successful cultural weed management.

Mechanical Weed Control

Mechanical weed management in natural farming involves the use of physical tools and equipment to control weeds without relying on synthetic chemicals. This method aligns with the principles of natural farming by promoting sustainability and minimizing environmental impact. The mechanical methods include tillage, hoeing, hand weeding, sickling, mowing, burning, floods, mulching, and digging.

Tillage

Weeds are killed by tillage because it removes them from the soil. By damaging the pruning of the roots and stems, it may harm plants by lowering their ability to compete or regenerate. Also, weeds are buried by tillage.

Hoeing

The best and most popular weeding instrument for ages has been the hoe. It is still a really helpful tool for getting results quickly and affordably, though. For row crops, it is an addition to the cultivator. Hoeing can totally eradicate weed growth, making it especially more effective on annuals and biennials.

Weeding by hand

It is accomplished physically by pulling weeds out by hand or by using tools called khurpis, which resemble sickles. It is most likely the earliest method of weed control, and it is still a useful and effective way to get rid of weeds in both cropped and uncropped regions.

Mowing and sickling

In order to starve the subsurface sections of weeds and hinder seed formation, sickling is also done by hand with the aid of a sickle. It is common in muddy places where only the tall

weed growth is sickled, leaving the soil's root system to retain the soil and avoid soil erosion. The majority of the time, machines are used to mow lawns and the sides of roadways.

Adjustable Row Spacing: Designing planting configurations with wider row spacing can make it easier to use mechanical tools and equipment for weed management. This can improve accessibility and reduce competition between crops and weeds.

Burning

Burning weeds in natural farming is generally not recommended as a primary weed management practice. Natural farming emphasizes sustainable and environmentally friendly methods that work with, rather than against, the natural ecosystem. Burning weeds can have several drawbacks:

1. Soil Health Impact: Burning weeds can lead to a loss of organic matter in the soil, reducing soil fertility. The heat from burning can also alter soil structure, potentially damaging the soil's physical properties.
2. Loss of Beneficial Organisms: Soil microorganisms, beneficial insects, and other organisms essential for a healthy ecosystem can be harmed or destroyed by the intense heat from burning.
3. Air Quality Concerns: Burning releases particulate matter and pollutants into the air, contributing to air pollution. This can have adverse effects on human health, especially for those with respiratory issues.
4. Weed Seed Survival: Some weed seeds may survive the burning process, potentially leading to new weed growth after the burn.

Instead of burning, consider alternative methods for weed management in natural farming, as mentioned in the previous response. Mulching, cover cropping, crop rotation, hand weeding, and other organic practices are generally more aligned with the principles of natural farming. These methods promote soil health, maintain biodiversity, and minimize negative environmental impacts.

If you are facing persistent weed issues, it's crucial to understand the specific weeds present, their life cycle, and the conditions that favor their growth. Tailoring your weed management strategy to address these specifics will contribute to a more sustainable and effective natural farming approach.

Using fire or burning is frequently a cost-effective and useful way to get rid of weeds. It is employed in conditions when cultivation and other conventional procedures are impractical to (a) get rid of vegetation (b) destroy adult weeds' dry tops, and (c) kill green weed development.

Flooding

Against weed species that are susceptible to prolonged submersion in water, flooding is effective. By limiting the amount of oxygen available for plant growth, flooding destroys plants. The success of flooding hinges on the weeds being completely submerged for longer periods of time.

Biological Weed Control

Biological control agents in natural farming refer to living organisms that are encouraged to control weeds in an ecological and sustainable manner.

Introducing Beneficial Insects: Encourage and introduce beneficial insects that are natural predators of weed seeds, larvae, or adult stages. Examples include ladybugs, predatory beetles, and parasitic wasps that can help control specific weed pests.

Biological Herbicides: Some microbial-based herbicides, such as those containing beneficial bacteria or fungi, can be used for weed control. These products may target specific weed species while having minimal impact on non-target plants and the environment.

Biological Control Agents: Identify and release natural enemies of specific weed species, such as insects, mites, or pathogens, as biocontrol agents. Thorough research is necessary to ensure that the introduced agents are specific to the target weed and do not harm beneficial species.

Soil Microorganisms: Foster a healthy soil microbial community, as certain microorganisms can compete with weeds for nutrients or produce substances that inhibit weed growth. Practices such as adding compost and other organic matter can contribute to a thriving soil microbiome.

Phytotoxic Plants in Crop Rotation: Include crops with phytotoxic properties in rotation to suppress weed growth. These crops release substances that inhibit the germination or growth of certain weeds.

Utilizing Birds for Seed Predation: Attract and provide habitat for birds that feed on weed seeds. Birds, such as sparrows and finches, can help reduce weed seed banks.

Grazing Livestock: Introduce grazing livestock, such as goats, sheep, or cattle, to naturally control weed growth by consuming and trampling the plants. This method is particularly effective in pasture and rangeland management.

Plant Protection Systems

15. INTRODUCTION TO PESTS AND THEIR OCCURRENCE

In natural farming, the introduction of pests is a concept rooted in ecological principles and the promotion of a balanced ecosystem. This approach, often associated with sustainable and organic farming practices, aims to work with nature rather than against it. The idea is to create an environment where beneficial insects and organisms thrive, keeping pest populations in check naturally. This method relies on biodiversity and the interconnectedness of species to maintain a healthy and resilient ecosystem.

What is a Pest?

The major aim for the natural farmer is to create conditions, which keep a plant healthy as a healthy plant is less vulnerable to pest and disease (biotic and abiotic stress) infestation. The way to a healthy plant is a healthy soil. A diversified cropping system will not allow an insect to build up to the level where it causes economic damage.

In nature there is no such thing called a 'pest'. They are only consumers at primary, secondary and tertiary levels. As insects are competing with food for human beings they are termed as pests. This is an anthropocentric view and not from natures point of view.

Transition in pest management practices:

In traditional agriculture apart from the few organic chemicals that were used, pests were managed by cultural, agronomical practices and ITKs. At times there were huge losses to crops due to locust infestation, etc.

The first major pesticide that came into agriculture is DDT. The insecticidal properties were identified during war time research and application for control of mosquitoes (malaria) in the war fronts. Then slowly came the plethora of chemical pesticides. In the initial stages of euphoria scientists thought that they would eradicate all the agricultural pests.

This was quickly proved wrong with the resistance development in insects, resurgence and secondary pest attack. Apart from this there were problems of pollution and health hazards. This led to the idea that insects cannot be eradicated and that one has to control their numbers at which they do not cause economic damage to the crops. This, over a period of time, led to the Integrated Pest Management (IPM) theory with cultural, biological, mechanical, agronomic methods with chemical methods being the last option. However, in farmers practice chemical options continued as the first rather than the last option.

To avoid the poisoning due to chemical pesticides Non-Pesticide Pest Management (NPM) was propagated without the chemical option of the IPM methods. This NPM forms the

broad basis for the Natural Farming Pest Management (NF-PM) with the core objective of building soil fertility and crop diversity.

One of the first important steps in managing the insects is to understand them. There are several ways of classifying and understanding insects.

A. Based on incidence:

- Regular pest- Frequently- Rice stem borer, Pod borer.
- Occasional – Case worm in rice, Mango stem borer.
- Seasonal Pests- Red Hairy Caterpillar, Cotton pink bollworm, Mango Hopper.
- Persistent pests- Round the year- Chilli Thrips, Mealy bug on guava, cotton.

B. Based on feeding mechanism:

- Sucking pests. (These also transmit viral diseases.)
- Borers/Chewing (leaf eaters).

C. Based on the number of crops they attack:

- Polyphagous pests – attacks several crops – e.g. Helicoverpa/ cotton pod borer
- Monophagous – attacks only one crop – e.g. Brinjal shoot and fruit borer (BSF)

Understanding the insects helps choosing the management strategy/ options.

In natural farming the pests (and weeds) are seen as a symptom rather than as the problem. Whenever the farmers observe an increase in the number of insect pests they should see it as an indication of something that is wrong with the farming system/ cultivation practices, which could be:

- Crop/ variety not suitable to the region
- Grown in an inappropriate season.
- Cultivating susceptible cultivars.
- High Density plant population
- Mono-cropping.
- Deficiency or excess of nutrients
- Water logging or water stress.

A well-managed farming system is a successful way of reducing the level of pest or disease population. Certain crop varieties have more effective mechanisms than others due to the adaptive nature to the environment and therefore have a lower infection risk. Mono-cropping increases the risk of pest infestation.

The health condition of a plant depends to a large extent on the fertility of the soil. When nutrition and pH is well balanced, the plant becomes stronger and is therefore less vulnerable to infection. Climatic conditions, such as suitable temperatures and sufficient water supply, are further factors which are crucial for a healthy plant. If one of these conditions is not suitable, the plant can become stressed. Stress weakens the defense mechanisms of plants and makes them easy targets for pests and diseases. One of the most important points for a natural farmer is therefore to grow diverse and healthy plants. This avoids many pest and disease problems.

Farmers have observed that the insect population is also affected by the waning and waxing phases of the moon. The aspects of improving soil health and crop diversity are long term measures. Some of these measures are:

Preventive Measures:

1) Selection of varieties which are well adapted to the local environmental conditions (temperature, nutrient supply, pests and disease pressure), as it allows them to grow healthy and makes them stronger against infections of pests and diseases.
2) Selection of good seeds/ planting material which has been inspected for pathogens and weeds at all stages of production.
3) Mixed cropping systems can limit pest and disease pressure as the pest has less host plants to feed on and more beneficial insect life in a diverse system. Crop rotation reduces the chances of soil borne diseases and breaks the life cycle of monophagous pests and increases soil fertility.
4) Green manuring and cover crops increases the biological activity in the soil and can enhance the presence of beneficial organisms (but also of pests; therefore, a careful selection of the proper species is needed).
5) No chemical fertilizers: steady growth makes a plant less vulnerable to infection. Synthetic fertilizers lead to lush growth resulting in susceptibility to insect pests and also reduces soil fertility, opening the way for secondary infections.
6) Input of organic matter increases micro-organism density and activity in the soil, thus decreasing population densities of pathogenic and soil borne fungi. It stabilizes soil structure and thus improves aeration and infiltration of water.
7) Application of suitable soil cultivation methods facilitates the decomposition of infected plant parts, regulates weeds, which serve as hosts for pests and diseases, and protects the microorganisms which regulate soil borne diseases.

8) Conservation and promotion of natural enemies: Natural farming practices such as pest management and crop diversification help to build the natural enemies of pests.
9) Pest avoidance: Most pests attack the plant only in a certain life stage; therefore, it's crucial that this vulnerable life stage doesn't correspond with the period of high pest density and thus that the optimal planting time is chosen.
10) Remove infected plant parts (leaves, fruits, crop residues) from the ground to prevent the disease from spreading and eliminate residues of infected plants after harvesting.

Identifying and understanding insects:

The predominance of chemical agriculture has created a belief that 'a good insect is a dead insect'. However, this is not true.

The first step is to differentiate the beneficial insects from harmful insects.

It is also important to understand and identify the insects in all the stages of their life cycle. Normally there are two types of life cycles:

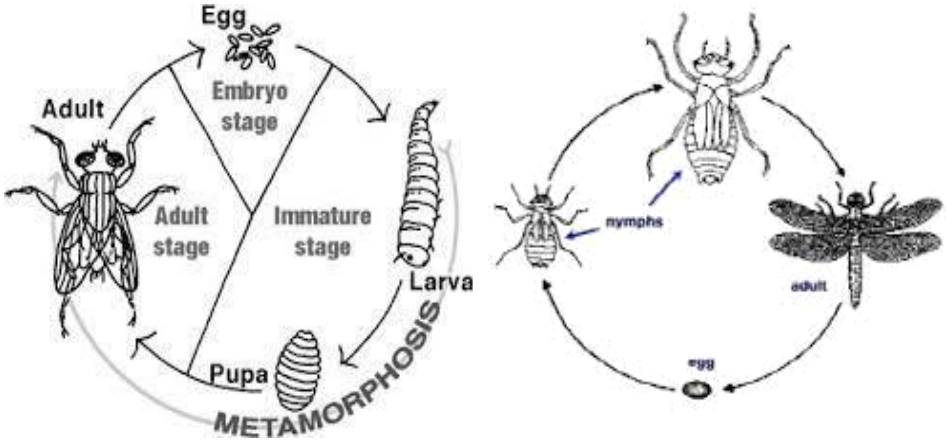
i) Egg – larva – pupa – Adult

ii) Egg – nymph – Adult

Understanding the life cycle will help the farmers to know the stage in which the insect causes damage and the stage in which it can be easily managed.

The second step is Pest Monitoring and Surveillance. A Natural Farmer should be regularly visiting the fields and observing the crops. Appropriate methods should be followed for monitoring the insects:

- Weather based monitoring
- Sticky traps for sucking pests such as whitefly, jassids and thrips.
- Light traps/ Solar light traps- Moths all sucking pests.
- Insect nets and field observations.



The third step is to know the Economic Threshold Levels (ETL); i.e., the number at which an insect can cause potential damage. This concept is more suitable for single host pests (monophagous pests). Farmers should be aware of the right time to take up pest management practices.

It's important to note that the introduction of pests in natural farming is not about causing harm but about fostering a balanced and sustainable agricultural system. The emphasis is on understanding the natural processes and relationships within an ecosystem and leveraging them to create conditions that are conducive to both plant health and the well-being of beneficial organisms.

16. PEST MANAGEMENT IN NATURAL FARMING

Natural agriculture is a holistic production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity, and cycles adapted to local conditions rather than the use of inputs with adverse effects.

Pest management in Natural farming is achieved by using appropriate cropping techniques, biological control, and natural pesticides (mainly extracted from plant or animal origins). Weed control, the main problem for natural growers, can be managed through cultural practices including mechanic cultivation, mulching, and biodiversity. Natural farming is characterized by higher diversity of arthropod fauna and conservation of natural enemies than conventional agriculture.

The ecological and economic problems of pests and pesticides in agriculture gave rise to several eco-friendly innovative approaches which do not rely on the use of chemical pesticides. These initiatives involved rediscovering traditional practices and contemporary grass root innovations supplemented by strong scientific analysis mainly supported by non-formal institutions like NGOs. Such innovations have begun to play an important role in development sector. This trend has important implications both for policy and practice.

The “Non Pesticidal Management” which emanates from collaborative work of public institutions, civil society organizations and Farmers in Andhra Pradesh shows how diverse players join hands to work in generating new knowledge and practice, can evolve more sustainable models of development.

Several voluntary agencies, farmers from different regions and few scientists from the subject area established that:

- Red Hairy Caterpillar
- This pest infests crops only on light red soils
- There is only one generation of moths that lay eggs producing the cater- pillars which later hibernate in the soils. Adult moths appear in waves at the onset of the monsoon. Controlling the pest necessitated the destruction of the early emergence moths.
- The caterpillars are also attracted to some wild non-economical plants such as calatropis, wild castor and yellow cucumber.
- The later instars of larvae had dense red hairs all over the body, which prevents pesticides from reaching the body of the insects as a result any pesticide sprayed will not cause the mortality of the insect.

Package of practices were evolved based on the insect behavior, which can manage the RHC before it reaches damaging stages and proportions. Deep summer ploughing exposes the resting pupae, adults of RHC. These insects are attracted to light-community bonfires. Bonfires were used to attract the insects and kill them. Alternatively light traps (electric bulbs or solar light) were also used. Trenches around the field to trap migrating larvae by use of calatropis and jatropha cuttings were found to be effective. Neem sprays on the early instar larvae was found to be effective.

A successful pest management in natural farming incorporates a variety of pest management tactics such as cultural, mechanical/physical and biological tactics individually or in combination. A different set of mechanisms for preventing and suppressing pest populations are,

Cultural pest control: The goal of cultural control is to alter the environment, the condition of the host, or the behavior of the pest to prevent or suppress an infestation. It disrupts the normal relationship between the pest and the host and makes the pest less likely to survive, grow, or reproduce. In agricultural crops, crop rotation, selection of crop plant varieties, timing of planting and harvesting, irrigation management, crop rotation, and use of trap crops help reduce populations of weeds, microorganisms, insects, mites, and other pests. These cultural practices are more preventive than curative and thus may require planning in advance. The diversified habitat provides these parasites and predators with alternative food sources, shelter, and breeding sites. Removal of the protective cover, elimination of food plants, and disruption of the insect life cycle generally killing many of the insects through direct contact, starvation or exposure to predators, and weather. The use of trap strip crops can control insect damage at the field edges and at the same time avail refuge and food for beneficial insects. Insect resistance is an important component of pest and disease management. Quality-based resistance can be induced in plants through management of nutrients and irrigation. Intercropping and biodiversity play an important role in pest management in natural farming.

Mechanical and physical pest control: One of the simplest methods of physical or mechanical pest control is handpicking insects or hand-pulling weeds. This method works best in those situations where the pests are visible and easily accessible. Physical or mechanical disruption of pests also includes such methods as mowing, hoeing and cultivation.

Biological pest control: Biological methods are the encouraging the multiplication practices which interm activates the beneficial organisms in field that can be used in the field to reduce

insect pest populations. The role of beneficial species on pests is of relatively greater importance in natural agriculture than in conventional agriculture.

Pest is not a problem but a symptom. Disturbance in the ecological balance among different components of crop ecosystem makes certain insects reach pest status. From this perspective evolved the Non Pesticidal Management which is an "ecological approach to pest management using knowledge and skill-based practices to prevent insects from reaching damaging stages and damaging pro- portions by making best use of local resources, natural processes and community action."

Non Pesticidal Management is mainly based on:

- Understanding crop ecosystem and suitably modifying it by adopting suitable cropping systems and crop production practices. The type of pests and their behavior differs with crop ecosystems. Similarly, the natural enemies' composition also varies with the cropping systems.
- Understanding insect biology and behavior and adopting suitable preventive measures to reduce the pest numbers.
- Building farmers knowledge and skills in making the best use of local resources and natural processes and community action. Natural ecological balance which ensures that pests do not reach a critical number in the field that endangers the yield. Nature can restore such a balance if it is not too much meddled with. Hence no chemical pesticides/pesticide are applied to the crops. For an effective communication to farmers about the concept effectively, and to differentiate from Integrated Pest Management which believes that chemical pesticides can be safely used and are essential as lost resort it is termed as "Non Pesticidal Management".

Growing Healthy Plants from Good Quality Seed

Selection and use of good quality seed which is locally adopted either from traditional farmers' varieties or improved varieties released by the public sector institutions is important. Farmers are suggested to make their decision based on a seed matrix with information on value for cultivation and use is important which includes information regarding suitability of the different varieties into their cropping patterns, based on the soil types, reaction to insect pests and diseases and their consumption preference. They maintain the seed in their seed banks. This ensures farmers to go for timely sowing with the seeds of their choice. In rainfed areas timely sowing is one critical factor which affects the health and productivity of the crop. The seed is treated with concoctions depending on the problem for example cow urine, ash and asafetida

concoction provides protection against several seed borne diseases like rice blast, or *beejamrut* to induce microbial activity in the soil and kill any seed borne pathogens. Similarly in crops like brinjal where there is a practice of dipping of seedlings in milk and dipping fingers in milk before transplanting each seedling was observed to prevent viral infections. Several such practices are documented and tested by the farmers. Non Pesticidal Management involves adoption of various practices which prevents insects from reaching to damaging stage and proportions (Fig. 1).

Reduce Stress

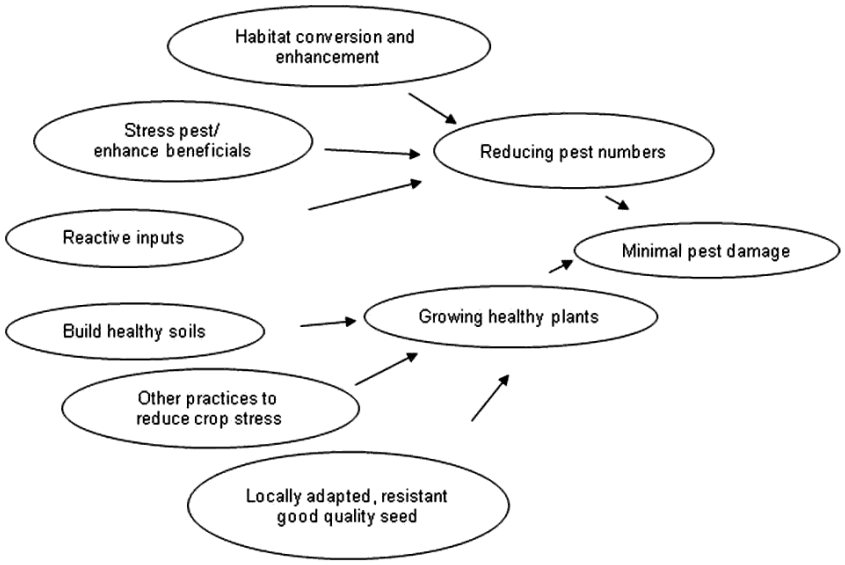


Fig. 1 Schematic representation of non-pesticidal management

The pest and disease susceptibility increases with abiotic stress. Practices like mulching will improve the soil moisture availability.

Build Healthy Soils

Healthy soils give healthy crop. Chemical fertilizers especially nitrogenous fertilizer makes the plants succulent and increases the sucking pests like brown plant hopper in rice. Production practices, such as putting on crop residues or other biomass as surface mulch, using compost and green manures, intercropping of legumes in cropping systems, and biocontrol of insect pests and diseases, all help to enhance yields and sustain soil fertility and health.

Enhancing the Habitat

Crop Diversity

Crop diversity is another critical factor which reduces the pest problems. Tradition- ally farmers have evolved mixed cropping systems, intercropping and crop rotation systems. These systems will create a better environment for nutrient recycling and healthy ecosystems. On the

contrary the monoculture of crops and varieties lead to nutrient mining and insect pest and disease buildup. Under NPM farmers adopt mixed and intercropping systems with proper crop rotations.

Trap and Border Crops: Many sucking pests fly from neighboring farmers' fields. In crops like chillies, groundnut, cotton, sunflower where thrips are a major problem, sowing thick border rows of tall growing plants like sorghum or maize will prevent insects from reaching the crop. Farmers adopt marigold as a trap crop for the gram pod borer and it reduces the pest load on pigeon pea. The flowers that have been oviposited by the female moths of *Helicoverpa* can be picked out and destroyed (Table 2).

Table 2 Trap crops used for pest management

Crops	Pests	Trap crops
Cotton, groundnut	Spodoptera	Castor, sunflower
Cotton, Chickpea, pigeonpea	Helicoverpa	Marigold
Cotton	Spotted bollworm	Okra

Source: KVK DDS, 2003

Other Agronomic Practices: Several crop specific agronomic practices like alley ways in rice to allow enough light to reach the bottom of the plant are documented by the farmers and suggested by the scientists.

Understanding Crop Ecosystem

The pest complex and the natural enemy complex are based on the crop ecosystem. The pest complex of cotton is completely different from that of sorghum. The pest complex in wet rice ecosystem differs from the pest complex in dry rice. Decision about any pest management intervention should take into account the crop ecosystem which includes cropping pattern, pest-predator population, stage of the crop etc. Similarly, the management practices followed in one crop cannot be adopted in all other crops. For example: to manage *Helicoverpa* in pigeon pea, the farmers in Andhra Pradesh and Gulbarga shake the plants and falling insects are collected over a sheet and killed (see box). Similarly in paddy there is a practice of pulling rope over the standing crop to control leaf folder.

Fig. 3 Egg laying behavior of (a) *Spodoptera litura* (egg mass) (b) *Helicoverpa armigera* (single egg)

Reactive Sprays

Insect population may reach pest status if the preventive steps are not taken in time, changes in weather conditions and insects coming from neighboring farmers' field. In these situations based on the field observations farmers can take up spraying botanical extracts and natural preparations (Green sprays) instead of chemical pesticides. There are wide ranges of these preparations which are evolved by the farmers.

Based on the process of making, these sprays can be classified into four categories

Aqueous or Solvent Extracts

Extracts are made by dissolving the required material in water (aqueous) or other liquids (solvent). For example, neem seed kernel extract is prepared by dissolving crushed neem seed kernel in water. For extracting "Allenin" from garlic, kerosene is used as a solvent. After extraction this solution is mixed with chilli extract and used against sucking pests.

Fig. 4 Shaking method in pigeon pea for removing pests

Decoctions

In natural farming, decoctions are commonly used as a form of botanical pest and disease management. Decoctions are liquid extracts obtained by boiling plant materials in water. They are often utilized because they contain bioactive compounds that have insecticidal, fungicidal, and bactericidal properties. Here are some commonly used decoctions in natural farming for pest and disease management:

Neem Decoction:

Ingredients: Neem leaves or neem cake.

Preparation: Boil neem leaves or neem cake in water and let it cool.

Usage: Neem has natural insecticidal properties and is effective against a broad spectrum of pests. It also helps in controlling fungal diseases.

Turmeric Decoction:

Ingredients: Turmeric powder or fresh turmeric.

Preparation: Boil turmeric in water and let it cool.

Usage: Turmeric has antifungal and antibacterial properties. It can help in controlling fungal diseases and some bacterial infections.

Agniasthra:

Ingredients: 10 liter Desi Cow Urine, 5 kg Neem leaves paste, 1 kg tobacco leaves, 1-2 kg green chilli paste, 500 gm desi garlic paste

Preparation: Take 10 liter cow urine, 1 kg tobaaco leaves paste, 5 kg neem leaves paste, 1-2 kg green chilli paste and 0.5 kg garlic paste in a container and boil the contents for some time after the lid is covered. Cool the contents for 48 hrs and filter with thin cloth before storing the solution in a container. Use 2-3 liters of Agniasthra per acre by mixing with 100 liters of water which is effective for 3months.

Uses: It works against borers such as stem borer, fruit borer and other types of borers. Spray 200 liters of water with 6 litres of Agniastra to kill both root borer pests.

Brahmasthram:

It is a natural insecticide prepared from leaves which contain specific alkalis (alkaloids) to repel insects. It controls all sucking insects and hidden insects present in pods and fruits.

Neem Leaves 5 Kg, Pogemia Leaves 2 Kg, Custard Apple Leaves 2 Kg, Datura Leaves 2 Kg, Guava Leaves 2 Kg, Lantana 2 Kg, Bitter gourd leaves 2 kg, Castor leaves 2kg, Parthenium leaves 2kg, Pomegranate leaves 2 kg, Vitex spp leaves 2kg, Cow Urine 20 liter

Preparation:

- Take 20 liters of cow urine
- Add any 5 types crushed leaves contents and mix thoroughly clockwise with the help of a stick, close it with a lid and boil the contents
- After 48hrs, filter the solution with a thin cloth After 3-4 boils, cool it
- Stir the solution morning and evening for a minute for 3 days
- Solution is ready to spray on the crop

Uses: 2-3% Spray with water or 6 litre in 200 litre of water for acre. For the control of sucking insects and pod/fruit borer.

Concoctions

In natural farming, concoctions refer to mixtures of various natural ingredients that are used for pest and disease management. These concoctions often incorporate different plant extracts, microbial solutions and other natural elements to create a potent mixture that helps control pests and diseases in a sustainable manner. Here are some common concoctions used in natural farming:

Fermented Products

Products made by fermenting the different botanicals with animal dung and urine. These products have rich microbial cultures which help in providing plant nutrients in addition to acting as pest repellents and pest control sprays. For example, cow dung urine- asafetida solution is used to manage rice blast.

While the sustainable models in agriculture like NPM are established on smaller scale scaling up these experiences poses a real challenge in terms of:

- Relevance of small experiences for a wider application,
- Availability of resources locally,
- Farmers willingness to adopt these practices,
- Lack of institutional and support systems,
- Supplementing farmers' knowledge and enhancing the skills,
- Reducing the time of transformation,
- Reaching to larger areas with minimal expenditure, and
- Establishing extension system which give community a central stage.

Neemastra:

Neemastra is a natural pesticide it is a very effective insecticide for leaf miners and sap sucking insects by using it, enemy insects and moths do not come out in the field.

Ingredients Used: Neem Leaves 10 Kg, Cow Urine 10 Liter, Cow Dung 2 Kg, Water 200 Liter

Preparation:

- Take 10 kg of crushed neem leaves/neem dried fruits
- Add this crushed neem leaves in 200 liters of water
- Put 10 liters of cow urine in it and mix two kg of cow dung.
- Stir it with wood and keep it covered for 48 hours. Keep in shade places
- After 48 hours filter the solution with a cloth.
- Now solution is ready for spray

Uses: Spray 200 litre per acre for the management of sap sucking insects and small caterpillars.

Dashparni Extract:

One stop concoction for various pesticides. This can be used instead of all the above astra.

Ingredients Used:

- 200 litre Water
- 20 litre Desi Cow Urine
- 2 kg Desi Cow Dung
- 200 gm Turmeric Powder
- 500 gm Ginger Paste
- 10 gm Hing (Asafoetida) powder
- 1 kg Tobacco powder
- 1 kg Hot Green chilli Paste
- 500 gm Desi Garlic Paste

1. **2kg Neem leaves and twigs cut into smaller pieces**
2. **2kg Karanj / Ponga leaves (Not paste)**
3. **2kg Custard Apple Leaves (Not Paste)**
4. **2kg Castor Leaves (Not Paste)**
5. **2kg Dhatura leaves (Not Paste)**
6. 2kg Bael Leaves (Not Paste)
7. 2kg Krishna Thulasi stem, leaves, seeds. cut into small pieces
8. 2kg Marigold root, branch, stem, flower, leaves. cut into small pieces
9. 2kg Calotropis leaves
10. 2kg *Nerium oleander* leaves
11. 2kg Mango leaves
12. 2kg Papaya leaves
13. 2kg Hibiscus leaves
14. 2kg Moringa leaves
15. 2kg Ber leaves
16. 2kg Babul tree (*Acacia nilotica*) with stem and leaves
17. 2kg Turmeric leaves cut into pieces
18. 2kg Ginger leaves cut into pieces
19. 2kg Coffee leaves cut into pieces
20. 2kg Bouganville leaves with flowers cut into pieces
21. 2kg *Casia tora* leaves and flowers
22. 2kg Pomegranate leaves

Note: First five leaves is compulsory and choose 5 types of leaves from remaining list as per availability

Preparation:

Step 1: Take 200 liters of water in a drum, add 20 liters of cow urine and 2 kg of cow dung. Mix it well and cover with the gunny bag and keep aside for 2 hours.

Step 2: Add 500 gram of turmeric powder, 200 gram of ginger paste, 10 grams of Asafoetida into the mixture. Stir it well in the clockwise direction; cover with gunny bag and keep overnight.

Step 3: Next morning, add 1 kg of tobacco powder, 2 kg of hot green chilli paste and 500 gram of garlic paste and stir it well with wooden stick in the clockwise direction, cover with gunny bag and leave for 24 hours under shade.

Step 4: Next morning, add paste of any 10 types of leaves* (first five leaves is compulsory and choose 5 types of leaves from remaining list as per availability) to the mixture.

Step 5: Stir thoroughly and cover with the gunny bag. Keep it for 30-40 days for fermentation so that the alkaloids present in the leaves will get dissolve in the mixture. Stir twice a day.

Step 6: Filter this after 40 days with a muslin cloth and use it.

Uses: 2-3% spray with water for all types of sucking pest and for control of all caterpillars.

Fermented Fruit Juice (FFJ): It is a nutritional activation enzyme and is very effective in natural farming. FFJ is a kind of FPJ that only uses fruits as its main ingredients. It is used to revitalize crops, livestock and humans. As the main fruit ingredients we can use Banana, Papaya, Mango, Grape, Melon, Apple etc (the fruits must be sweet).

Ingredients: Fruits, brown sugar, and water.

Preparation: Extract juice from fruits, mix with brown sugar, and ferment. Strain after fermentation.

Use: FFJ helps improve plant vitality and resilience. It can be effective in pest and disease prevention.

Aerobic Microbial Solution (AMS):

Ingredients: Various plant materials, brown sugar, and water.

Preparation: Mix chopped plant materials with brown sugar and water. Allow it to ferment aerobically, promoting beneficial microorganisms.

Use: AMS contains beneficial microbes that contribute to soil health and can suppress harmful pathogens.

When using these concoctions, it's important to test them on a small portion of your plants first to ensure they don't cause harm. Also, be mindful of the concentration and frequency of application to avoid any negative effects on your crops.

Some other pest control formulations

Many farmers and NGOs have developed large number of innovative formulations which are effectively used for control of various pests. Although none of these formulations have been subjected to scientific validation but their wide acceptance by farmers speak of their usefulness.

Cow urine

- Cow urine, popularly known as "gomutra," (germicidal, antibiotic, antimicrobial, and medicinal properties)
- Nutrient-rich cow urine with nitrogen, potassium, and phosphorous is highly beneficial to soil
- Besides macronutrients, the presence of sulfur, sodium, manganese, iron, enzymes, and chlorine make cow urine an integral natural pest repellent
- Cow urine diluted with water in **ratio of 1: 20** and used as foliar spray is not

Only effective in the management of pathogens & insects, but also acts as effective growth promoter for the crop.

Broad spectrum formulation - 1

- In a copper container mix 3 kg fresh crushed neem leaves +1 kg neem seed kernel powder +10 liter of cow urine
- Seal the container and allow the suspension to ferment for 10 days
- After 10 days boil the suspension, till the volume is reduced to half
- Ground 500 gm green chilli in 1 liter of water and keep overnight
- In another container crush 250gm of garlic in water and keep overnight
- Next day mix the boiled extract, chilli extract and garlic extract
- Mix thoroughly and filter
- This is a broad spectrum pesticide and can be used on all crops against wide variety of insects
- Use 250 ml of this concentrate in 15 liter of water for spray

Broad spectrum formulation – 2

- Suspend 5 kg neem seed kernel powder +1kg Karanj seed powder + 5 kg chopped leaves of Besharam (*Ipomea* sp.) + 5kg chopped neem leaves, Add all contents in one drum
- Add 10-12 liter of cow urine and fill the drum with water to make 150 liter
- Seal the drum and allow it to ferment for 8-10 days. After 8 days mix the contents and distil in a distiller
- Distillate will act as a good pesticide and growth promoter
- Distillate obtained from 150 liter liquid will be sufficient for one acre
- Dilute in appropriate proportion and use as foliar spray
- Distillate can be kept for few months without any loss in characteristics

Broad spectrum formulation – 2

- Suspend 5 kg neem seed kernel powder +1kg Karanj seed powder + 5 kg chopped leaves of Besharam (*Ipomea* sp.) + 5kg chopped neem leaves, Add all contents in one drum
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eKrishi: Using IT tools

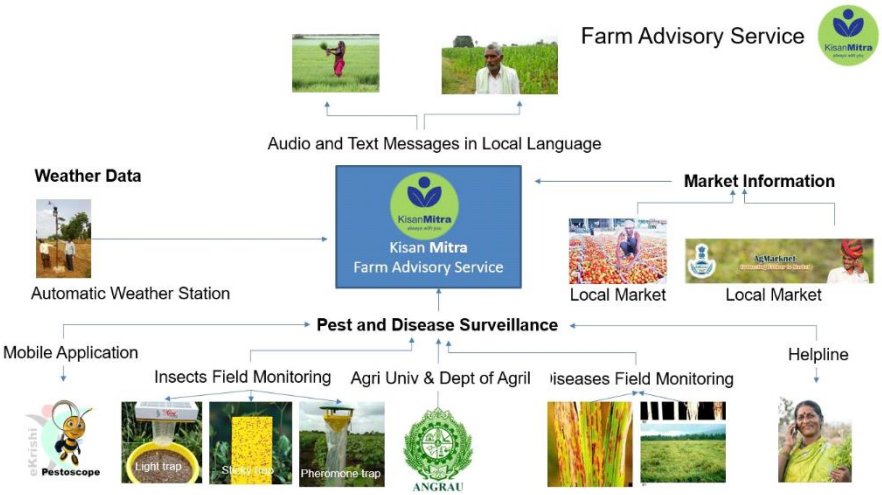
In the initial stages, the resource material was published to help farmers to identify the insect life cycles and natural enemies. With the advent of modern IT tools and social networks like WhatsApp were used to share the problems and solutions. In 2016 Centre for Sustainable Agriculture began working on a suit of IT tools which helps farmers to manage their crop production and marketing.

eKrishi Pestoscope is an android based problem diagnostic tool to help farmers and field extension staff to identify the pests and diseases in their field and find ecological solutions. It's currently under field testing. It can also be accessed online at http://www.pestoscope.com.

Functionality

Farmer/extension personnel can

- Can find a solution from the existing library if he/she can identify the problem and suggested practices to manage, otherwise
- take a picture of the problem he/she observes marking the crop and plant part,
- Text, audio or video can be added to further describe the problem
- system automatically geotags the place
- Expert will respond with diagnostics and suggest a solution
- Farmer/extension personnel can also locate farmers with same crop/adopting similar practices who are nearby so that they can visit and mutually learn.



17. DISEASE MANAGEMENT IN NATURAL FARMING (ITK)

Plant diseases have caused severe losses to humans in several ways. The crop losses due to pests, diseases and weeds are approximately assessed to be ranging between 10-30% of crop production. Plants are injured or damaged by many factors. Among them two important factors such as abiotic, that is, environmental, factor, and by biotic ones, such as various pests, for example, insects, and by diseases caused by pathogens. In all organisms, diseases and injury are caused by internal or external abiotic, that is, environmental factors, such as nutritional deficiencies, freezing temperatures, droughts, floods, pollution, and so on or by pathogens. Although abiotic factors may cause damage to plants over extensive areas, they differ from pathogens in that they (1) do not multiply and (2) do not spread from plant to plant. As a result, abiotic factors, although they cause damage to plants, do so much less frequently than plant pathogens, they are unpredictable and, usually, are easy to diagnose but difficult to control.

Disease in plants, then, can be defined as the series of invisible and visible responses of plant cells and tissues to a pathogenic organism or environmental factor that result in adverse changes in the form, function, or integrity of the plant and may lead to partial impairment or death of plant parts or of the entire plants (Agrios,2005).

Host plant resistance, Natural plant products, bio pesticides, natural enemies and agronomical practices offers a potentially viable option for IDM. Plant diseases are important because of the losses (qualitative and quantitative) they cause. Loss may occur at any time between sowing of the crop and consumption of the produce. Measures taken to prevent the incidence of the disease, reduce the amount of inoculum that initiates and spreads the disease and finally minimize the loss caused by the disease the fundamental principles of disease managements are

Fundamental principles of disease management

I. **Avoidance:** Geographical area, selection of a proper field, planting time and disease escaping varieties, avoidance of insect vectors and wed hosts
II. **Exclusion:** Quarantine, inspection & certification, seed treatment
III. **Eradication:** Crop rotation, sanitation, rogueing, soil treatment, heat and chemical treatment to diseased plant material, use of antagonists
IV. **Protection:** Use of natural plant protection astras/ Kashayas
V. **Immunization:** Resistant varieties, induced systemic resistance
VI. **Therapy:** Chemotherapy, thermotherapy

I. **Avoidance of the pathogen**:

It involves tactics that prevent the contact of the pathogen on susceptible stage of the plant and favorable conditions for the pathogen.

This is achieved by

a) Selection of Geographic area

Ex: Red rot of sugar cane, , late blight of potato, wilt diseases of arhar, green ear of bajra, root knot nematodes, bacterial wilt of vegetables.

b) Selection of field

Ex. Pea and Gram planted soon after rain, when soil temp and moisture level are high, shows high incidence of root rot, blight and wilt. Delayed sowing will help in reducing the incidence of disease.

c) Choice of time of sowing

Alteration of date of sowing can help in avoidance of favourable conditions for pathogen.
Ex. Pea and Gram planted soon after rain, when soil temp and moisture level are high, shows high incidence of root rot, blight and wilt. Delayed sowing will help in reducing the incidence of disease.

d) Disease escaping varieties:

The disease escaping quality of crop varieties due to characteristics of growth and time of maturity e.g. early maturing varieties of Pea and wheat which matures early (by January) usually escape damage from powdery mildew and rust.

e) Selection of seed

Selection of seed and planting material from healthy sources will effectively manage the diseases such as loose smut of wheat caused by *Ustilago nuda tritici*, bunchy top of banana (Banana virus-1), Fusarium wilt of banana (Panama wilt), whip smut and red rot of sugarcane and virus free potato tubers through tuber indexing.

f) Modification of cultural practice

Modification in various cultural practices like method of sowing, choice of crop, crop rotation, irrigation time/method, application of fertilizers and soil amendment will help in management of plant diseases.

II. **Exclusion of the pathogen**

It means preventing the entrance and establishment of pathogens in uninfected crops in a particular area. Objective of the exclusion is to prevent spread of the disease and this can be achieved by:

- **Seed treatment**

The seed treatments increase the seed germination and reduce disease development in the field.

- **Inspection and certification:**

Crops grown for seed purpose are inspected periodically for the presence of diseases that are disseminated by seed. Necessary precautions are to be taken to remove the diseased plants in early stages, and then the crop is certified as disease free. This practice will help in the prevention of inter and intra-regional spread of seed borne diseases.

- **Plant quarantine**

Plant quarantine prevent the import and spread of plant pathogens into the country or individual states by legal restriction, certain federal and state laws regulate the conditions under which certain crops may be grown and distributed between states and countries.

- **Eradication of insect vector**

It involves elimination of a pathogen once it has become established on a plant or in a field.

i). Biological control of plant pathogen

ii). Crop rotation

iii). Removal and destruction of diseased plants or plant organs

v**). Soil treatment**: In this method, the soil treatment with chemicals, heat and some cultural practices as mulching, flooding and fallowing will help to inactivate or eradicate the pathogens present in the soil.

III. Protection

- It is the use of some protective barrier between the susceptible part of the suscept or host and the pathogen.
- In most cases, a protective spray or dust applied to the plant in advance of the arrival of the fungus spores.
- Sometimes, it is achieved by killing insects or other inoculating agents.
- Sometimes it is achieved by erection of a wind-break or other mechanical barrier.
- Improvement of aeration under crop canopy reduces the humidity on aerial parts of the plant and thus checks the growth of fungi which flourish in humid atmosphere.

- Spraying of plant based fungicides

IV. **Immunization/Disease resistance**

- Disease resistant and tolerant varieties are the cheapest, easiest and most efficient way to reduce disease losses.
- Varieties should be selected that possess resistance or tolerance to one or more disease organisms.
- For some diseases, such as the soil-borne vascular wilts and the viruses, the use of resistant varieties is the only means of ensuring control.
- Certified seed of resistant varieties is available and sold commercially.
- The use of varieties of plants resistant to particular diseases has proved to be very effective against stem rust of wheat, rust of dry bean and Rhizoctonia root rot of sugar beet.
- Resistant varieties may become susceptible to new races of a pathogen, as happens with cereal rusts, powdery mildews, downy mildews and *P. infestans*.
- Use of microorganisms and chemicals to induce systemic acquired resistance and activations of plants' defense system could also be used for the management of plant diseases.

Symptoms of plant diseases caused by fungi

External expression or the evidence of the abnormalities in the appearance of the diseased plants brought about by the pathogens after host-pathogen interaction.

Example

Mildews

- Mildews consist of white, grey, brownish or purplish pathogen growth on the host surface.
- Downy mildew is characterized by a tangled cottony or downy growth mostly on the lower surface of the leaves or other plant parts.
- Powdery mildew consists enormous number of spores are formed on superficial growth of the fungus giving a dusty or powdery appearance on the host surface. Black minute fruiting bodies may also develop in the powdery mass.

Rust

- Rust appears as relatively small pustules of the spores, usually breaking through the host epidermis.

- Pustule is a small blister-like elevation of the epidermis, often opening to expose spores. The pustules may be dusty or compact, and red, brown, yellow or black in colour.

Smut

- Smut means a sooty or charcoal like powder.
- The affected parts of the plants show black or purplish black dusty areas.
- Symptoms usually appear on floral organs, particularly the ovulary areas.
- The pustules on the leaves and stems are usually larger than those of rusts.

White Blister

- **White blister**-like pustules appear on the leaves and other parts of cruciferous plants which break open the epidermis and expose powdery masses of spores.
- Such symptoms are called 'white rust', although there is nothing common with them and the rusts.

Blotch

- It consists of superficial growth giving the affected plant parts i.e., fruits and leaves smoky (blotched) appearance, e.g. sooty blotch of apple.

Sclerotia

- A **sclerotium** is a compact, often hard mass of dormant fungus mycelium.
- **Sclerotia** are mostly dark in colour and are found mixed with the healthy grains as in the case of ergot of wheat and rye.

Mycelial growth

- Appearance of white cottony, mycelial growth of the fungi like *Dematophora necatrix* on affected roots of apple is an important diagnostic feature of white root rot in the field.

Hypertrophy

- The abnormal increase in the size of the plant organs due to increase in the size of the cells of a particular tissue, whereas

Hyperplasia

- The abnormal increase in the size of the plant organs due to increase in the number of cells of which the tissue or organ is composed, owing to increased cell division.

Necrosis

- Death of the cells, tissues and organs occurs as a result of parasitic activity.
- The characteristic appearance of the dead areas differs with different hosts, host organs and with different parasites.
- Necrotic symptoms include spots, streaks or stripes, canker, blight, damping off, burn, scald or scorch and rot.

Wilt

- Characterized by drying of the entire plant.
- Leaves and other green or succulent parts loose their turgidity, become flaccid and droop down.
- Usually seen first in some of the leaves.
- Later, the young growing tip or the whole plant may dry up.
- May be caused by injury to the host system or the conducting vessels.
- Wilting due to disease is different from the physiological wilting where the plant recovers as soon as the supply of water is retained.

Die-back or Wither Tip

- Symptoms are characterized by drying of plant organs, especially stems or branches, from the tip backwards.
- It is also a form of necrosis caused directly by the pathogen or its toxins.

Diseases caused by Plant Parasitic Nematodes

The name nematode was derived from the Greek word nemas (thread) and adios (form or resembling). Nematodes are triploblastic (having three layers), bilaterally symmetrical, multicellular, unsegmented, generally microscopic worms with single cavity (Pseudocoelomic). It has been estimated that on global basis 12 percent crop loss due to diseases, 7 percent due to insects, 3 percent due to weeds and 11 percent due to nematodes. The annual crop losses due to these obligate parasites have been estimated to be about $78 billion worldwide. Estimated overall average annual yield loss of the world's major crops due to plant parasitic nematodes was 12.3%. Estimated losses due to plant parasitic nematodes in developing countries were 14.6% and 8.8% for developed countries. On worldwide basis, the ten most important genera were reported to be *Meloidogyne, Pratylenchus, Heterodera, Ditylenchus, Globodera, Tylenchulus, Xiphinema, Radopholus, Rotylenchulus and Helicotylenchus.*



The following major nematode species.

1. **The seed gall nematode,** *Anguina tritici* is responsible for ear cockle disease of wheat in Northern India. It also causes tundu or yellow slime disease with the association of a bacterium, Clavibacter tritici. The overall damage is one percent but sometimes it is as high as 80 percent.
2. **The root-knot nematode,** *Meloidogyne spp.* is one of the few nematodes known to the farmers due to the spectacular symptoms of root gall formation on vegetable, pulses, fruits and ornamental plants. The percent yield losses due to this nematodes has been estimated to the tune of 28-47 percent in tomato, 26.2-50 percent in brinjal, 19.7-33 percent in chillies, 6.0-90 percent in okra, 38-47.2 percent in bitter gourd and 18-33 percent in melons at different AICRP projects in India.
3. **The cereal cyst nematode,** *Heterodera avenae* causes Molya disease of wheat and barley in the states of Rajasthan, Haryana, Punjab, Delhi, U.P., Himachal Pradesh, Jammu & Kashmir. It may cause up to 50 percent or even a total loss of the crop.
4. **The reniform nematode,** *Rotylenchus reniformis* attacks a large number of plants and causes considerable losses to vegetables and pulses varying from 4.8 to 14.9 percent loss in yield in different crops.
5. **Citrus nematode,** *Tylenchulus semipenetrans* causes slow decline disease of citrus and also associated with 'die-back' in citrus.

6. **The burrowing nematode,** *Radopholus similis* causes severe damage to many fruit crops including banana, spice crop and other plantation crops. It is responsible for spreading decline of citrus, black head disease of banana and root-rot disease of crops.
7. **The golden nematode of potato,** *Globodera rostochinensis* is a serious problem in Nilgiri and Kodaikanal hills. An average loss of 9 percent is caused by this nematode.
8. **The root lesion nematode,** *Pratylenchus coffeae* is important pest of coffee in South India. It causes foot-rot of young plants and decline or die-back of older plants.

The above examples include only the major nematode pests. Besides infesting alone, they are also known to be associated with various bacteria, fungi and viruses in causing complex plant diseases which further increases the losses in yield of crops. The nematode problem is more important in developing countries, in tropical and subtropical regions.

Crop Diseases Caused By Bacteria

Among the most common infections in agriculture are crop diseases caused by bacteria. In this regard, the prevention and control of this kind of disease are pretty tricky.

To infect the causal agent needs to get into the culture's tissue. It occurs mainly through damaged areas, such as caused by agricultural tools, insects (fleas), or simply unfavourable weather conditions (dust, wind, heavy rain). But bacteria can also infect plants through natural holes or glands (for example, which secrete nectar).

Another feature of bacterial crop diseases is that causal agents, once in a plant or soil, can remain dormant for a long time until unfavourable conditions arise for them. First of all, significant temperature fluctuations and high levels of humidity act as catalysts for bacterial activity.

Symptoms of Bacterial Crop Diseases

The main bacterial disease indications include vascular wilting, necrosis, soft rot and tumour. Although this type of plant disease can be identified due to its pronounced symptoms, identifying a specific causal agent requires laboratory methods.

Common bacterial diseases

As noted earlier, due to a huge number of bacteria, there are many disease types. Here are some examples of the most common diseases of crop plants:

1. Black rot - *Xanthomonas campestris*
2. Bacterial canker - *Clavibacter michiganensis*
3. Bacterial soft rot - *Pseudomonas spp*
4. Bacterial leaf spot/Bacterial spot - *Pseudomonas syringae* - various strains
5. Bacterial wilt - *Pseudomonas syringae pv. pisi*
6. Bacterial leaf spot/Bacterial spot/Bacterial blight - *Pseudomonas syringae*
7. Bacterial brown spot - *Pseudomonas syringae*

Crop Diseases Caused By Virus

The most minor but most critical plant enemies are viruses and viroids (subviral contagious agents). After infection, it is almost impossible to save a plant. Therefore the effect of plant diseases on crop production is of critical importance throughout the world. In most cases, the infection spreads as a result of healthy plants with sick contact. Viruses can also spread through vegetative reproduction, through seeds, pollen, and insects. But viruses most often spread through the soil.

Symptoms of viral diseases

- **Chlorosis:** Yellowing of normally green tissues due to chlorophyll destruction or failure of chlorophyll formation is known as chlorosis.
  - Ex: Cucumber Mosaic Virus (CMV)
  - Vector Aphids - *Aphis gossypii* and *A. maidis*
- **Mosaic**: Intermingling patches of green and light green or pale green or yellowish colour on the leaves is known as mosaic.
  - Mottling and streaking of banana leaves and flowers due to cucumber mosaic virus
  - Tobacco mosaic-Tobacco mosaic Virus (TMV) / Nicotiana Virus
  - Mungbean Yellow Mosaic Virus (MYMV)
- **Stripe:** Stripe is characterized by elongataed or areas of pale green to yellow or white, of indefinite length, on leaves with parallel venation or on stems.
  - Barley stripe mosaic –
- **Streak:** Development of chlorotic streaks on leaves.
  - Maize streak - Maize Streak Virus Symptoms
  - Vector-Leaf hopper
- Vein clearing: Yellowing of veins or clearing of the tissues in or immediately adjacent to the veins is called vein clearing.
  - Ex: Vein clearing or yellow vein mosaic of bhendi
  - Vector Whitefly(*Bemisia tabaci*)
- Vein banding: The tissues along the veins are dark green than the tissues between the veins is called vein banding.
  - Ex: Potato vein banding
  - Vector: Myzus persicae (Aphid).
- **Leaf crinkle:** In leaf crinkle the surface of leaves is not uniform and is with undulations. The leaves are thick and brittle and remain green till harvest.
  - Leaf crinkle of Blackgram - urdbean leaf crinkle virus (ULCV)
  - Vector :Whitefly - *Bemisia tabaci*
- **Leaf curl:** In leaf curl the leaves curl from the margins backward bringing the centre of the lamina upward.
  - Ex: Tomato and tobacco leaf curl - Tobacco leaf curl virus.
  - Vector : Whitefly - Bemisia tabaci

- **Necrosis:** Necrosis (death of cells) of tissues in the growing shoots due to virus infection.

➢ Ex: Bud necrosis of groundnut - Tomato spotted wilt virus (TSWV).

➢ Vector: Thrips - *Frankliniella schultzei, Thrips tabaci* etc.

- **Rosette:** In rosette shortening of internodes with reduction in leaf size is seen. The plants show stunting with bushy appearance.

➢ Groundnut rosette - Groundnut rosette virus (GRV)

➢ Vector: Aphids- *Aphis craccivora*

- **Bunchy top:** In bunchy top extreme stunting of the plant with bunching of small, erect and brittle leaves at the crown of plants is seen.

➢ Ex: Bunchy top of banana - Banana bunchy top virus (BBTV)

➢ Vector: Banana aphid- *Pentalonia nigronervosa var. typica*.

Strategies for Management of diseases

1. Crop rotation

Crop rotation, *i.e.,* growing different crops in different seasons in the same field, is among the most effective ways to control soil-borne plant diseases (Cook and Veseth 1991). The rotation of different crops reduces the disease inoculum due to host absence, or other effects of the hosts, and organic residues that can affect the pathogens or antagonistic organisms (Hoitink and Boehm 1999). The inoculum of the pathogen is greatly reduced with the length of the non-host period during the growth of a specific crop (Garret and Cox 2006). The rotation design is important for managing the specific pathogens present (Krupinsky *et al.* 2002).

For example, crop rotation between upland maize and wetland rice affects the root colonization by archaea and bacteria (Breidenbach et al. 2017). Additionally, the microbial communities in the plant and soil are also influenced by crop diversity and diverse crop residues, which further affects the pests, weeds and plant diseases (Hoitink and Boehm 1999; Garbeva et al. 2004). A variety of different pathogens and pests can be effectively managed through crop rotation.

2. Intercropping

Growing two or more crop species at the same time in the same field is termed intercropping (Ofori and Stern 1987). The main purpose of intercropping is to allow for more important biological and crop interactions. The advantages of intercropping include reducing weeds, using the available resources more efficiently, increasing yields, and most

importantly, providing biological and economic stability (Brooker *et al.* 2015; Vandermeer 1989). A more recent study found that cassava brown streak disease was significantly suppressed by intercropping with a legume in Western Kenya (Ememwa *et al.* 2017). Several integrated management systems were employed to study the variability of early and late leaf spot of groundnut for seven seasons (Boudreau *et al.* 2016). The yields of groundnut increased significantly, as disease pressure was reduced in the intercropping field. The impact of maize intercropping on early leaf spot was determined and the infection affected the dispersal of the pathogen with disease reduction.

3. Cover cropping

A cover crop is defined as any living ground cover that is planted with or after the main crop, and usually killed before the next crop is planted (Hartwig and Ammon 2002). It includes double cropping into one main crop to increase organic matter and reduce weeds, pests and soil erosion. Moreover, relay cropping, overseeding, and interseeding are also types of cover cropping (Hartwig and Ammon 2002). Vesicular-arbuscular mycorrhizae can also benefit from this type of cropping system, which helps to suppress weeds (Jordan *et al.* 2000).

4. Cultivar mixtures

Cultivar mixtures are combinations of cultivars that are agronomically compatible but have no additional breeding for phenotypic uniformity. They are mainly implemented to reduce pathogen populations, and the cultivars' phenotypic variation can also suppress weeds and pests as well.

5. Organic amendments

The role of organic amendments in stimulating beneficial microbe quorum formation related to the host-plant-pathogen interactions, and its role in facilitating induced systemic resistance and systemic-acquired resistance against diseases was evaluated. Organic amendments serve as soil conditioners, and their mechanism of action needs to be further elaborated to ensure food safety.

Disease management in natural farming (ITK)

1. BIJAMRIT

Ingredients

- ✓ Cow Dung- 5kg
- ✓ Cow urine- 5L
- ✓ Lime- 50g

- ✓ Water- 20L
- ✓ Bund soil- Handful (200gm)

Methodology:

- ✓ Take 20 litres water.
- ✓ Then take 5 Kg Desi cow dung.
- ✓ Mix it by the fingers.
- ✓ Take it in a cloth and bound it by small rope as a small bundle
- ✓ Hang this bundle of cow dung in the taken 20-litre water for a night (12 hours).
- ✓ Take one litre water and add 50 gm lime in it, let it stable for a night.
- ✓ Then next morning, squeeze this bundle of the cow dung in that water thrice continuously, so that all essence of cow dung will accumulate in that water.
- ✓ Then add a handful of soil in that water solution and stir it well.
- ✓ Then add 5 litre Desi cow urine in that solution
- ✓ Then add the lime water and stir it well.
- ✓ Keep it overnight for proper fermentation.
- ✓ Now Bijamrita is ready to treat the seeds.

2. Sonthastra/Shunti astra

Materials required

- Water - 2 liters
- Ginger Powder - 200 grams
- Desi (native) cow milk - 2 liters

Procedure for preparation

- Take 2 litres of water, add 200 grams of ginger powder (Sonth) and mix it and cover with a lid. Now boil it till it reduces to half of the solution. Keep this solution for cooling.
- Take 2 litre of desi cow milk in another container and boil it slowly on low flame. After boiling milk, allow it to cool down, remove the cream from the milk.
- Now take 200 litres of water, add a solution of ginger powder and milk without cream. Mix it properly and cover this solution with gunny bags for two hours.
- During this process ion exchange will occur, filter it with muslin cloth and spray this solution within 48 hours.

3. Sour butter milk

Materials required

- Water - 200 liters
- Fermented sour buttermilk - 6 liters

Procedure for preparation

- Take 6 litres of milk and make curds with it.
- Remove the Creamy layer on it.
- Let it remain for 3 to 5 days.
- Churn it well and mix in water, filter and spray on infected trees.

Dosage: 20 DAS (Days after sowing) -6 liters of sour buttermilk in 100 liters of water
Works against all foliar diseases.

4. Tutikadarasam

Tutikadarasam is prepared from Datura leaves and cow urine. The leaves are boiled in cow urine for 2-3 hours, cooled and then filtered using cloth.

5. Jungle Ki Kanddi

- Take 5 Kg kanddi powder (powder of indigenous cow's dung also known as jungle ki kanddi) and keep it in muslin cloth.
- Tie one end of this bag in the centre of a wooden stick in such a way so that this bag hangs above the centre of the drum filled with 200 litres of water drum and leave for 48 hours.
- Stir this solution two times in a day for 2-3 minutes in the clockwise direction.
- The colour of the solution will change to a reddish brown colour (Katha/brass colour).
- After 48 hours, take out this bag and squeeze it, dip it again and then squeeze. Repeat this process three times, Stir this solution properly and filter this solution before use.

Dosage: Spray this solution within 48 hours.

6. EARTHEN POT ARKH

Materials required

- Earthen pot - 1 unit
- Indigenous Cow Urine - 5 litres
- Neem leaves - 1 kg
- Pongamia Leaves - 1 kg
- Calotropis Leaves - 1 kg
- Jaggery - 50 g

Procedure for preparation

- Collect the fresh leaves of Neem, Pongamia and Calotropis and crush them
- Mix the Cow urine, cow dung and jaggery properly in the earthen pot.
- Add the crushed leaves to the earthen pot and stir well.
- Cover the mouth of the earthen pot with a clean cloth.
- Store it in a shade place for 7-10 days.
- Collect the extract and further add 5 litre of cow urine and again collect the extract every 10 days.

Method of application

For use dilute 20 ml of extract per litre of water and spray the crop or drench the soil in a rose cane for control of disease.

Other ITKs followed for management of diseases

1. A mixture of ash (2-3 kg) and 1 liter of castor oil is spread on a seed bed of a size of about 100 m^2.

   -The application is repeated 2-3 times at intervals of 7-10 days. This provides protection against soil borne diseases in tobacco nurseries.

2. A mixture of 2 kg of turmeric powder and 8 kg wood ash is used as dust over leaves for treatment against powdery mildew.
3. Ginger powder at 20 gm/lit of water and sprayed thrice at interval of 15 days for management of powdery mildew and other fungal diseases.

4. Mixed cropping of chilli, coriander and garlic to manage wilt diseases of chilli (Gohain *et al.,* 2019). The smell of coriander and garlic also works as repellent for the vector insects, i.e., aphids.
5. Cattle and goat urine have fungicidal properties. -Two cups of cattle urine with 5ml peppermint oil and 10 lit of water can be used to control fungal diseases on grapes.
6. To control groundnut ring mosaic, dried sorghum or coconut leaves are powdered and boiled in water to 60^0 C for one hour, filtered, diluted and sprayed for two times at 10 and 20 days after sowing.
7. Spraying the leaf extract of *Prosopis juliflora*, two months after planting to control leaf spot, powdery mildew and fruit rot in chillies.
8. Spraying fresh cow dung suspension (1 kg raw cow dung in 10-12 L of water).
9. Cow dung suspension controls Bacterial Leave Blight (BLB) to some extent. Further the crop is protected from cat the as because the cattle do not like to graze on cow dung treated crop.
10. Dusting of wood ashes on the standing crop. Ashes check the spreading of infection of brown spot disease.
11. Application of cow dung cake/wood ash as top dressing provides pest resistance and better germination.
12. Turmeric (Curcuma longa) powder 100 gm + indigenous cow urine 1.5 liter + Water 100 liter application during Cloudy weather To manage powdery mildew of vegetables and fruit crops 70-80% vegetable and fruit crops are free from powdery mildew attack.
13. Pulse seeds sprayed with cow urine to protect against soil-borne fungus and improve development.

Strategies for the sustainable management of specific nematodes as

1. Use of nematode free planting materials;
2. Use of non-chemical practices like crop rotation and soil cultivation;
3. Use of different organic soil amendments;
4. Use of multiple cropping systems to increase tolerance to nematodes.

Some ITKs in Management of Plant parasitic nematodes

- Oilseed cakes such as mustard oil cake was found affecting the mortality of *M. incognita* (Goswami 1993).
- The populations of phytonematodes *Rotylenchulus reniformis, Meloidogyne incognita, Helicotylenchus indicus* and *Tylenchorhynchus brassicae* were significantly suppressed by oilseed cakes of castor bean (*Ricinus communis*), neem (*Azadirachta indica*), Duan (*Eruca sativa*) and Mustard (*Brassica campestris*).
- Sunn hemp (*Crotalaria spp.*) as a cover crop is often cultivated for intercrops and soil amendment or direct seeding and is considered as an antagonistic crop for phytonematodes, especially *Meloidogyne spp*.
- Root-lesion and root-knot nematodes have been shown to be suppressed by when marigolds (*Tagetes spp*.) were sown as a cover crop followed by potato.
- Plants rich in terpenoids, such as *Salvia officinalis*, *Azadirachta indica*, *Origanum majorana, Ocimum basilicum,* and *Lantana camara*, caused significant reduction in *Rotylenchulus reniformis* and *M. incognita* infesting melons and cucumber, respectively (El-Deriny 2016).
- Reduction in root-knot nematode population *(Meloidogyne spp.)* infecting cucumber was listed when dried leaf powder of *Gomphrena globose*
- Chopped pineapple leaves to the soil reduced root knot nematode.
- One kg each of powdered neem cake and tobacco waste are soaked separately in 5 lit. of water each. In the next day they are filtered and decanted solutions are mixed together in which suckers are immersed before planting to prevent nematode attack.
- Dried neem fruits are powdered and applied @ 500g. per tree to control the nematode attack.
- Mixed cropping of potato with Marigold (Tagetes sp.) reduces the risk of root nematode.

Some ITKs in Management of bacterial diseases

- Spraying of papaya leaf extract (10Kg of papaya leaves + 200 litres of water) to control bacterial and viral diseases (TNAU)
- Controlling bacterial infections with marigold cultivation followed by solanaceous vegetable crops is efficient
- Tribal farmers of Chhindwara district of Madhya Pradesh use fermented solution of 5 kg of cow dung, 5 litre of cow urine, 150 gm lime + 100 litre of water to control khaira disease, bacterial and viral diseases in paddy (Shakrawar et al., 2018).
- Cowdung is mixed with water thoroughly and kept for 3-4 hours till the course materials settle down. The solution on top is filtered and sprayed on paddy leaf for control of bacterial blight. Bactericidal action of cowdung helps reduce the population of the bacteria *(Xanthomonas sp*.) (Shakrawar et al., 2018).
- 5 kg cow dung, 5 litre of cow urine, 150 gm of lime are mixed with 100 litres of water and then kept for one month for fermentation. After fermentation it can be sprayed to control aphids, bacterial and viral diseases of vegetable crops (Shakrawar et al., 2018).
- Cultivation of marigold with solanaceous vegetable crops are effective to the management of bacterial wilt.
- Chilouney (*Schima wallichii*) is used as mulching material to manage soft rot, bacterial wilt, Fusarium dry rot of Ginger (*Zingiber officinale*)

Some ITKs in Management of Virus diseases

- "In Karur district of Tamilnadu 10Kg of papaya leaves were soaked in 200 liters of water to get 10% extract. Papaya leaf extract is sprayed on all types of crops for the management of bacterial and viral diseases.
- The formulation, prepared from buttermilk, effective against plant virus.
- One kg. of leaves of seemai karuvel/Jaali (*Prosopis juliflora*) is pounded and diluted with water and sprayed to control yellow mosaic virus.(TNAU)

Farm Machinery

18. FARM IMPLEMENTS, TOOLS AND SOURCE OF IMPLEMENTS RELATED TO NATURAL FARMING

The successful implementation of natural farming on an individual field hinges on the careful adjustment of crop geometry to accommodate intercropping alongside the main crop. Additionally, the utilization of mulch materials plays a vital role in preserving soil moisture, which is later made available to the crops through decomposition. This mulch layer also serves to suppress weed growth, which is particularly important during the kharif season when weed control can be challenging. Such challenges can lead to reduced yields for both the main crop and intercrop. Furthermore, a noteworthy aspect of natural farming is the prudent utilization of water through alternating furrows. This practice ensures adequate aeration in the root zone of the crops. However, these activities necessitate alterations in crop geometry. In flat-bed cultivation, it becomes challenging to execute all these practices effectively. Therefore, specific implements are required to minimize the overall disorder linesof the field and facilitate efficient bed preparation, allowing for optimal soil modification to support natural farming practices. Different components of Natural Farming with details and associated implements are given in Table number 1.

Table 1. Components of Natural Farming and associated implements

Components /Practice	Details	Suitable implements
Solid and liquid concoctions	Beejamrit, Jeevamrit, Ghanjeevamrit, etc.	Plastic drums, muslin cloth and wooden stick for steering purpose
Multi-cropping / Intercropping	Ideally 365 days soil cover, live mulch, bund cropping	Trencher, bed planter, dibbler etc.
Mulching	Cover crops or crop residues, etc.	Mulcher, rotary weeder/cono-weeder
Aeration	Humus development process, Soil aeration, alternate furrow irrigation, alternate wetting and drying in case of rice	Ridge and broad bed maker
Prophylactic pest control measures	Use of Bio formulations	Plastic drums, muslin cloth and wooden stick for steering purpose

Fig:-1. Geometric arrangements to grow (wheat + chickpea) on bed and furrow for irrigation purpose

Essential Farm Implements and Tools:

- **Hand Tools:** Hand tools are the backbone of natural farming, allowing farmers to work closely with the land and crops. Tools like hoes, spades, and digging forks enable gentle soil manipulation, reducing compaction and disturbance. Weeding implements, such as scuffle hoes and hand weeders, facilitate precise weed removal without disrupting the soil structure. In case of natural farming in general weeds are controlled through mulching but in extreme conditions it can follow light weeding through hand tools as mention above. Some important tools used in Natural farming are given in Table 2. These are only illustrative examples and the tools/ names vary according to the region.
- **Mulching Equipment:** Mulching stands as a cornerstone within the framework of natural farming serving multiple essential functions such as moisture conservation, weed suppression, and soil enrichment. To facilitate the uniform application of organic matter throughout fields, various mulching implements such as straw spreaders, rotary mulchers, hay rakes, and mulch layers are used. These tools contribute to the even distribution of

mulch materials. This uniformity is crucial, as uneven distribution can pose challenges during the seeding and emergence of subsequent crops.

- Proper mulch distribution prevents complications like obstructing zero-till seed drills or happy seeders. These obstructions can lead to inadequate seed placement in the soil, subsequently impacting the desired crop population at the individual farm level. Challenges with crop residue management become particularly pronounced after harvesting non-basmati rice. This type of rice generates substantial residues, ranging from 7 to 10 tonnes per hectare. Such residues pose difficulties during the sowing of the next crop.

- **Seed Planters and Spreaders:** To enhance the precision of planting and sowing in the context of natural farming, these hand-operated seed planters and spreaders are readily available. These implements are designed to ensure optimal seed spacing and appropriate planting depth, contributing to consistent germination and uniform growth of crops seed without damaging the soil layer.

- In the case of intercropping within natural farming systems, precise adjustments in planting arrangements are crucial. Over time, various implements have been developed to cater to these needs. Examples include sugarcane trenchers, bed planters, and broad bed and furrow makers. These implements, create furrows for irrigation purposes and establish raised beds for crop planting. But their use causes harm to the nutrient layers and earthworms of the soil. For the actual planting process, a dibbler can be utilized. A dibbler is particularly useful for small-scale vegetable growers who might not have the resources to invest in a planter. This tool aids in creating holes forseed placement, facilitating the planting process without the need for more advanced equipment.

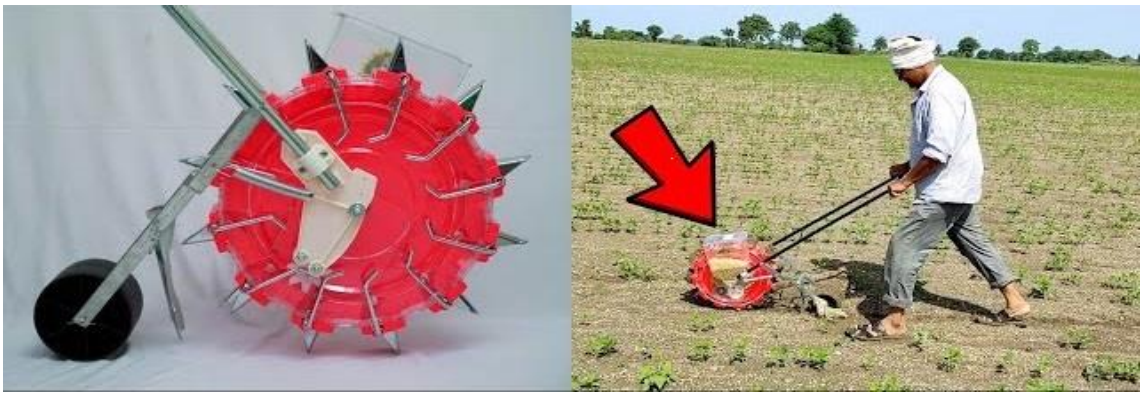


Fig. 2. Seed Planter

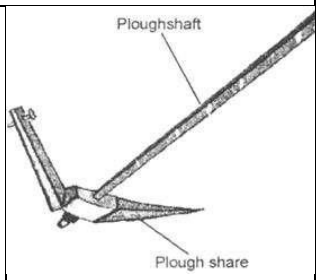
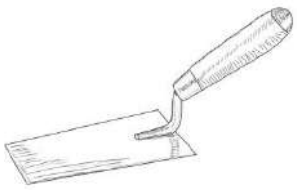
Fig: - 3. Glimpse of intercrops with sugarcane in trench method

Fig:-4. Sugarcane dibbler used for vegetable sowing in between papaya and banana

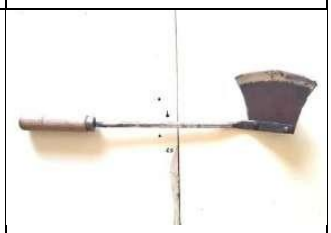
3. **Animal-Drawn Implements:** In accordance with the principles of natural farming, harnessing the capabilities of animals for ploughing and cultivating fields aligns seamlessly with the philosophy. The utilization of animal-drawn plough and cultivators serves multiple purposes: it reduces dependence on fossil fuels, minimizes soil compaction, and fosters a more harmonious relationship between humans, animals, and the environment. Furthermore, the implementation of animal-drawn implements contributes to the responsible utilization of male cows, which might otherwise be left wandering on roads and streets. The issue of stray cattle is particularly pronounced in the cow belt of India. Farmers often voice concerns about this matter on various platforms. The presence of stray cattle hampers the cultivation of diversified crops, including legumes, as they can cause damage. By effectively channeling these bulls for farm work, akin to practices from earlier periods, a win-win situation can be created. This approach not only addresses the issue of stray cattle but also harnesses their potential to contribute positively to agricultural endeavors.

Tools and their use: - Different tools and implements and their uses are given below.

Table 2. Different small tools/ implements used fordifferent purposes in Natural Farming

Tool/implement	Description	Image
Tillage implements		
1. Plough (*Hal)*	Drawn either by oxe, it is used for ploughing.	
Intercultural operation tools		
2.Khurphi	Used to intercultural operation in small plots in mainly vegetables	

3. Spade(*Fawda*)	Used for digging and weeding operations. It used to irrigation to manage water channel and earthling up in sugarcane	
4. *Panjja*	Used to collect the garbage andplant waste material in the field	

Harvesting tools		
5.Sickle (*Daranti*)	It used to cut the fodder crops andweeds	
6. *Balkati*	It is specially used to harvest thesugarcane	
7.Chopper(*Gandasa*)	Chopper is used to chop the greenforage for animals and feed them	
8. Knife	Use to remove leaves and cut the sugarcane	

10. Jelli	Used to manage the chopped wheat,rice, mustard etc straw	

Animal drawn cultivator: This type of cultivator is designed to be pulled by an animal, such as a buffalo or bullock, and is used for intercultural operations in fields, particularly in sugarcane cultivation. The cultivator has specific features such as 3-5 tynes (tines) for cultivating the soil, wheels to reduce the effort required by the operator and to improve maneuverability, and a plastic-covered handle for comfortable handling. Intercultural operations involve activities like weeding and soil loosening, which are crucial for maintaining the health and growth of crops like sugarcane. The cultivator helps remove weeds, aerate the root zone, and reduce soil compaction, which can contribute to better crop yields. In the sugarcane belt of Uttar Pradesh, India, this type of animal draw cultivator is commonly used. It's attached behind a male buffalo, which pulls the implement through the field.

Fig 5. Animal drawn cultivator used in sugarcane for weeding and intercultural operation

Rotatory conoweeder: Intercropping with rice poses a consistent challenge due to the constraint of finding compatible crops that can thrive in the standing water conditions unique to rice fields. To address this, it is recommended that farmers consider cultivating either azolla or Sesbania aculeata as intercrops. These options can be effectively incorporated into the soil using a rotary conoweeder. This process serves to not only integrate the green intercrop material into the soil but also to suppress competing weeds and enhance the root zone's aeration. In instances where Sesbania aculeata is chosen for intercropping with rice, providing light irrigation during the initial growth stages is advisable.

Fig 6. Rotatory conoweeder in rice field

Sources of Implements for Natural Farming:

Local Artisans: Many local artisans possess the skills to create custom-made farm implements tailored to the needs of natural farming. These artisans can craft tools from locally sourced materials, reducing the environmental footprint associated with long-distance transportation. Gadia lohar a nomadic community in India is expert in preparing small agriculture tools.

Fig 7. Gadiya Lohars at the outskirts of the Meerut city with agriculture tool

Farm Co-operatives and Workshops: Farmers engaged in natural farming often collaborate to establish co-operatives or workshops focused on creating and sharing sustainable implements. These collective efforts help disseminate knowledge and provide access to specialized tools that might not be readily available elsewhere. Small, marginal and landless farmers should be aggregated which can double-up as custom hiring centers to provide the implements for Natural Farming.

Sustainable Agriculture Organizations: Numerous organizations are dedicated to promoting sustainable agriculture practices, including natural farming. These organizations may offer guidance on selecting appropriate implements, connect farmers with reputable suppliers, and even host workshops or training sessions on implement usage.

Online Market places: In the digital age, online market places have emerged as valuable platforms for sourcing natural farming implements. These platforms connect farmers with manufacturers and suppliers who prioritize sustainable and eco-friendly solutions.

Implement Maintenance and Care: Maintaining and caring for farm implements is vital to their longevity and effectiveness. Regular cleaning, proper storage, and timely repairs ensure that implements remain functional and serve their purpose over a long term.

Farm implements and tools are integral to the success of natural farming, enabling farmers to work in harmony with the land while minimizing ecological impact. By adhering to the principles of natural farming and selecting appropriate implements, farmers can enhance soil health, promote biodiversity, and contribute to a more sustainable and resilient agricultural system. By utilizing local resources, collaborating with fellow farmers, and seeking guidance

from sustainable agriculture organizations, practitioners of natural farming can access the tools they need to cultivate a healthier and more vibrant future for agriculture. The key to successful natural farming lies not only in the tools that are used but also in the understanding and application of the underlying principles that guide the actions on the land.

Certification & Marketing

19. CERTIFICATION

What is Certification?

Certification is a formal attestation of any good/service is produced/carried out as per the standards of the category. Upon compliance to standards and regulations, the accreditation body may allow a third party to provide certification. It ensures and assesses compliance with the defined standards and provides an official certification mark or a declaration of conformity to the operator. This enables the product to have a competitive advantage in various markets, add to the brand value and gain premium prices.

Why is Certification Needed?

The growing demand for naturally grown products has stimulated the growth of natural produce.

The Covid situation in the country has also impacted on consumers in India to go for safe, healthy and immunity boosting products. Recently the market for chemical free and natural products has rapidly grown to 25-30%. To address this demand the quality of produce has to be checked and fraud has to be prevented. Therefore, certification assures the quality of a product.

There are several states practicing Natural Farming. Prominent among them are Andhra Pradesh, Chhattisgarh, Kerala, Gujarat, Himachal Pradesh, Jharkhand, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh and Tamil Nadu.

Why Natural Farming Certification is required

To build Trust: A strong certification mechanism and institutional structure is to be developed to identify natural products. In case of identity and trust in the product by consumer, the products should have uniform labelling which consists of logo or certification mark as per the specific standards.

Identity and differentiate products from non-certified products: Every product should have its own identity enabling differentiation among many products when placed together.

Quality: Quality is the most important aspect of any product. In India, several quality control mechanisms have been developed in the food sector namely BIS, ISI, FSSAI,

HALMARK, AGMARK etc. In the same way, natural products should have specific standards to assure their quality.

Guarantee: Any product which follows certification under proper institutional mechanism with rules and regulations will guarantee the consumer regarding the quality.

Uniqueness: Uniqueness of a product enables specific differentiation among the certified products.

Ownership: Any product which comes under certification mechanism with proper labelling, i.e., by logo or UID no. enables any producer/ salesperson to build their brand with ownership of the specific logo.

Brand: In the market, many products are sold by retailers/ producers and most popular products become brands. By way of issuing certification for the natural farming products, it may facilitate making the product a brand.

Consumer acceptance: The certified products will likely have more acceptance among the consumers which may enable the farmer to get premium prices for their natural produce. It increases confidence of consumers in their choice for naturally grown food

Traceability: Provides traceability across the entire value chain.

General Requirements for certification of Natural products:

Currently there are no specific standards for certification of Natural products. However, the following general requirements can be followed for grant of certificate in the future:

a) **Inputs:** Use of synthetic/ chemical inputs (chemical fertilizers, pesticides, hormones or synthetic growth hormones/ growth stimulants, synthetic feed additives) and genetically modified seeds/ planting material or their derivatives or products either directly or indirectly are prohibited. Natural farming system avoids use of purchased inputs (organic, chemical or otherwise), therefore all inputs shall be prepared on-farm. Preferably the entire landholding with livestock should be converted to natural farming.

b) **Parallel production/split production:** If the whole farm cannot be converted, it should be ensured that the natural and conventional parts of the farm are separate and distinct. For this purpose a buffer zone or a natural barrier should be maintained. Simultaneous production of same crop (parallel production) in natural and conventional method should be avoided.

c) **Farm Field – GPS, Coordinates Photos:** Every farm field should be recorded by a unique

survey number or land record and also GPS co-ordinates. This documentation also enables to integrate in future with GI system.

d) **Purchase of Seeds:** In the market, several type of seeds like chemically treated, botanical treated seeds, GM seeds, traditional seeds are available. In the Natural Farming, farmers are encouraged to use traditional seeds/ locally available seeds. To track farmers whether they are using seeds as per requirement the bill's copy may be documented.

e) **Cultivation/ Production Practices:** The Natural farmers are to adopt diversified crops, intercropping, multiple cropping, crop rotation etc. Its integration with horticulture and agro-forestry is a common feature. These practices need to be documented throughout the year at different intervals. This can be documented digitally also by taking photographs and making videos. Farmer shall maintain a diary depicting all hi practices on daily basis.

f) **Natural Farming Inputs:** In Natural Farming, locally available inputs / on-farm inputs are supposed to be used. To track inputs used by farmers, throughout the cultivation period, they need to be recorded. The unit's/ field preparations/ utensils pictures (Panchagavya, Jeevamrit, Beejamrit, botanicals, compost etc.,) can be taken from time to time and recorded for verification.

g) **Natural Ways of Pest Management:** In Natural Farming, pests and diseases are to be managed by use of locally available botanicals/ ITKS/ soil fertility management / cropping pattern etc. Usually, the pest and diseases will be managed by using various bio inputs. These practices need to be documented including their preparation, application and time/ quantity of application.

h) **Buffer Zone:** The neighbouring farmers may not be practising Natural Farming. The chances of movement of chemical and pesticide residues to Natural Farming fields is possible. In order to avoid this, a clear buffer zone may be created between Natural Farming and conventional farming. The buffer zone may include bunding/ planting trees around the boundary of farm fields and making proper water channels to prevent entry of water from neighbouring fields.

i) **Before and After Harvest:** The field pictures/ videos during the crop duration and also after harvest may be documented. The product pictures in the field should be documented for double verification and validation for quantity of crop produced.

j) **Storage:** The Natural Farming products should be stored separately to avoid mingling with other products. A separate storage unit/ utensils/ material should be used for Natural products. The pictures of storage units, materials used for handling Natural Farming products may be recorded.

k) **Transportation:** When Natural Farming produce is harvested, care should be taken to transport it without mingling with conventional product. Preferably, a separate transport facility may be used. The transport unit can be recorded/ documented.

l) **Labelling and Branding:** The label is most important to identify/ to bring uniqueness. The pictures/ online traceability system may be developed/ used in labelling.

m) **Package and practices in the farm:** To make sure that farmers or groups adopted Natural Farming package and practices in the farm, livestock rearing, etc documentation is necessary.

n) **Farmer's Identification:** Farmer's document related to their identity like ID card, Aadhaar card, driving license, passport etc. are to be recorded so that the farmers practicing Natural Farming can be easily identified.

o) **Processing and Handling Unit with Machineries and Infrastructure:** The processing units their machinery, storage, transportation, production, packaging, labelling, sale all need to be documented in a proper way to maintain quality of the products. Therefore, it is essential to keep records by way of pictures/ videos from time to time.

p) **Training Records:** Farmer has to be exposed to regular training to update their knowledge on the latest package and practices and certification requirements on Natural Farming. The regular participation of the farmers in trainings will directly influence overall quality of Natural Farming production.

q) **Meeting Records:** The farmers practicing Natural Farming either individually or in groups need regular interactions among the members to identify and resolve various issues. The regular participation in the meeting will enhance their shared vision and focused approach.

Such kind of meetings conducted by Natural Farmer groups need to be documented.

Even though there are no National wide specific standards for certifying the Natural products, Himachal Pradesh is implementing Natural farming certification in the state through

Prakritik Kheti Kushal Kissan Yojna (PK3Y)) which is a Self-Assessment Certified Evaluation Methodology. It has been named as Certified Evaluation Tool for Agriculture Resource Analysis-Natural Farming (CETARA-NF).

Certification System of Department of Agriculture, Government of Himachal Pradesh

The Sustainable Food Systems Platform for Natural Farming (SuSPNF) programme is initiated by the Department of Agriculture, Government of Himachal Pradesh. It is based on intensive engagement with smallholder farmers since 2018 and has a network of 106705 farmers were certified in Natural Farming. This project plans to cover all farming families of the state and aims to extend its coverage to 20000 ha. Upto 2023.

Key Principles of CETARA-NF are:

- Simple for farmers and implementation agency
- Based on principles of No use of Agro-chemicals and GMOs
- Based on principles of Natural Farming as propounded under PK3Y Scheme
- Scalable with other schemes/regulations at national and international level
- Based on transparency and traceability between Farmer and Consumer

Highlights of the Certified Evaluation system: The features that makes CETARA-NF distinct from existing certification system are:

- Self-certification – has easy process at the end of the farmer
- Convenient for new joining farmers as there is a defined rating from the start
- Fast in response as the certification is generated within a set time frame
- Possibility for individual farmers to also apply and certify their produce
- Review process based on peer farmers as well as nodal officers at the block level

Procedure for certification process in CETARA-NF: In the digital certification system, any farmer who practices natural farming can use this methodology for self-evaluation based on the parameters defined under this methodology.

Self-Certification Performa

Step1: To register in Natural Farming Khushhal Kisan Yojana "Sitara", click on "Registration" menu and fill the given form.

Registration form for Example	
Fill the form given below to register in Prakritik Kheti Khushhal Kisan Yojana.	
Name of Farmer: Sh/ Mr. Vikrant Lekhi	**Fathers / Husband Name:** Sh/Lt./D/o Balram singh
Date of Birth: Year or 15/11/1978	**Mobile no:** 94183xxxxxx
Eg. 1234	
Enter Captcha (here)	
Login for old farmer	**Registration for new farmers**

Step 2: Receive OTP on registered mobile number and enter the OTP in prescribed form

OTP Form	
OTP will generate in mobile no……	
6 digit OTP entered eg : 123456	Click for Submit

Step 3: Provide personal details (Category, District, Block, Panchayat, Village, Email ID, Gender, Aadhar Number) to complete the registration process.

Personal Detail (all information are mandatory)		
Category*	District *	Block/ Taluka*
Gen, SC, ST, OBC, others		
Panchyat; *	Village *	Lok sabha constituency
Email id (optional)	Adhaar No *	Sex *
		Male. Female/ other
		Click : Enter for next Level/ Step

Step 4: Land & crops detail

Land details		
After filling the land details, click on the signs (+) given symbol		
Farmer's cultivable land		
Farmer's total cultivable land* Example (bigha/acer/Hectare)	Total land under SP Natural Farming* Example (bigha/acer/Hectare)	
SPNF Land Details		
land khasra number	Land Latitude (Example-26.839399)	Land Longitude (Example- 80.949623)
		Click here to save all above record (+)

SPNF Crops description			
Kharif Season Crops			
Type of crops	**Crop name**	**Area (Bigha)**	**Sowing date**
Examples: **Cereals** **Pulses** **Oilseed** **Vegetables** **Millets** **Root crops** **Fodder crops** **Horticulture crops**	For cereals Wheat, Rice, maize	In hec/acer	Date: d/m/yy
Companion/Intercrops crops	**Estimated Yield (in quintals)**	**Market yield (in quintals)**	**Upload a photo of your farm or crop**

Cereals **Pulses** **Oilseed** **Vegetables** **Millets** **Root crops** **Fodder crops** **Horticulture crops**	**xxx**	**xxx**	
			Click here to save all above record (+)
SPNF Crops description			
Rabi Season Crops			
Type of crops	**Crop name**	**Area (Bigha)**	**sowing date**
Companion/Intercrops crops	Estimated Yield (in quintals)	Market yield (in quintals)	Upload a photo of your farm or crop
	xx	xx	
SPNF Crops description			
Fruit crops with mixed crops			
Type of crops	**Crop name**	**Area (Bigha)**	**sowing date**
Fruits: Mango, Apple, pomegranate	Apple	In hec/acre	Date: d/m/yy
Companion/Intercrops crops	**Estimated Yield (in quintals)**	**Market yield (in quintals)**	**Upload a photo of your farm or crop**
Legume millets,cereals,root,tuber etc	**xx**	**xx**	**Click here to save all above record (+)**
Click for next Step			

Step 5: Questionnaire

Questionnaire		
SPNF Input Usage And Practices		
Beejamrit ○ Yes ○ No	Jeevamrit ○ Yes ○ No	Ghanjeevamrit ○ Yes ○ No
Mulching (Cover With Grasses) ○ Yes ○ No	Vapsa ○ Yes ○ No	Mixed Cropping With Pulses/Legumes ○ Yes ○ No
Experience In SPNF Methodology ○ More Than 2 Years ○ From 2 Years ○ 1 Year		

Livestock (Cow)

Desi Cow	**Cross Breed Cow**	**Jersey Cow**
○ **Yes** ○ **No**	○ **Yes** ○ **No**	○ **Yes** ○ **No**

Trainings

Attended Training On NF	**If Yes Then For How Many Days**
○ **Yes** ○ **No**	○ **6 Days** ○ **2 Days**

Self-Generated SPNF Input

Self-Generated SPNF Input And Uses	**Separate Storage Facility For SPNF Formulations**
○ **Yes**	○ **Yes**
○ **No**	○ **No**

Appling SPNF formulations or Not

Sour Butter Milk	**Saptdhanyankur Ark**	**Neemastra**
○ **Yes**	○ **Yes**	○ **Yes**
○ **No**	○ **No**	○ **No**

Using External organic inputs

Use Of Organic Fertilizers	**Use Of Botanical Extracts/Bio Pesticides**	**Use Of Vermicompost**
○ **Yes**	○ **Yes**	○ **Yes**
○ **No**	○ **No**	○ **No**

Use of chemical fertilizers and Pesticides

Fertilizer (urea etc.)	Fungicides	Pesticides	Herbicide
○ Yes	○ Yes	○ Yes	○ Yes
○ No	○ No	○ No	○ No

How farmer know about SPNF?

From Facebook	**From Youtube**	**Subhash Palekar Programe**	**Any Other (Need To Specify In Written**
			○ Yes
○ Yes	○ Yes	○ Yes	○ No
○ No	○ No	○ No	
Radio	**Newspaper**	**ATMA/SPNF training programs**	
○ Yes	○ Yes	○ Yes	
○ No	○ No	○ No	

Any subsidy/ Grant received from PK3Y

Cow Shed Lining	Assistance For Approved By Spiu/Pk3y For Indigenous Cow	Drums	Sansadhan Bhandar/ Input Center
○ Yes	○ Yes	○ Yes	○ Yes
○ No	○ No	○ No	○ No

Declaration given by farmer:

I hereby declare that the details furnished above are true and correct to the best of my knowledge and belief and I undertake the responsibility to bear the consequences arising out of the wrong information provided by me in this proforma.

Date: Signature of Farmers

Place:

Step 6: For verification of SPNF practices at least three neighbouring farmers detail is compulsory (name, father/husband name, mobile number) by whom farmer is to be verified.

Name of first farmer*	**First farmer's father's name***	**First farmer's mobile number***	**Re-enter mobile number***
Eg. Ram singh	Sh keshav Ram	98160xxxxx	98160xxxxx
Name of first farmer*	First farmer's mobile number*	First farmer's mobile number*	Re-enter mobile number*
……..	…….	……	…….
Name of first farmer*	First farmer's mobile number*	First farmer's mobile number*	Re-enter mobile number*
……..	**…….**	**……..**	**……..** **Click for next Step**

Verification & approval authority

Verification of details provided by individual farmer and confirmation from neighboring farmers through ATM/BTM / Block level officials and Star Rating Certificate" will be received once verified by ATM/BTM. And District level authority will approve for SPNF certification.

ATM/BTM Name…….Block…….Phone no……

Approval By

Project Director (ATMA)/ District Level authority

Grading and Rating System in the Certified Evaluation System:

The Department of Agriculture, Government of Himachal Pradesh has laid down the standards of the NF practices and has provided an appropriate score for each under the PK3Y scheme. The ratings are received based on the final score obtained to promote natural farming practices and conventional farming practices are discouraged by lowering the score to an entry level rating. This ensures fairness as well as the distribution of ratings across the number of farmers. It has defined three levels and rating of NF:

I. **Antral-PK3** ★ Entry level rating which signifies a farmer's initial conversion from chemical to NF.
II. **Sadharan-PK3** ★★ NF practices adopted by farmers with some use of external non-chemical inputs. This is provided after one year of Antral-PK3
III. **Vishisht-PK3** ★★★ This rating specifies a farmer practicing NF strictly. This is provided after a year of Sadharan-PK3.

Procedure for Ranking

• Farmers scoring equal to or more than 50 points in Self-Declared Evaluation Methodology and cultivating crops entirely with SPNF ingredients and practices are assigned three stars and labelled as "Vishisht-PK3 (Strict)" farmers.

• Farmers scoring between 30 to 50 points will be labelled "Sadharan-PK3 farmers (External Non-Chemical Inputs)" are assigned two stars. These products can use the word "SPNF naturals". Both Vishisht and Sadharan will be allowed to display the SPNF logo on their products.

• A third category, less than 30 points, can be labelled "Antral-PK3 (Conversion from Chemical)" and assigned only one star. Products Antral-PK3 ranking cannot advertise the word "SPNF naturals and the SPNF logo on their products to consumers and can only mention this fact in the product's ingredient statement.

20. MARKETING OF NATURAL FRESH PRODUCE AND PRODUCTS

Marketing enables the farmers to achieve economies of scale, streamline distribution from various sources into a single, centralized location, collection of fresh produce and products from multiple farmers or farmer groups into a common pool to access larger markets, and streamline distribution.

Important Steps for Successful Marketing

A) Aggregation of fresh produce and products.

Aggregation is the process of collecting and combining data or items from various sources into a single, centralized location. In the context of agriculture and farming, aggregation refers to the collection of fresh produce and products from multiple farmers or farmer groups into a common pool. This pooling of resources enables farmers to achieve economies of scale, access larger markets, and streamline distribution. Farmers should be made aware of the contamination and commingling. There could be contamination while storing, processing and value addition. Cold storage should be avoided where chemical fumigation is done. Persistent or carcinogenic pesticides and disinfectants are not permitted for storing. Produce can be protected from destruction by rodents by physical barriers, traps (including static bait traps), sound, ultrasound, light and UV light.

The steps involved in the aggregation process:

1. **Identifying Farmer Interest Group (FIGs) & Collection Centre units:** FIGs are community-based farmer organizations that are formed to promote collective farming, marketing, and support. Identify and collaborate with these groups to understand their produce and products.
2. **Cataloging Fresh Produce and Products:** Create a comprehensive catalogue of the various types of fresh produce and products being cultivated and produced by the FIGs & FPOs. This catalogue should include details like product name, description, quantity available, packaging, and any other relevant information.
3. **Quality Assessment:** Establish quality standards for the produce and products to ensure consistency and customer satisfaction. Implement a quality assessment process to monitor the products before aggregation.
4. **Logistics and Transportation:** Arrange for efficient logistics and transportation to collect the produce from different farmer groups and transport it to the aggregation center. This could involve setting up collection centres at various locations or coordinating with

farmers for delivery. If any sub-contracts are made the details are to be documented the logistics should be given clear instructions on prevention of contamination and comingling.

5. **Storage and Warehousing:** Have proper storage facilities in place to preserve the freshness and quality of the collected produce and products. Proper warehousing is essential to prevent spoilage and wastage. Labelling of areas should be followed for clear identification of natural products.
6. **Market Access:** Develop a distribution network to sell the aggregated produce and products to retailers, wholesalers, or directly to consumers. Establish partnerships with supermarkets, restaurants, and other potential buyers.
7. **Financial Management:** Set up a transparent financial management system to ensure fair revenue distribution among the farmer groups involved. This is crucial for building trust and fostering long-term partnerships.
8. **Data Management & Analysis:** Maintain detailed records of the aggregation process, including the quantity of produce collected, sales data, customer feedback, and any challenges faced. Analyze this data to make informed decisions and improvements.

B) **The steps to manage the supply chain of fresh produce under FIGs & collection centres.**

1. **Demand Forecasting:** Understand market demands and consumer preferences for various fresh produce. Analyze historical data, market trends, and customer feedback to forecast the demand accurately. This will help farmers plan their production accordingly.
2. **Communication and Coordination:** Establish clear communication channels between FIGs, collection centres, and other stakeholders in the supply chain. Regularly update each party on product availability, quality, and transportation schedules.
3. **Quality Control and Standardization:** Implement strict quality control measures at both the farmer level and the collection centres. Standardize grading, packaging, and labelling to maintain consistency and meet market requirements.
4. **Inventory Management:** Use technology to track inventory levels and manage stock efficiently. This minimizes wastage and ensures a steady supply of fresh produce.
5. **Compliance and Regulation:** Stay informed about relevant agricultural regulations, certifications, and food safety standards. Ensure that all produce meets the necessary compliance requirements.
6. **Training and Capacity Building:** Provide training to farmers and collection centre staff

on best practices for handling, storage, and transportation of fresh produce. Continuous education enhances the overall efficiency of the supply chain.

By following these steps and continuously refining the process, FIGs and collection centres can streamline the supply chain, minimize losses, and deliver high-quality fresh produce to the market consistently. Effective supply chain management ultimately benefits both farmers and consumers by ensuring a reliable and sustainable flow of fresh agricultural products.

C) Value addition aspect of naturally cultivated fresh produce

Value addition refers to the process of enhancing the value of a product through various methods and techniques. For small farmer collectives involved in naturally cultivated fresh produce, value addition can play a significant role in increasing their profitability, expanding market opportunities, and creating a competitive advantage. Here are some value addition aspects that small farmer collectives can consider:

1. **Processing & Preservation:** Small farmer collectives can process their naturally cultivated fresh produce into value-added products such as jams, sauces, pickles, dried fruits, frozen items, or canned goods. This not only extends the shelf life of the produce but also opens up new market segments.

2. **Packaging and Branding:** This is detailed out separately.

3. **Market Diversification:** Explore different market channels, such as farmers' markets, speciality stores, online platforms, and restaurants. Diversifying the distribution channels can lead to increased sales and a broader customer base.

4. **Product Differentiation:** Highlight the unique qualities and flavours of the naturally cultivated produce to differentiate it from conventionally grown products. Educate consumers about the benefits of consuming naturally grown food.

5. **Adding Convenience:** Offer pre-cut, pre-washed, or ready-to-eat fresh produce to cater to the convenience-seeking consumer segment. This can be especially appealing to busy urban dwellers.

6. **Value-Added Services:** Provide value-added services like recipe cards, cooking tips, or educational workshops to create a deeper connection with customers and showcase the versatility of the produce.

7. **Collaborations and Partnerships:** Partner with local chefs, restaurants, or food companies to create unique dishes or products using naturally cultivated fresh produce. Such collaborations can enhance brand visibility and credibility.
8. **Export Opportunities:** Explore export opportunities for value-added products in regions where there is a demand for organic and naturally cultivated produce.

Value addition can significantly improve the economic viability of small farmer collectives engaged in naturally cultivated fresh produce. It empowers farmers to capture a larger share of the value chain, create a niche market, and foster long-term customer loyalty. By leveraging these value addition aspects, small farmer collectives can build sustainable businesses while promoting environmentally friendly and socially responsible practices.

D) Packaging

Packaging of value-added products from naturally cultivated produce is a critical aspect of the overall branding and marketing strategy. The packaging should not only protect the product but also reflect the premium nature of value-added offerings and communicate their unique selling points. Here are some key considerations for packaging value-added products:

Premium and Eco-Friendly Materials: Use high-quality and eco-friendly packaging materials to convey the premium nature of the product and align with the values of naturally cultivated produce. Recyclable, biodegradable, or compostable materials can be excellent choices.

Packaging with paper, wax paper, cold boxes with coating film or inside bag with food grade liners, textile packaging (tested for harmful substances), glass and other methods (clip seals).

1. **Differentiation:** Create packaging that stands out from conventional products on the market. Consider unique shapes, colours, and designs that catch the consumer's eye and convey the product's speciality.
2. **Product Information:** Provide clear and comprehensive information about the value-added product on the packaging. Include the product name, key ingredients, nutritional facts, usage instructions, and any certifications or sustainability credentials.
3. **Story Telling:** Use the packaging as a canvas to tell the story of the small farmer collective and the unique journey of the naturally cultivated produce. Storytelling enhances the emotional connection with consumers.
4. **Brand Identity:** Ensure that the packaging design reinforces the brand identity of the

small farmer collective. Use consistent brand colours, fonts, and logos to create a recognizable and cohesive visual presence.

5. **Functional Packaging:** Consider packaging that enhances the convenience and usability of the value-added product. For example, resalable pouches or containers can prolong the shelf life of the product and offer easy storage for consumers.
6. **Window Packaging:** For products with appealing visual qualities, consider window packaging that allows consumers to see the product inside. This can enhance the product's appeal and help build trust with customers.
7. **Regulatory Compliances:** Ensure that the packaging complies with all relevant food safety and labelling regulations. Adhere to packaging size requirements, allergen labelling, and other industry-specific regulations duly following FSSAI guidelines.
8. **Batch or Lot information:** Add batch or lot numbers on the packaging to facilitate traceability and quality control. This is especially important for products with limited shelf life or seasonal variations.
9. **Consumer Engagement:** Use packaging as a tool to engage consumers. This could include adding QR codes that lead to the product's webpage, recipes, or information about the farmer collective's practices.
10. **Sustainable Packaging Practices**: Consider implementing sustainable packaging practices throughout the value chain, such as using minimal materials, optimizing packaging sizes to reduce waste, and encouraging consumers to recycle or reuse the packaging. Include trail packs packs/small packets for attracting more consumers.
11. **Packaging Durability:** Ensure that the packaging protects the value-added product during transportation and handling. Fragile products may require additional protective measures.

By paying attention to these packaging considerations, small farmer collectives can elevate the presentation of their value-added products, effectively communicate their brand message, and appeal to consumers seeking premium, sustainable, and naturally cultivated offerings. A thoughtful and attractive packaging design can significantly impact the success of value-added products in the market. During package care should be taken that the content on package should not mislead the consumer.

Branding

1. **Brand Name:** Choose a compelling and memorable brand name that reflects the essence of the value-added products and resonates with the target audience.

2. **Logo Design:** Design a visually appealing logo that embodies the natural and organic values of the produce and establishes brand recognition. Logos of any accreditation body or certification body or any other complimenting authority cannot be misused or duplicated.

3. **Brand Colors and Fonts:** Establish a consistent colour palette and font selection that reinforces the brand identity across all marketing materials, including packaging and promotional materials.

4. **Brand Story:** Craft a captivating brand story that narrates the origin, mission, and values of the small farmer collective. Share this story through packaging, websites, and marketing materials to create an emotional connection with consumers.

By integrating thoughtful packaging design and a compelling branding strategy, small farmer collectives can create a strong market presence for their value-added products of naturally cultivated produce. A well-executed packaging and branding approach can attract loyal customers, drive sales, and ultimately contribute to the success and growth of the brand.

Preservation of naturally cultivated products

Instead of using chemical preservatives, small farmer collectives that focus on naturally cultivated produce may employ various other techniques to extend the shelf life of their products:

1. **Refrigeration and Cold Storage:** Keeping produce at low temperatures helps slow down spoilage and maintain freshness. Many naturally cultivated products are sold in refrigerated sections or stored in cold storage facilities.
2. **Drying and Dehydration:** Drying fruits, vegetables, and herbs removes moisture and inhibits the growth of microorganisms, making the produce less susceptible to spoilage.

3. **Canning and Fermentation:** Freezing fresh produce immediately after harvesting helps retain its nutrients and quality until it reaches the consumers.

4. **Freezing:** Freezing fresh produce immediately after harvesting helps retain its nutrients and quality until it reaches the consumers.

5. **High-Acid and Low pH Foods:** Certain fruits and vegetables have natural acidity that acts as a preservative. Pickling and preserving in vinegar are examples of this preservation technique.

6. **Salt and Sugar:** Salt and sugar are natural preservatives used in certain products, like salted vegetables or fruit preserves.

7. **Harvest Timing:** Harvesting produce at the optimal stage of ripeness ensures that it reaches the market at its peak freshness, reducing the need for preservation.

Proper packaging, such as vacuum-sealing or using airtight containers, can slow down the deterioration of produce by limiting exposure to air and moisture.

Preservation of naturally cultivated produce as per ITKs

Indigenous Traditional Knowledge (ITK) includes a wealth of practices and techniques developed by local communities over generations to preserve and utilize natural resources, including the preservation of agricultural produce. These practices are often rooted in the local ecosystem and take advantage of natural methods to extend the shelf life and nutritional value of produce.

Some common preservation methods from ITKs for naturally cultivated produce:

1. **Sun Drying:** Sun drying is a traditional method of preserving various fruits, vegetables, and herbs. Produce is spread out in the sun until it loses most of its moisture, making it less susceptible to spoilage.
2. **Smoking:** Smoking is used for preserving meat, fish, and certain fruits and vegetables. The smoke acts as a natural preservative and helps protect the produce from insects and bacteria.
3. **Fermentation:** Fermentation is a technique used to preserve foods by promoting the growth of beneficial micro-organisms: It is commonly used for preserving some vegetables.
4. **Salt Curing:** Salting is a traditional method for preserving fish, meat, and certain vegetables. Salt draws out moisture from the produce, preventing bacterial growth and spoilage.
5. **Pickling:** Pickling involves preserving produce in a solution of vinegar, salt, and spices. The acidic environment inhibits the growth of spoilage-causing microorganisms.
6. **Root Cellars:** Root cellars are cool and dark storage areas used to preserve root vegetables, tubers, and fruits. The stable temperature and humidity slow down spoilage and maintain freshness.
7. **Herbal Preservatives:** Some ITKs involve using specific herbs with natural preservative properties to extend the shelf life of produce.

8. **Covering with Ash or Sand:** In some cultures, produce like root vegetables or fruits are stored by burying them in ash or sand, providing protection and insulation against spoilage.
9. **Honey and Syrup preservatives**: Coating certain fruits in honey or syrup can preserve them while also adding sweetness.
10. **Oil Preservatives:** Storing produce submerged in oil can prevent spoilage and infuse flavours.
11. **Use of Natural Antimicrobial Agents**: Some ITKs use natural antimicrobial agents, such as garlic, ginger, or neem leaves, to protect produce from spoilage.

It's important to note that while ITKs can offer valuable insights into traditional preservation methods, it's also essential to ensure food safety and hygiene standards are met. Combining these traditional preservation practices with modern food safety guidelines can help small farmer collectives preserve naturally cultivated produce in a sustainable and safe manner for market sale.

Different types of Marketing Strategies

a) Offline Marketing

1. Canopies

- Set up canopies or pop-up stalls in high-traffic areas, such as local fairs, festivals, community events, and public gatherings.
- Create an inviting display showcasing the naturally cultivated fresh produce. Use banners, posters, and product samples to attract attention
- Engage with potential customers by offering product tastings, sharing information about farming practices, and answering their questions.
- Provide promotional materials like brochures or flyers with details about the FPO, their produce, and contact information.

2. Captive Outlets

- Establish captive outlets at strategic locations like transportation hubs, tourist spots, or recreational areas where there is a steady flow of people.
- Ensure that the outlets are well-branded and visually appealing to capture the interest of passersby.
- Offer a diverse range of naturally cultivated produce, including seasonal offerings, to cater to the varying demands of customers.
- Implement regular quality checks and ensure a consistent supply of fresh produce.

3. **Shops at Vantage Points and Reputed Market Locations**
   - Partner with existing shops or retail outlets at vantage points and renowned market locations to display and sell naturally cultivated produce.
   - Ensure that the packaging and labelling of the products are attractive and convey the FPO's branding and story effectively.
   - Train the shopkeepers or staff to educate customers about the benefits of naturally cultivated produce and the practices of the FPO.
   - Exclusive deals or promotions to incentivize customers to purchase the products.

4. **Visual Merchandising**
   - Utilize effective visual merchandising techniques to make the produce display visually appealing and draw the attention of customers.
   - Use natural elements like wooden crates or baskets to enhance the natural and organic appeal of the fresh produce

5. **Sampling and Product Demos**
   - Conduct product sampling and demos regularly to allow customers to taste the freshness and quality of the produce.
   - Engage customers by demonstrating how naturally cultivated produce can be used in different recipes and dishes.

6. **Seasonal Marketing**
   - Tailor the marketing strategies to highlight the seasonal produce and create a sense of urgency and excitement around the limited-time offerings

7. **Customer Loyalty Programs**
   - Implement customer loyalty programs to encourage repeat purchases and reward regular customers.

8. **Collaborations and Partnerships**
   - Collaborate with local chefs, restaurants, or hotels to feature the naturally cultivated produce in their menus and dishes.

The offline platform for marketing naturally cultivated fresh produce of Farmer Producer Organizations (FPOs) through offline platforms, such as canopies, captive outlets,

and shops at vantage points and reputed market locations can be an effective way to directly connect with consumers and promote the unique qualities of the produce.

1. **Farmers' Markets and Local Events:** Participate in farmers' markets and local community events to directly engage with consumers, offer samples, and share information about your naturally cultivated produce and products.
2. **In-Store Promotions:** Work with retailers to conduct in-store promotions, such as product tastings or demos, to attract customers and showcase the unique qualities of your produce.
3. **Flyers and Brochures:** Distribute flyers and brochures at local grocery stores, community centres, and events to inform consumers about your naturally cultivated produce and products.
4. **Word-of-Mouth Marketing:** Encourage satisfied customers to spread the word about your products through word-of-mouth marketing. Positive reviews and recommendations from happy customers can significantly impact brand reputation.
5. **Collaborations with Restaurants and Chefs:** Partner with local restaurants and chefs to feature your produce in their dishes, creating a buzz around your brand and enticing more consumers to try your products.
6. **Community Outreach:** Engage with the local community by organizing workshops, seminars, or farm visits to educate people about the benefits of naturally cultivated produce.
7. **Local Media Coverage:** Reach out to local newspapers, radio stations, and community publications to share your brand's story and promote your products.

b) Online Marketing

Establishing online e-commerce platforms for marketing naturally cultivated fresh produce of farmers or Farmer Producer Organizations (FPOs) can be a powerful way to reach wider consumers and facilitate direct sales. The steps to set up such an e-commerce platform are described later. The following are the online marketing strategies:

1. **Market Research:** Conduct market research to understand the target audience, demand for naturally cultivated produce, and potential competitors in the online marketplace.
2. **Professional Website:** Create a user-friendly and visually appealing website that showcases your naturally cultivated produce and products. Include information about the farming practices, product range, and purchasing options.
3. **Domain and Hosting:** Purchase a domain name that reflects your brand and the type of products offered. Secure reliable hosting to ensure the website's performance and security.

4. **Website Design and Development:** Design an attractive and user-friendly website that showcases the naturally cultivated produce, highlights the FPOs' unique selling points, and provides essential product information.
5. **Product Catalogue:** Create a comprehensive product catalogue with high-quality images, detailed descriptions, and pricing information for each type of naturally cultivated produce available.
6. **Seasonal Offers and Discounts:** Offer seasonal promotions and discounts to attract customers and encourage repeat purchases.
7. **Sustainable Packaging:** Highlight your commitment to sustainability by using eco-friendly packaging materials for shipping the products.
8. **Online Payment and Security:** Set up secure online payment gateways to allow customers to make purchases easily and safely. Consider SSL certificates for enhanced security.
9. **Shipping and Delivery Options:** Implement a shipping system that calculates shipping costs based on location and provides multiple delivery options for customers to choose from.
10. **Order Management:** Set up an efficient order management system to track orders, manage inventory, and process shipments promptly.
11. **Customer Support:** Offer multiple channels for customer support, such as live chat, email, or phone, to address any inquiries or concerns.
12. **Legal and Regulatory Compliance:** Ensure compliance with all relevant laws and regulations related to e-commerce, food safety, and data protection.
13. **Continuous Improvement:** Regularly gather feedback from customers and monitor website performance to identify areas for improvement and make necessary adjustments.
14. **Social Media Marketing:** Leverage social media platforms like Facebook, Instagram, Twitter, and LinkedIn to share product updates, farm stories, and engage with your audience.
15. **Content Marketing:** Write blog posts and create informative content related to organic farming, sustainable agriculture, and the health benefits of naturally cultivated produce.
16. **Email Marketing:** Build an email subscriber list and regularly send out newsletters with product updates, seasonal offers, and valuable content to keep customers informed and engaged.
17. **Digital Advertising:** Invest in online advertising through platforms like Google Ads or social media ads to promote your products to a targeted audience.

18. **Video Content:** Create engaging videos showcasing your farm, production process, and product usage to connect with consumers on a deeper level.
19. **Customer Reviews and Testimonials:** Encourage customers to leave reviews and testimonials on your website or social media pages to build trust and credibility.
20. **Search Engine Optimization (SEO):** Optimize your website and content for relevant keywords to improve visibility on search engines and drive organic traffic.
21. **Partnerships with Influencers:** Collaborate with influencers or bloggers in the food and health niche to feature your products in their content.

By setting up a well-designed and user-friendly e-commerce platform, FPOs can expand their market reach, connect directly with consumers, and promote the benefits of naturally cultivated fresh produce.

The following are the approaches for marketing strategies for Natural Farming produces.

Some have been around for decades others have been developed more recently.

1. Marketing strategies at Farmers' level
2. Community Supported Agriculture (CSA)
3. Subscription base marketing.
4. Farmers Markets
5. U-Pick farms
6. Farm Stands, Restaurants
7. Farm to School and Institutions
8. Agritourism
9. Move from 1-To-Many to 1-To-1 Marketing

1. Marketing Strategies at Farmers' Level

Farmers should record their presence in society by using social media platforms like Facebook, WhatsApp, Telegram and YouTube etc.

In this social media platform farmer should post their daily farming, activities in particular sowing, input preparation, harvest and post-harvest. This will help to popularize their farm produce. It also increases credibility and authenticity amongst their group members and supposed customers. When the group member sees the farm work on social media it will be converted in to customer base.

2. Community Supported Agriculture

Community Supported Agriculture (CSA) is a relatively recent and innovative concept that is intended to create a relationship between farmers and consumers, wherein risks and bounties are shared. CSA customers buy shares for a season by paying a fee in advance. In return, they receive regular (in most cases weekly) supplies. Having cash in advance of the growing season and a regular customer following provides financial security for farmers. The regular supply of food directly from the farm provides nutritional security and a sense of community for customers. On some farms, get-togethers with customers or workdays are part of the agreement. In its purest form, customers share in the risk of low production and crop failures, as well as any abundance, by receiving less or more food. This aspect has seen a variety of adaptations on CSA farms. Operating a CSA requires excellent crop management skills to provide attractive and diverse weekly food baskets, as well as good customer service. CSA can be integrated with farmers' market sales and other techniques. It has been an excellent start-up strategy for many small organic farms, providing crucial cash flow at the beginning of the growing season and allowing farmers to "boot strap" their way into farming.

CSA can be implemented in the following way.

- Traditional single farm models,
- Cooperatives/ multi-farm CSAs,
- Low-income consumer-targeted CSAs,
- Multi-farm innovations targeting unique consumer segments with a health and wellness marketing partner
- CSAs associated with urban market innovations

Food hub concept with CSA aggregation and distribution model. Farmers who have adapted and innovated to reach growing local market demand have found numerous ways to adapt the CSA subscription model in a way that fits their goals and unique market conditions. The model is highly flexible to accommodate a variety of products produce, meat, dairy, eggs, as well as value-added and processed products coming from the farm.

3. Subscription Base Model for Natural Farming

The subscription based model is similar to CSA, but the only difference is farmers need to take care of the continuous supply of fruits and vegetables without break. This model provides financial security to farmers in advance, and the subscribed customers get regular produce from natural farms.

4. Farmer's Markets

A farmers' market is a place where a number of growers assemble on a particular day to sell farm products directly to consumers. The sites are often parking lots, streets closed during the market, parks, etc. Farmers at these markets sell their products from "stands" that may consist of the back of a farm truck or a simple tabletop to elaborate and attractive covered displays, 'canopies', etc. Farmers generally receive retail prices or higher for their products. Start-up costs for becoming involved in a farmers' market can be very inexpensive- like stall fee in some instances. Because of the low start up investment, farmers' markets can provide a low risk setting for new farmers or an opportunity to try out new products. Many farmers participate in more than one market to increase their sales. Farmers' markets also provide the opportunity to build a customer base. Some farms advertise other outlets for buying their products. Farmers can create a natural farming farmers market where they all gather and sell their produce and also process food.

Ima Keithel (Mother's Market), also known as Women's Market is a market run exclusively by women in Imphal, India. It is a commercial center and a popular tourist attraction in the state of Manipur and is currently located in Khawairaband Bazaar. Developing markets like this all over India, will help in women empowerment and strengthen the women farmer condition.

5. U-PICK Farms

U-Pick or Pick-Your-Own farms grow crops specifically to be harvested by customers. In this manner, the task of picking the crop, one of the major costs of growing fruits and vegetables, is passed on to customers. There continues to be an interest by families in picking produce for fresh use and, in some instances, having their children experience where their food comes from. U-Pick operations can be blended with other marketing techniques such as roadside markets, farmers' markets, etc. U-pick operations serve as an alternative selling method that supplements other marketing strategies. Such strategies defiantly help natural farming farmers to grow their income and to find new consumers. The Farm, Bannerghatta Road. Bangalore, Karnataka, is one example of such marketing.

6. Farm Stands, Restaurants

Farm stands or markets are structures of some type from which the farm products are sold. They tend to be located on the farm, often on a well-travelled road with good access and parking. They can operate seasonally or all year and focus on one product or a full line of

products. Roadside markets usually charge near retail prices. Given that farm stands or markets are structures, they are subject to local building codes and highway setback regulations.

Many farms are now marketing directly to restaurants providing the specific products and the high quality that chefs are demanding. Many restaurants cultivate relationships with farms even noting the farm name and its product on their menu. These restaurants serve a niche of customers who find high quality food produced locally appealing. Supporting local farms is a philosophical goal for these restaurants. Similar opportunities for farm direct sales are to institutions that serve food to large or "captive" groups such as: Hospitals Retirement and nursing facilities. Om Made Cafe is an example where farmers sell their natural farm products.

7. Farm to School and Institutions

This provides farmers, school administrators, and institutional food-service planners with contact information and descriptions of existing programs that have made connections between local farmers and local school lunchrooms, college dining halls, or cafeterias in other institutions. To help communities initiate similar programs, this publication includes resource lists of publications on how to initiate and manage local food programs, funding and technical assistance sources, and provisions of the 2002 Farm Bill that support farm-to-school and other community food programs.

Farm to School programs is popping up all over the world and same can be implemented in India. These programs connect schools with local farms with the objectives of serving healthy meals in school cafeterias, improving student nutrition, providing health and nutrition education opportunities that will last a lifetime, and supporting local small farmers. Unlike other guides, this one focuses on agricultural practices, because these practices are inseparable from nutrition and sustainability. This guide establishes the best and worst practices in the field. It provides a list of questions you need to ask to get the very best product for your institution. It also offers helpful hints, so that you can learn from work that has been done.

8. Agri-tourism

Agri-tourism appeals to customers who have a desire to visit a farm and experience its activities. As urban families are loosing ties with agriculture, many are interested in maintaining some sort of contact with farming, especially for their children. This is a theme with most types of direct marketing and is also a key feature of agri-tourism. The concept of Agri tourism is very simple, whereby the urban tourists go the farmers home; stay like farmer, engage in farming activities, experience the bullock cart, tractor ride, eat authentic

food, wear traditional clothes, understand the local culture, enjoy the folk songs and dance, buy fresh farm produce. The sells his farm produce at a better price and earns a livelihood all year round. Agri-tourism and entertainment techniques can work in both urbanized areas and very rural areas. As with many direct marketing techniques, people skills are crucial. Maharashtra and Karnataka are the pioneers in agri-tourism. Green path, Bangalore is an example in this aspect.

9. Move from 1-To-Many to 1-To-1 Marketing

The old approach to advertising (general ads placed in newspapers, directories, radio, TV etc.) spreads one message to many consumers. Combining traditional methods for quick buys don't require any real investment or thought. One-to-one relationship building digital marketing methods for bigger purchases can be a winning formula. Natural farmers must do more to position themselves as competitive alternatives to traditional food providers.

Health & Nutrition

21. HEALTH AND NUTRITION

The holistic concept of health is contained in the expression of wholeness. Health is a relative state in which one is able to function well physically, mentally, socially, and spiritually to express the full range of one's unique potentialities within the environment in which one lives.

As per WHO health is "a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity". Good health helps people live a full life. Health is a state that allows the individual to adequately cope with all demands of daily life.

Health is a state of balance, an equilibrium that an individual has established within oneself and between oneself and the social and physical environment.

The concept of health as a balance between a person and the environment, the unity of soul and body, and the natural origin of disease, was the backbone of the perception of health in ancient civilisations. All modern concepts of health recognize health as more than the absence of disease, implying a maximum capacity of the individual for self-realization and self-fulfillment.

Environmental health examines the interaction between the environment and our health. Environment can be defined as a sum total of all the living and non-living elements and their effects that influence human life. We rely on forests, rivers, oceans and soils for numerous goods and services for our health, happiness and prosperity. A healthy environment means a healthy human.

Clean air, stable climate, adequate water, sanitation and hygiene, safe use of chemicals, protection from radiation, healthy and safe workplaces, sound agricultural practices, health-supportive cities and built environments, and a preserved nature are all prerequisites for good health.

Global Health includes chemical pollution, air pollution, climate change, disease-causing microbes, lack of access to health care, poor infrastructure, and poor water quality. Climate change is impacting human lives and health in a variety of ways. It threatens the essential ingredients of good health.

Why Environmental health is Important

All Living organisms draw all energy from environment for their survival and growth. FOOD, WATER and the AIR we breathe comes from the environment. This Body depends on the environment for its survival hence the environmental health is of utmost importance.

Land, water, air, space are contaminated due to the food production systems, our life style – heavy use of chemicals, burning fossil fuels, free flow of affluent from our industries in to the rivers, oil spills in our oceans, mindless dumping of garbage in to landfills, indiscipline in disposing of plastic. This is choking life on earth, air and water.

Agriculture is one of the main activities in our country, it contributes to 14% of GDP and 70% of our population is engaged in agriculture. Agriculture is also a major water guzzler making a large drain on the natural resources.

The current food production system with usage of heavy dose of chemicals is causing a direct loss of bio diversity in and above the soil.

Cocktail of chemicals used to store, process, add value, preserve and extend the shelf life of the products are taking a toll on the health and impacting the environment too.

What we eat is what we are – Jaisa Ann vaisa Mann…

Energy comes from food. Plants manufacture their food by harnessing the solar energy. Grains, fruits seeds form food for multitude of creatures on this planet earth. Balanced, nutritive food begets a healthy and energetic body, a happy mind and a happy society in general. Our dependence on the environment for our existence is enormous and our environment depends on the inhabitants.

Our seas and oceans are defiled and contaminated, our skies are contaminated. ANNAM – food which is regarded as sacred is contaminated. Farmer the Annadata produces contaminated food, the trader sells contaminated food and the lady at home cooks and serves this poisonous food. We are unaware of the food that we are eating, whether it is chemically laden food, genetically modified food, organic or naturally produced. This cluelessness is responsible for a host of physical and mental diseases that we are experiencing today.

Food miles and ultra-processed food

Food miles is the distance the food travels to reach our plates - the distance food travels from where it is grown to where it is ultimately purchased or consumed by the end user. Fewer food miles help to create a more sustainable chain, protecting the future of our economy, energy efficiency and planet. These “food miles” are responsible for about 6% of the world's greenhouse gas emissions. Instead of heading to a big supermarket for your next food shopping, try getting your food from a local independent store, a farm shop, or a farmers market. These outlets tend to supply food from local farms, which means they won't have to travel very far.

Transporting food is a fuel-guzzling process. The use of fossil fuels generates large quantities of carbon dioxide, a heat-trapping greenhouse gas, that warms our atmosphere. Simply put, the more food we transport, the more greenhouse gases we emit.

Eight ways to reduce food miles

1) Buy local
2) Shop at farmers markets
3) Grow your own vegetables
4) Eat seasonally
5) Pick your own
6) Learn to cook from scratch
7) Walk or cycle to the shop
8) Shop less frequently

For those of us concerned about our carbon 'footprint', trying to eat foods with fewer food miles on the clock can be a useful thing to do.

Buying food items like grains and flour, which have a longer shelf life in large quantities not only reduces the food miles but also reduces the time and energy spent on frequent shopping.

“Food-miles emissions are driven by the affluent world,” a study says. It finds that while “high income nations” represent only about 12.5% of the world’s population, they are responsible for 52% of international food miles and 46% of the associated emissions. Food miles also includes emissions from transporting fertilisers, machinery and animal feed as well as the more obvious shipping and vehicle emissions from sending food products around the world.

The current global food system requires food and related equipment to be transported a total of 22 trillion “tonnes-kilometres” per year, This drives 3 billion tonnes of CO2 equivalent (CO2e), accounting for almost one-fifth of total food system emissions. Studies also indicates that the “cold chain” of keeping food in a temperature-controlled environment throughout transit and sales accounts for 5% of global food system emissions. Recent studies have shown that this distance has been steadily increasing over the last 50 years. Studies estimate that processed food in the United States travels over 1,300 miles, and fresh produce travels over 1,500 miles, before being consumed. Reducing the energy intensiveness of our food has several economic, social and environmental benefits.

- Enjoy fresher, healthier food
- Support local farmers
- Keep their money in the community
- Know where their food comes from
- Reduce their carbon footprint

Ultra-Processed food

Some foods are highly or ultra-processed. They most likely have many added ingredients such as sugar, salt, fat, and artificial colors or preservatives. Ultra-processed foods are made mostly from substances such as fats, starches, added sugars, and hydrogenated fats. They may also contain additives like artificial colors and flavors or stabilizers. Examples of these foods are frozen meals, soft drinks, hot dogs and cold cuts, fast food, packaged cookies, cakes, and salty snacks.

Ultra-processed foods include ice cream, ham, sausages, crisps, mass-produced bread, breakfast cereals, biscuits, carbonated drinks, fruit-flavoured yogurts, instant soups, and some alcoholic drinks.

Ultra-processed foods are packaged foods that have been made by food companies using many manufactured ingredients. But in Natural Farming they maintain the integrity or nutritional content of the original foods.

Unprocessed or minimally processed foods are whole foods in which the vitamins and nutrients are still intact. The food is in its natural (or nearly natural) state. These foods may be minimally altered by removal of inedible parts, drying, crushing, roasting, boiling, freezing, or pasteurization, to make them suitable to store and make them safe for consumption. Unprocessed or minimally processed foods would include carrots, apples, raw chicken, melon, and raw, unsalted nuts.

Whenever possible, try to avoid or limit ultra-processed foods. Consider the examples in this table to help you quickly determine if a food is minimally processed, processed, or ultra-processed.

Minimally Processed	Processed	Ultra- processed
Corn	Canned corn	Corn chips
Apple	Apple juice	Apple pie
Potato	Baked potato	French fries
Carrot	Carrot juice	Carrot cake
Wheat	Flour	Cookies

Ultra-processed foods are linked to more greenhouse gases than other food groups, creates greenhouse gases that trap the sun's heat and contribute to climate change. About a third of all human-caused greenhouse gas emissions is linked to food.

Packaging waste is responsible for polluting our climate, blocking our drains and potentially harming wildlife when it ends up in our oceans and rivers. When plastics are left to degrade in the environment, they emit several greenhouse gases, such as methane and ethylene. Once released, these gas emissions can be toxic and have adverse effects on the environment and human health.

Often referred to as convenience or pre-prepared foods, processed foods are suggested to be a contributor to the obesity epidemic and rising prevalence of chronic diseases like heart disease and diabetes.

Advantages and disadvantages of processed food:

Advantages	Disadvantages
Improved microbial food safety and increased shelf life	Excess fat, sugar, and salt
Removal of pesticides and toxins (e.g., aflatoxin)	Inclusion of additives with unclear health implications
Decrease of toxin formation (e.g., acrylamide)	Leaching of chemical contaminants

In comparison to processed food, unprocessed and freshly cooked food contains all the essential nutrients and vitamins, and are free of additives and preservatives that can cause things like Insulin resistance, diabetes, obesity.

Carbon neutral food

For carbon neutral food, we calculate the carbon emissions throughout the life cycle of the product. This includes emissions caused by raw materials, production, distribution, processing and packaging of the product plus end-of-life.

A diet rich in peas, pulses and nuts can be incredibly low-carbon. Producing 100g of protein from peas emits almost 90 times less than getting the same amount of protein from beef.

Carbon neutral refers to offsetting carbon emissions by implementing practices that remove carbon from the atmosphere. The result is net-neutral carbon emissions. This makes it clear that food plays a big role in climate change.

Creating a sustainable lifestyle means rethinking our way of living, what we consume, how we buy and being aware of the personal energy we use for transportation and in the home and taking steps to reduce that energy use. It's thinking about the products we purchase and their impact on our health as well as the environment. It's giving consideration to waste produce and considering how it may be reduced, recycled or reused.

Nutrition

It is the process of providing or obtaining the food necessary for health and growth. There are more than 40 different kinds of nutrients in food and they can be classified into the following 7 major groups:

- Carbohydrates
- Proteins
- Fats
- Vitamins
- Minerals
- Dietary fibre
- Water

Why Nutrition is required?

Proper nutrition helps keep energy levels up and protects against many age-related illnesses and diseases like heart disease, cancer, and diabetes. Malnutrition is a global problem

Do we have nutrition in our food?

Millions of people are suffering from different forms of malnutrition. In fact, 1.9 billion adults are overweight or obese while 462 million are underweight. Among children, 52 million under-fives are suffering from wasting, where they have a low weight for height.

Rising carbon dioxide levels in the atmosphere are also undercutting the nutritiousness of our foods. An average Indian is having 15% more chemicals in their food than an average American. Our daily food that we eat is a cocktail of chemicals.

Farmer's ignorance leads to enormous health hazards. Out of their ignorance farmers spray a lot of pesticides more than the prescribed dosage. Consumer eats chemically laden food which is highly carcinogenic in nature. Milk supplied is also laden with hormonew like bST Bovine Somatotropin.

The one and only solution to all the problems is Natural farming, sustainable, eco-friendly, integrating farm with farm animals and following the principals of agro ecological practices.

Chemical free Natural farming helps reduce public health risks. Mounting evidence shows that food grown organically are rich in nutrients, such as Vitamin C, iron, magnesium, and phosphorus, and with no exposure to nitrates and pesticide residues.

Millets are easily grown in natural farming systems and provide essential nutrients for healthy living.

Basic Food Groups

A classification based on nutrients present will ensure that all nutrients are made available to the body and offer greater variety within the group.

There are five basic food groups suggested by the Indian Council of Medical Research (ICMR).

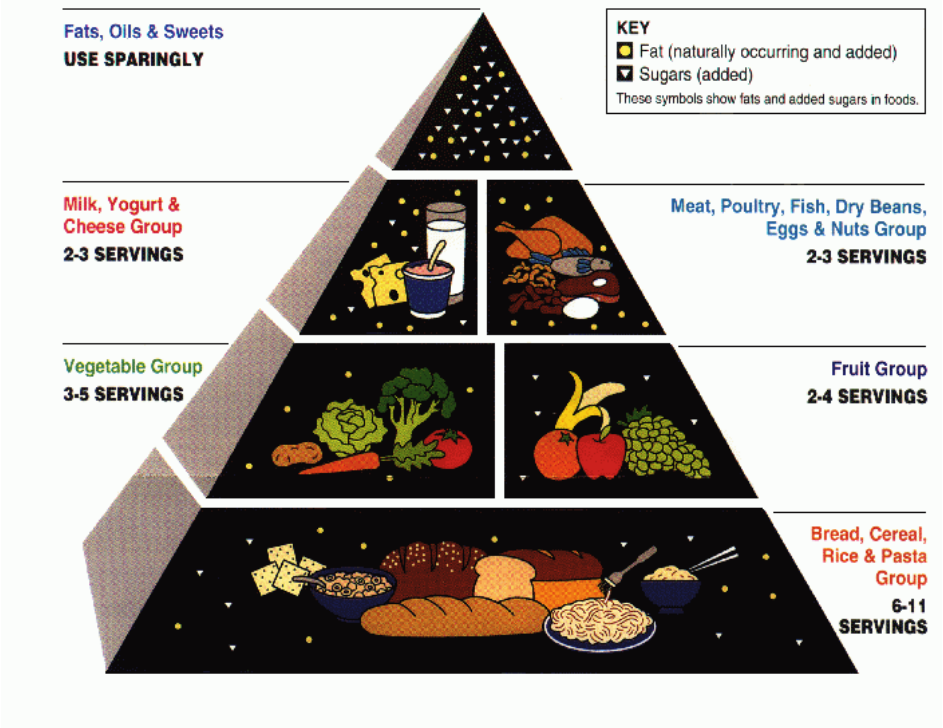
These include:

- Cereals, grains and products
- Pulses and legumes
- Milk and meat products
- Fruits and vegetables
- Fats and sugars

Table 1: Five Food Groups	
I. Cereals, Grains and Products Rice, Wheat, Ragi, Bajra, Maize, Jowar, Barley, Rice flakes, Wheat flour.	Energy, protein, Invisible fat, Vitamin – B1, Vitamin – B2, Folic Acid, Iron, Fibre
II. Pulses and Legumes Bengal gram, Black gram, Green gram, Red gram, Lentil (whole as well as dals) Cowpea, Peas, Rajmah, Soyabeans, Beans.	Energy, Protein, Invisible fat, Vitamin – B1, Vitamin – B2, Folic Acid, Calcium, Iron, Fibre.
III. Milk, Meat and Products Milk **Milk,** Curd, Skimmed milk, Cheese **Meat** Chicken, Liver, Fish, Egg, Meat.	Protein, Fat, Vitamin– B12, Calcium. Protein, Fat, Vitamin – B2
IV. Fruits and Vegetables Fruits Mango, Guava, Tomato Ripe, Papaya, Orange. Sweet Lime, Watermelon.	Carotenoids, Vitamin – C, Fibre.
Vegetables (Green Leafy) Amaranth, Spinach, Drumstick leaves, Coriander leaves, Mustard leaves, Fenugreek leaves.	Invisible Fats, Carotenoids, Vitamin – B2. Folic Acid, Calcium, Iron, Fibre.
Other Vegetables Carrots, Brinjal, Ladies finger, Capsicum, Beans, Onion, Drumstick, Cauliflower.	Carotenoids, Folic Acid, Calcium, Fibre
V. Fats and Sugars **Fats :** Butter, Ghee, Hydrogenated oils, Cooking oils like Groundnut, Mustard, Coconut.	Energy, Fat, Essential Fatty Acids
Sugars : Sugar, Jaggery	Energy

Nutrion Food Pyramid

The Food Guide Pyramid displayed proportionality and variety in each of five groups of foods and beverages, which ascended in horizontal layers starting from the base and moving upward toward the tip: breads, cereals, pasta and rice; fruits and vegetables; dairy products; eggs, fish, legumes, meat and poultry; plus alcohol, fats and sugars.



Nutrients for optimal immune functions

Vitamins A, E and D - the three fat soluble vitamins; C & B vitamins, and minerals such as zinc, selenium, iron, copper etc. and phytonutrients, amino acids, fatty acids are necessary for optimal immune function (to prevent establishment of viral infection) and immune regulation (to check uncontrolled proliferation of immune cells that may cause more harm than good to the body).

These nutrients are critical for the function of T cells, B cells, killer cells, macrophages, neutrophils/ granulocytes that are involved in the killing and elimination of infectious microbes.

In addition, there are many other immune related functions that are carried out by these nutrients and phytonutrients. For instance, vitamin A maintains structure and function of the mucosal epithelial cells of the respiratory tract and enhances mucosal immunity (critical for prevention of respiratory infection). Vitamin E, beta-carotene, vitamins C & B, Zinc, Selenium act as potent antioxidants and reduce oxidative stress in the body.

It is prudent to obtain these nutrients through a good balanced diet. In addition to the nutrition an individual should also follow a regular daily routine – eating, exercise, balancing work and life skillfully to have a balance physical, mental and emotional health that should enable one to live up to his/her potential.

Health benefits

Fertilizers and pesticides have been shown to have adverse impacts on farmers as well as consumers. Farmers are exposed to contaminants while applying chemical inputs. By replacing such external inputs with locally made natural concoctions, inoculums, and decoctions, NF can reduce the incidence of non-communicable diseases, such as acute and chronic neurotoxicity, respiratory diseases and even cancer, which are associated with the use and application of inorganic chemicals in agriculture. Pesticides contain endocrine-disrupting chemicals (EDCs), which enter humans through diet and can have negative health impacts such as breast cancer, reproductive disorders, and poorer intellectual development in children. Discontinuing chemical pesticides and fertilizers in fields will prevent run-off into water sources, further reducing communities' exposure to such chemicals.

Natural Farming products have a much higher nutritional content. Protein, amino acid, crude fat and other essential nutrient were about 300% higher than ordinary products. Chemical residue such as nitrate is almost undetectable in Natural Farming produce. A research study on 'Assessment of Post NF effects on the Health and Nutrition Profile of Households' through interviewing 570 households spread across 8 pilot districts and 19 clusters of Andhra Pradesh revealed that almost 80% of the NF families have experienced improvement in gastric problems, Hypertension and Diabetes post NF consumption. All the NF households revealed improvement in stamina and improvement of health in their infants post NF consumption.

Ecosystem Services

22. ECOSYSTEM SERVICES

An ecosystem is a group or community composed of living and non-living things and their interactions with each other. It is a dynamic complex of biotic components and abiotic components. These biotic and abiotic interactions maintain equilibrium in the ecosystem. We as humans are an integral part of it. The numerous benefits we obtain from the ecosystem are known by the term ecosystem services.

The earth is home to millions of species. Every organism depends on one or another organism for energy, survival, and other life processes. This dependence of organisms on one another and their surroundings forge an interacting system called ecosystem. The interaction among different components of ecosystem are fundamental to a well-defined environment.

As a part of an ecosystem, humans derive lots of benefits from the biotic and abiotic components. These benefits are collectively termed as ecosystem services. Life and biodiversity on earth depend on these services. For example, Wetland provide fresh, clean water, regulate pollution, and reduce climate risk and uncertainty for people, agriculture and aquaculture (fisheries). They are also hot beds of biodiversity and are home to a vast range of animals, especially bird species.

Some examples of ecosystems are:

1. **Deciduous forest ecosystem-** A deciduous forest is characterized by trees that shed their leaves annually and renew them at the beginning of the next growing season. They shed leaves as an adaptation to the cold season in temperate climates or the dry seasons in subtropical and tropical climates.

2. **Savannah ecosystem-** Savannah ecosystems combine woodland and grassland elements. Light can penetrate and reach the ground thanks to the widely spaced, scattered canopy trees. As a result, grass-dominated shrubs and herbaceous strata are able to develop abundantly as well.

3. **Coral reef ecosystem-** The coral reef is an ecosystem formed by corals that build reefs. Coral reefs are groups of coral polyps, such as stony corals, that live together in colonies. They are one of the world's most diversified ecosystems. As a result, they're known as the sea's rainforests.

4. **Hot spring ecosystem-** A hot spring is one with water temperatures that are higher than the ambient temperature. The water from the spring is geothermally heated, meaning it is heated by the earth's mantle.

5. **Micro-ecosystems-** Micro-ecosystems are ecosystems that are confined to small or microscopic spaces yet are determined by unique environmental conditions. Consider the environment of a tree. A tree produces a miniature ecosystem that is home to a variety of species. Lichens and other epiphytes, for example, may be found on a tree (arboreal plant).

Ecosystem services are classified into four types:

Provisioning Services

This includes the products/raw materials or energy outputs like food, water, medicines and other resources from ecosystems. Ecosystems are a source of food, water, medicines, wood, biofuels, etc. Also, they provide conditions for these resources to grow.

Regulating Services

This includes the services which regulate the ecological balance. For example, terrestrial environments like forests purify and regulate air quality, prevent soil erosion, and control greenhouse gasses. Biotic components such as birds, rats, frogs, act as natural controllers and thus help in pest and disease control. Hence, ecosystems act as regulators.

Supporting services

Supporting services form the basis for other services. They provide habitat for different life forms, retain biodiversity, nutrient cycling, and other services for supporting life on the earth.

Cultural services

It includes tourism; provides recreational, aesthetic, cultural and spiritual services, etc. Most natural elements such as landscapes, mountains, caves, are used as a place for cultural and artistic purposes. Even a few of them are considered sacred. Moreover, ecosystems provide enormous economic benefits in the name of tourism.

Agricultural ecosystems

Provide humans with food, forage, bioenergy and pharmaceuticals and are essential to human wellbeing. These systems rely on ecosystem services provided by natural ecosystems, including pollination, biological pest control, maintenance of soil structure and fertility, nutrient cycling and hydrological services. Preliminary assessments indicate that the value of these ecosystem services to agriculture is enormous and often under appreciated.

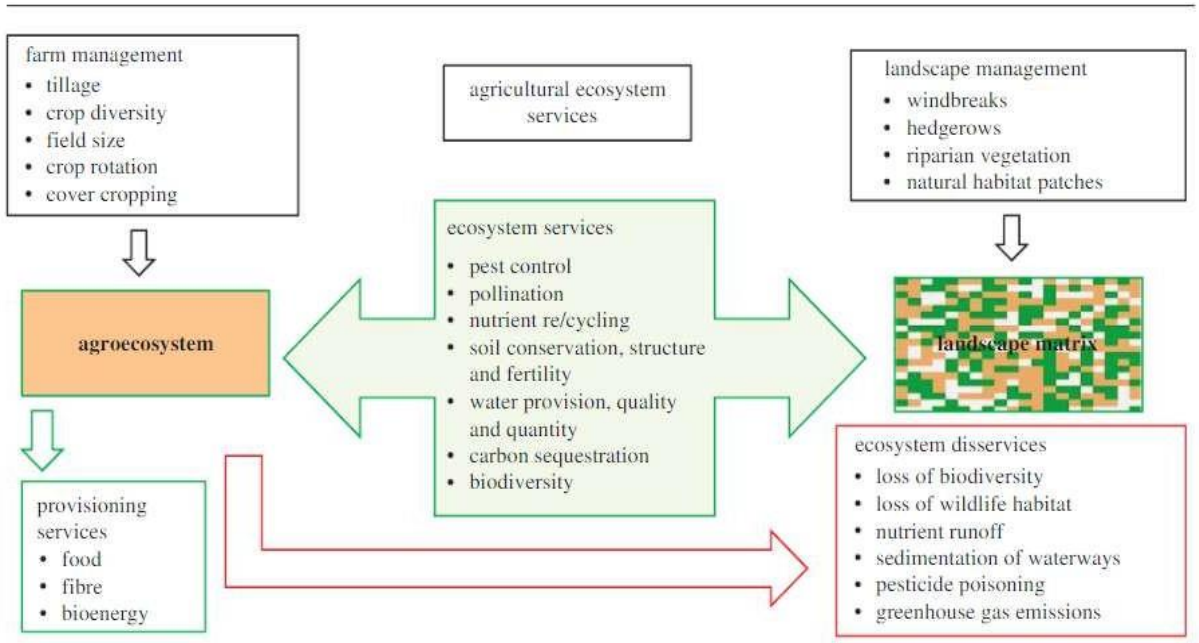
Agroecosystems also produce a variety of ecosystem services, such as regulation of soil and water quality, carbon sequestration, support for biodiversity and cultural services. Depending on management practices, agriculture can also be the source of numerous disservices, including loss of wildlife habitat, nutrient runoff, sedimentation of waterways, greenhouse gas emissions, and pesticide poisoning of humans and non-target species. The tradeoffs that may occur between provisioning services and other ecosystem services and disservices should be evaluated in terms of spatial scale, temporal scale and reversibility. As more effective methods for valuing ecosystem services become available, the potential for 'win-win' scenarios increases. Under all scenarios, appropriate agricultural management practices are critical to realizing the benefits of ecosystem services and reducing disservices from agricultural activities.

Supporting services include genetic biodiversity for use in breeding crops and livestock, Soil formation and structure, soil fertility, nutrient cycling and the provision of water. Regulating services may be provided to agriculture by pollinators and natural enemies that move into agroecosystem from natural vegetation. Natural ecosystems may also purify water and regulate its flow into agricultural systems, providing sufficient quantities at the appropriate time for plant growth.

Traditionally, agroecosystems have been considered primarily as sources of provisioning services, but more recently their contributions to other types of ecosystem services have been recognized. Influenced by human management, ecosystem processes within agricultural systems can provide services that support the provisioning services, including pollination, pest control, genetic diversity for future agricultural use, soil retention, regulation of soil fertility and nutrient cycling. Whether any particular agricultural system provides such services in support provisioning depends on management, and management is influenced by the balance between short-term and long-term benefits.

Management practices also influence the potential for ‘disservices’ from agriculture, including loss of habitat for conserving biodiversity, nutrient runoff, sedimentation of waterways, and pesticide poisoning of humans and non-target species. Since agricultural practices can harm bio- diversity through multiple pathways, agriculture is often considered anathema to conservation. However, appropriate management can ameliorate many of the negative impacts of agriculture, while largely maintaining provisioning services.

Impacts of farm management and landscape management on the flow of ecosystem services and disservices to and from agroecosystems.



Source - https://www.researchgate.net/publication/45659710_Ecosystem_services_and_agriculture_tradeoffs_and_synerg ies_Philos_Trans_R_Soc_B_Biol_Sci

Ecosystem Services Flowing to Agriculture

The production of agricultural goods is highly dependent on the services provided by neighbouring natural ecosystems, but only recently have there been attempts to estimate the value of many of those services to agricultural enterprises. Some services are more easily quantified than others, to the extent that they are essential to crop production or they substitute directly for purchased inputs.

(a) Biological pest control

Biological control of pest insects in agroecosystem is an important ecosystem service that is often supported by natural ecosystems. Non-crop habitats provide the habitat and diverse food resources required for arthropod predators and parasitoids, insectivorous birds and bats, and microbial pathogens that act as natural enemies to agricultural pests and provide biological control services in agro ecosystems. These biological control services can reduce populations of pest insects and weeds in agriculture, thereby reducing the need for pesticides. Because the ecosystem services provided by natural enemies can substitute directly for insecticides and crop

losses to pests can often be measured, the economic value of these services is more easily estimated than many other services.

(b) Pollination

Pollination is another important ecosystem service to agriculture that is provided by natural habitats in agricultural landscapes. Approximately 65 per cent of plant species require pollination by animals, and an analysis of data from 200 countries indicated that 75 per cent of crop species of global significance for food production rely on animal pollination, primarily by insects. Of the most important animal-pollinated crops, over 40 per cent depend on wild pollinators, often in addition to domesticated honeybees. Only 35–40% of the total volume of food crop production comes from animal-pollinated crops, however, since cereal crops typically do not depend on animal pollination. Based on data from the United Nations Food and Agriculture Organization (FAO) on the production of 87 globally important crops during 1961–2006 it is estimated that the consequences of a complete loss of pollinators for total global agricultural production would be a reduction of 3–8%. The percentage increase in total cultivated area that would be required to compensate for the decrease in production was much higher, particularly in the developing world where agriculture is more pollinator- dependent.

Like biological control, pollination services are more readily quantified than many other services. Early estimates of the value of pollination services were based on the total value of animal-pollinated crops, but recent estimates have been more nuanced. Since most crops are only partly dependent on animal pollination, a dependence ratio or a measure of the proportion reduction in production in the absence of pollinators can provide a better approximation of production losses in the absence of pollinators. Clearly, these estimates are also fairly crude and intended to provide a broad brush assessment of potential economic benefits.

(c) Water quantity and quality

The provision of sufficient quantities of clean water is an essential ecological service provided to agroecosystems, and agriculture accounts for about 70 per cent of global water use. Perennial vegetation in natural ecosystems such as forests can regulate the capture, infiltration, retention and flow of water across the landscape.

Water availability in agroecosystem depends not only on infiltration and flow, but also on soil moisture retention, another type of ecosystem service. While the supply of surface water and groundwater (‘blue water’) inputs to agriculture through irrigation are indispensable in some parts of the world, 80 percent of agricultural water use comes from rainfall stored in soil moisture (‘green water’). Water storage in soil is regulated by plant cover, soil organic matter

and the soil biotic community (bacteria, fungi, earthworms, etc.). Trapping of sediments and erosion are controlled by the architecture of plants at or below the soil surface, the amount of surface litter and litter decomposition rate. Invertebrates that move between the soil and litter layer influence water movement within soil, as well as the relative amounts of infiltration and runoff. These soil processes provide essential ecosystem services to agriculture.

(d) Soil structure and fertility

Soil structure and fertility provide essential ecosystem services to agroecosystems. Well-aerated soils with abundant organic matter are fundamental to nutrient acquisition by crops, as well as water retention. Soil pore structure, soil aggregation and decomposition of organic matter are influenced by the activities of bacteria, fungi and macrofauna, such as earthworms, termites and other invertebrates.

Micro-organisms mediate nutrient availability through decomposition of detritus and plant residues and through nitrogen fixation. Agricultural management practices that degrade soil structure and soil microbial communities include mechanical ploughing, cultivating and harvesting, but management practices can also protect the soil and reduce erosion and runoff. Conservation tillage and other soil conservation measures can maintain soil fertility by minimizing the loss of nutrients and keeping them available to crops. Cover crops facilitate on-farm retention of soil and nutrients between crop cycles, while intercrops and border vegetation reduce erosion and runoff among fields. Incorporation of crop residues can maintain soil organic matter, which assists in water retention and nutrient provision to crops. Together these practices conserve a suite of ecosystem services to agriculture from the soil.

One of the aspects of ecological services viz pollination through bees and other benefits flowing from them are discussed in detail here:

Role of Bee Pollination in Crop Production under natural farming (Quality and Quantity)

The number of visits and the aggregate effects of various bee species influence not only the quantity of crops produced but also their quality, which is important mainly from an economic perspective. Plant pollination by more than one bee species, including honey bees, carpenter bees, stingless bees, bumble bees, long-tongued bee, feral bees, social bees, and solitary bees, results in a better pollination/vegetation process. Bee pollination maintaining the natural balance of ecosystems and providing a link between agriculture and the cycle of life.

Honey bee have been widely used for honey production and crop pollination. They play a vital role in the pollination of plants and plants secrete a rich liquid sugar similar to nectar from their glands to attract pollinators to their flowers so that the pollen can adhere to bee-

pollen collector. For the examples pollination of oilseed, buckwheat and strawberry have been pollinated by honey bees, which have improved their quality and yield. Similarly, black cumin flowers are attractive to a range of pollinators, such as Hemiptera (true bugs), Coleoptera (beetles), Diptera (flies), and Hymenoptera (bees) For the apple (Malus domestica Borkh), increased flower visitation rates by high-quality honey bee colonies increased fruit set by 15%, as well as the fruit sugar content and increased fruit weight by approximately 20% .

Benefits of Beekeeping in Natural Farming

- Pollination is also increased with the help of honeybees leading to growth in the yield, fruits, berries/seeds and quality of produce.
- Pollination through bees also serve to protect the crops against pests.
- Beekeeping encourages ecological and diversity .
- Doubling farmer's income by supplementing/complimenting agriculture/ horticulture.
- Generates income without destroying habitat.
- Honeybees conserve natural resources due to it is destructive activity.

Linkages & Extension Services

23. LINKAGES & EXTENSION APPROCHES FOR PROMOTION OF NATURAL FARMING

Stake holder matrix as per the location should be prepared. Framework of linkages and extension approaches involving these stakeholders should be emphasized for promotion of Natural farming.

Importance of linkages: Linkages are important in the spread and diffusion of knowledge, which not only acts as building blocks for new knowledge which is further synergized through creative duplication and accumulation. Linkages with institutions and stakeholders are integral to the success of natural farming. These collaborations provide essential knowledge, resources, policy support, risk management strategies and community engagement creating an enabling environment for farmers to effectively implement and benefit from natural farming practices.

Many institutions and organizations are working towards the linkage frame work and extension approaches confined to promotion of Natural farming at all the levels i.e., Village level, District level, State level and National level for easy diffusion of knowledge and wide spread support.

- **MANAGE:** National Institute of Agricultural Extension Management (MANAGE), Hyderabad is the Centre of Excellence & Knowledge Repository on Natural Farming and it was recognized as the nodal agency for promotion of Natural farming.
- **NCONF:** National Centre for Organic and Natural Farming, Ghaziabad is responsible for Certification and Training. Further NCONF identifies the Trainer farmers and CRPs.
- **NRLM:** National Rural Livelihoods Mission (NRLM) focusing on women SHGs and their federation-based Natural Farming. Krishi Sakhis will be trained as Para extension workers at village and cluster level.
- **ICAR Institutions:** ICAR committee will draft syllabus and course curriculum for inclusion in UG and PG courses. Gujarat Natural Farming and Organic Agricultural University, Godhra, is running degree courses on natural farming.
- **EEIs:** Organizing different Natural Farming trainings for farmers and other stakeholders.
- **SAMETIs:** State Agricultural Management and Extension Training Institute will provide extension management input for extension functionaries of agricultural and allied departments and develop systematic linkages between the allied departments, state universities and regional and national institutes of outstanding accomplishments in the field of Natural farming. They study the Agricultural Extension Management Systems and policies together with operational problems and constraints at all levels and develop the management tools for improving the effectiveness of agricultural extension Services.

- **Externally aided and National projects:** Institutions such as IFAD, World Bank, GIZ etc are supporting natural farming projects of respective state governments.
- **KVKs:** KVKs as Model Centres for Natural Farming. The farmers associated through KVKs will be identified and Trainer farmers and CRPs will be selected.
- **Cooperatives and farmer collectives**: FPOs, SHGs, FIGs, FPOs, AMUL, SAFAL, HOPCOMS, PACS, IFFCO are also working on natural farming.

Focusing on PACS and higher-level coops-based development comprising of all types of agriculture. PACS which promote NF should be identified. Trainer farmers and CRPs should be identified for training and capacity building. Farmers Interest Groups (FIGs) and FPOs would be the key stakeholders.

SAUs, Agricultural Departments, Watershed Department, Soil and Waters Conservation, Animal husbandry, Fisheries, ATMA, KVKs etc., shall identify Trainer farmers and CRPs should be trained for NF. The PoPs for various crops under NF that are already are compiled under APCMNF. Similarly, region specific PoPs have to be developed as per the need.

- **NGOs:** WASSAN, CSA, RySS, NCNF, etc

Sahaja Samruddha and other initiatives have been working on seed conservation. Best practices can be upscaled. In addition, individual farmers are actively involved in traditional and indigenous seeds collection and distribution.

- **Input Supplies of NF:** Many of the women self-help groups are acting as Bio Resource Centres and they provide bioinputs for farmers practicing Natural farming
- **Spiritual Agencies:** Isha Foundation, Art of Living, Patanjali etc. have following in lakhs of persons who represent the urban and rural communities. Initiatives like Yoga and overall wellbeing of the individuals and communities is at the core of their initiatives which can be synergized for promotion of Natural Farming.
- **Consumers:** Family Farmer, Govt agencies, hostels, Temples etc.
- **Financing Agencies**: NABARD, GIZ, CSR etc.
- **Private Sector:** ITC, Mahendra, Swaraj etc.

However it is important that all these institutions, organizations and groups shall work together with a common objective of promoting natural farming, developing location specific solutions and outreaching the maximum beneficiaries. It is essential that collective contribution with goal oriented behavior of all these institutions will make the convergence easier.

Apart from these institutional mechanisms it is important to build linkages in such a way that the knowledge sharing and skill enhancement with local context shall be developed. Some examples for developing such linkages are as followed:

- **Branding & Marketing:** Content making, documentation, processing, branding & certification, advertising
- **Engaging with Schools, Universities with Students and Teachers:** learning through games, practical activities, short projects, debates, banner, poem writing activities etc.

Concept of voluntary knowledge sharing by farmers and stakeholders can be reviewed and up scaled

- **Extension Advisory Services**: Knowledge sharing can be done through the following options
    - Toll Free No.
    - Chat Bot
    - Websites
    - Social Media
    - Literature for Study material
- **Knowledge Sharing and Training:** Collaborating with agricultural research centers, universities, and extension services offers access to scientific knowledge and research-based information. These institutions can conduct workshops, training programs, and seminars to educate farmers about the principles and techniques of natural farming. Farmers gain a better understanding of the underlying science, helping them make informed decisions when implementing these practices.
- **Skill Enhancement:** Stakeholders, such as experienced farmers and local agricultural communities, hold valuable practical knowledge gained from years of working in the local environment. Their insights about local soil conditions, climate patterns, and indigenous crop varieties are invaluable. Linking with these stakeholders allows new natural farmers to benefit from their expertise, learn from their successes and failures, and gain hands-on experience in the field.
- **Adaptation to Local Context:** Natural farming practices need to be adapted to suit local conditions. Institutions and stakeholders provide context-specific advice and recommendations for optimizing natural farming techniques based on the specific agroecological characteristics of the region. This tailoring enhances the effectiveness of natural farming and ensures that practices are aligned with local realities.

- **Access to Resources and Inputs:** Natural farming often requires specific resources, such as Bio inputs and natural pest control methods. Collaborating with institutions can help farmers access these resources, either through research or direct connections. Stakeholder networks can provide practical insights on producing these resources locally, reducing costs and environmental impacts.
- **Policy Advocacy:** Institutions are often involved in policy research and advocacy. Collaborating with these entities allows farmers to voice their needs and concerns, influencing policies that promote and support natural farming practices. Building alliances with stakeholders also strengthens advocacy efforts, as collective voices have a greater impact on policymakers.
- **Market Access and Value Chains:** Establishing linkages with farmer cooperatives, local markets, and Natural food networks facilitates the transition from production to market. These stakeholders can connect natural farmers with consumers who value naturally grown products. Collaborating with such entities helps farmers access premium markets and receive fair prices for their produce.
- **Research and Innovation:** Research institutions are centers of innovation. Collaborating with them can lead to the development of new natural farming techniques, tools, and approaches. These innovations can improve productivity, reduce environmental impact, and address emerging challenges faced by natural farmers.
- **Risk Mitigation:** Institutions and stakeholders often have insights into managing risks associated with natural farming. They can provide information on pest and disease management strategies, climate-resilient practices, and methods to cope with adverse weather conditions. By sharing these strategies, they help farmers mitigate risks and ensure stable yields.
- **Community Support and Knowledge Exchange:** Collaborating with local communities and farmer groups creates a support network for natural farmers. Regular meetings, workshops, and knowledge exchange platforms allow farmers to share their experiences, troubleshoot challenges, and learn from one another's successes and failures. This sense of community support fosters a culture of continuous learning and improvement.
- **Scaling Up and Replication:** Once successful natural farming models are established, institutions and stakeholders can play a pivotal role in scaling up the practices. They can organize demonstration plots, field days and knowledge-sharing events to showcase the benefits of natural farming to a wider audience. This encourages more farmers to adopt

these practices and expand the movement.

The linkages with institutions and stakeholders are integral to the success of natural farming. These collaborations provide essential knowledge, resources, policy support, risk management strategies, and community engagement creating an enabling environment for farmers to effectively implement and benefit from natural farming practices.

EXTENSION STRATEGIES

The extension strategies to be followed for successful promotion and implementation of Natural farming can be divide in to four types as followed:

1. Extension strategies for creating awareness among producers and consumers
2. Extension strategies for increase in production and better practices
3. Extension strategies for diagnosis as problem solving approach
4. Extension strategies for training and knowledge dissemination

1. Extension strategies for creating awareness among producers and consumers

- **Mass awareness:** Mass awareness campaigns in natural farming aim to inform and educate both producers (farmers) and consumers about the principles, benefits, and practices of natural farming. These campaigns are crucial for building a sustainable and environmentally friendly agricultural system.
- **Kisan exhibitions:** Kisan exhibitions, also known as agricultural or farmer exhibitions, are events that bring together farmers, agricultural experts, researchers, agribusinesses, and other stakeholders to showcase and discuss the latest innovations, technologies, and practices in the agriculture sector. These exhibitions play a crucial role in disseminating knowledge, fostering networking opportunities, and promoting the exchange of ideas in the farming community.
- **Kisan melas:** Kisan Melas play a crucial role in the promotion of natural farming by providing a platform for farmers to learn about sustainable and natural agricultural practices. These events offer opportunities for interaction, education, and hands-on experiences related to natural farming.
- **Social Media Campaigns:** Popular social media platforms can be used to share engaging content, success stories, and educational material about natural farming to reach a wider audience.
- **Community Workshops:** Local workshops and seminars should be organized to raise awareness about the benefits of natural farming, addressing concerns and providing

practical insights for interested individuals.

- **Informational Pamphlets:** Designing and distribution of informative pamphlets in farming communities, emphasizing the advantages of natural farming and providing simple guidelines for implementation.
- **Radio and TV Programs:** Collaboration with local radio and television stations to broadcast programs that highlight the importance of natural farming, featuring experts and success stories.
- **Collaboration with Influencers:** Partnering with influential figures in the agricultural and environmental sectors to promote natural farming practices through their networks and channels.
- **Field Demonstrations:** Conduct on-site field demonstrations to showcase the positive outcomes of natural farming, allowing farmers to witness the practical application of these methods.
- **Mobile Apps:** Developing of mobile applications with user-friendly interfaces that provide information, tutorials, and resources on natural farming, making it easily accessible to a tech-savvy audience.
- **School Outreach Programs:** Implementing educational programs in schools to educate students about the principles of natural farming, encouraging them to share the knowledge with their families.
- **Collaboration with Extension Services:** Working closely with agricultural extension services to incorporate awareness campaigns into their outreach activities, ensuring a broader reach to farming communities.
- **Storytelling and Testimonials:** Sharing real-life success stories and testimonials from farmers who have successfully adopted natural farming, creating relatable narratives that inspire others to make the switch.

2. Extension strategies for increase in production and best practices

- **Farmer -to -farmer extension:** Extension Support at the village level to be provided to the farmers through a Farmer Friend (FF) in every village. This would be very useful in extending the reach of the agriculture extension system up to the farmer level. Krishi Sakhis/Krishimitras/pashumithras are a few initiatives made by government for effectively supporting the farmers. In the same way Corner meetings, group meetings with FIG, SHG, FPO, FPC meetings, personnel visits can be included in this farmer to farmer extension.
- **Kisan mobile advisory/Kisan call centers**: A "Kisan mobile advisory" refers to an

agricultural advisory service that utilizes mobile technology to provide guidance and information to farmers. This approach leverages the widespread use of mobile phones to disseminate agricultural knowledge, best practices in natural farming and timely information to farmers, especially in rural areas. There can be a variety of services like crop specific or location specific advice through Text Messages, SMS Alerts, voice messages and picture messages which can act as a problem solving approach

- **Training Programs:** Provide comprehensive training programs for farmers to build their skills and knowledge in natural farming techniques, covering aspects such as soil health, pest management, and organic fertilization. Farmer master trainers and Technical master trainers will play a major role in conducting this training programmes.
- **Supply of Quality Inputs:** Ensuring a consistent and reliable supply chain of high-quality organic inputs, such as seeds, compost, and biofertilizers, to support farmers in adopting and sustaining natural farming practices.
- **Technology Integration:** Integration of appropriate technologies, ITKs, precision farming tools and monitoring devices, to enhance efficiency and productivity in natural farming operations.
- **Research and Development:** Investing in research to develop improved varieties of crops suited for natural farming, as well as innovative methods and technologies that optimize yields while maintaining sustainability.
- **Collaboration with Agricultural Universities:** Foster partnerships with agricultural universities and research institutions to access cutting-edge research, expertise, and resources that can be translated into practical applications for farmers.
- **Demonstration Farms:** Setting up model farms/demonstration farms or model villages that showcase best practices in natural farming, allowing farmers to witness successful implementation and learn directly from practical examples.
- **Farmer field schools (FFS):** FFS is a season long training programme imparted to the farmer for one day in a week throughout the season. Intern these farmer train other farmers.
- **Farm school:** Farm Schools would provide season long technical backstopping/ training to target farmers by having an interactive session once at least during each of the 6 critical stages in a cropping season. This intervention is widely adopted in ATMA.
- **Market Linkages:** Facilitating market connections for natural farming products, helping farmers access markets that appreciate and pay a premium for sustainably produced goods.
- **Farmers' Cooperatives:** Encouraging the formation of farmers' cooperatives to pool

resources, share knowledge, and collectively market their natural farming products, increasing their bargaining power in the market.

3. **Extension strategies for diagnosis as problem solving approach**

- **Soil Testing Services:** Offering soil testing facilities to assess the health and fertility of the soil, providing farmers with personalized recommendations for natural farming practices based on their specific soil conditions. Eg: Soil health cards
- **Pest and Disease Identification Workshops:** Conducting workshops and training sessions to educate farmers on identifying common pests and diseases, enabling them to implement targeted and natural control measures.
- **On-Farm Consultations:** Providing on-farm consultations with agricultural experts who can assess the current farming practices, diagnose issues, and suggest corrective measures aligned with natural farming principles.
- **Mobile Apps for Diagnosis:** Developing mobile applications that farmers can use for quick diagnosis of crop issues, offering solutions and guidance on natural remedies and preventive measures.
- **Weather Monitoring Services:** Integrating weather monitoring systems to anticipate and address climate-related challenges, helping farmers plan and adapt their natural farming practices accordingly.
- **Collaboration with Plant Pathologists:** Collaborating with plant pathology experts to conduct regular surveys and diagnostic studies, identifying potential threats and sharing insights with farmers to prevent or manage issues proactively.
- **Demonstration Plots:** Establish small demonstration plots where farmers can observe the impact of different natural farming practices, aiding in the diagnosis of potential challenges and showcasing effective solutions.
- **Extension Hotlines:** Implementation of dedicated hotlines or helplines where farmers can seek immediate assistance for diagnosing issues in their crops and receive guidance on natural remedies.
- **Capacity Building Workshops:** Organizing workshops focused on enhancing farmers' diagnostic skills, enabling them to independently identify problems and make informed decisions about natural farming interventions.
- **Collaboration with Research Institutions:** Foster partnerships with agricultural research institutions to stay updated on emerging issues, diseases, and pests, ensuring that farmers receive the latest diagnostic information and solutions.

4. Extension strategies for training of extension functionaries for knowledge dissemination

These strategies shall be applicable for both Farmer master trainer and Technical Master Trainer

- **Workshops and Seminars:** Organizing regular workshops and seminars to provide hands-on training, covering various aspects of natural farming such as soil health, organic inputs, and pest management.
- **Training Modules:** Developing structured training modules that extension functionaries can access online or in-person, offering a comprehensive curriculum on the principles and practices of natural farming.
- **Training-of-Trainers Programs:** Conduct programs to train a cadre of individuals who can then serve as local trainers, spreading knowledge about natural farming within their communities.
- **Mobile Learning Apps:** Develop mobile applications with interactive content, tutorials, and quizzes to make training materials easily accessible to trainers especially in remote areas.
- **Farm Visits:** Arranging visits to successful natural farms where trainers can observe and learn directly from experienced practitioners, gaining practical insights into effective implementation.
- **Collaboration with Agricultural Extension Services:** Partner with agricultural extension services to integrate natural farming training into their existing programs, ensuring a wider reach to farming communities.
- **Demonstration Farms:** Setting up model farms where trainers can participate in practical training sessions, getting hands-on experience in implementing natural farming techniques.
- **Field Days:** Organize field days where trainers can come together to share experiences, exchange knowledge, and receive practical demonstrations in natural farming.
- **Online Webinars and Training Videos:** Utilize online platforms to conduct webinars and share instructional videos, making training resources accessible to a broader audience.
- **Certificates and Recognition:** Provide certificates or recognition to trainers who complete natural farming training programs, motivating them to actively promote sustainable practices.
- **Video Documentaries:** Producing video documentaries highlighting the journey of a

farm's transition to natural farming, showcasing challenges faced, solutions implemented, and the resulting benefits.

- **Extension Workshops:** Combine workshops with practical demonstrations on natural farming techniques, enabling farmers to apply their knowledge in real-time under the guidance of experienced trainers.
- **Creating promotional materials:** The master trainers and extension functionaries should be given training on effective Banners, posters preparation for reaching out the maximum beneficiaries.

24. IMPORTANCE OF SUPERVISION, MONITORING, EVALUATION AND FOLLOW-UP OF THE NATURAL FARMING TRAINING PROGRAMME

Monitoring refers to close observation/watching of events/activities/programme may be in respect of individual/organization/materials.

What is it?

- Monitoring is a process of keeping a watch/observation on the progress of a programme/ project in terms of its target and time schedule.
- Another way of defining monitor is that, it is a process of collecting, recording, measuring, processing and communicating information to assist project management in decision making.
- Monitoring reveals whether the components of the extension programme/ activity are operating as intended.
- To be precise and brief, "Monitoring is an information system for management decision making''. Thus, monitoring is a management function, which begins with the start of the project and ends with the completion of the project, but it is a continuous process during the implementation of project.
- The key requirement for monitoring is an "Action plan" without which monitoring is not possible.

Objectives of monitoring

1. To oversee proper allocation and utilization of resource such as money, Human Resources etc.
2. To supervise the activities of programme, i.e. concerned with supervision of schedule of activities
3. To identify areas of short coming and factors responsible to overcome/correct shortcomings.
4. Monitoring is need for accountability purpose, i.e. who is getting what and how.
5. To know operational performance of the programme so that desirable and needed change or alterations can be made in day-to-day activities.

Types of monitoring:

1. **Input monitoring:** It refers to monitoring of various resources which are needed to carryout activities. These, for e.g. include Human Resources, materials, money, machine, management, message, person hours etc.

2. **Activity monitoring:** It refers to monitoring of series of activities/ tasks carried out by the implementing staff and the target beneficiaries to achieve outputs. These include – conducting training, field days, demonstrations, field visits etc.
3. **Output monitoring:** Refers to tangible results of an activity or series of activities like number of field staff trained, number of leaflets distributed, no. of storage structure constructed etc.

Evaluation of Extension Programme

- Dictionary meanings of evaluation are the determination of the value, the strength or the worth of something, appraisal or making judgment of something.
- Evaluation as applied to the field of extension may be defined as a process of systematic appraisal by which we determine the value or worth of an activity or an enterprise or programme.
- Evaluation is a method for determining how far an activity has progressed & how much further it should be carried to accomplish objectives.

Evaluation is defined as:

- A process by which the values of an enterprise are analyzed by which one is able to understand and appreciate the relative merits or deficiencies of persons, group, programme, situations ,methods and process
- A comparison of the situation before and after a development programme has operated within it for a predetermined period
- The process of determining the value or amount of success in achieving a predetermined objectives
- A process of determining how well the desired behavioral changes have taken place or taking place as a result of extension educational effort.

Degrees of Evaluation

1. **Casual every day evaluation:** Simple observations are important for some things, but have their limitations.
2. **Self-checking evaluation:** making conscious attempt to apply principles of evaluation. i.e. checking ordinary observation by talking with other, getting other people judgment etc.
3. **Do it yourself evaluation:** It involves careful planning, application of principles of evaluation and are more systematically done. Ex. Surveys and collection of observation with score or observation cards/ schedule.

4. **Extensive studies:** More complex and use more scientific approach
5. **Scientific research:** Experimental studies scientifically carried out to determine cause and effect relationship.

Steps in Evaluation: The following steps may be adopted in evaluation of a project.

1. **Objective:** Decide on the purpose of evaluation. What information is needed and why?
2. **Sampling:** Decide on the sampling method and the sample size which shall furnish the required Information.
3. **Collection of information:** Decide when and how the information will be collected and who will do it. Train personnel for the purpose, if required. Prepare appropriate data collection devices like interview schedule, questionnaire etc.
4. **Analysis of data**: Select appropriate statistical tools. Take the help of statistician or computer, if needed. Analyze and interpret the data.
5. **Report writing**: Prepare an appropriate report, highlighting the major finding. Avoid producing a faulty report. State clearly the implications and recommendations and mention what specific action is to be taken at different levels and by whom.

Advantages of Evaluation

1. It helps to establish a 'bench mark'.
2. It helps to know how far our plans have progressed
3. Evaluation helps to know whether we are proceeding in the right direction or not.
4. It indicates the effectiveness of a programme.
5. It helps to locate strong and weak points.
6. It improves our skill in working with people.
7. Evaluation helps to determine priorities for activities in the plan of work
8. Evaluation brings confidence and satisfaction to extension work.

Tools and Techniques of Evaluation:

1. Study of Historical records
2. Observations
3. Interview schedule
4. Questionnaire
5. Interview
6. Tests

Training need assessment & conducting the training in a systematic manner

The understanding and application of Training Need Assessment will help the Master trainers to design the training programs for Trainer Farmer and CRPs in an appropriate manner. Before start of the training and after completion of the training the knowledge and skills acquired will be assessed and the results analyzed carefully for the future.

For the purpose of gaining holistic understanding of NF various tools that help the participants become more aware icebreaking tools such as the Snake and Ladder developed by Patanjali and other institutions can be used to invoke discussions and reach common understanding amongst the participants on the various chapters/components /principles of natural farming. Examples of PRA tools which can help to assess the farming system for the Master trainer will be provided.

Checklist of tasks to be done before, during and after each training event will be prepared to streamline the training activity and ensure that the tasks are planned and implemented systematically.

At various levels of the training trainers and stakeholders will be monitored in terms of delivery and outputs.

Feedback mechanism: assessment of knowledge and skills acquired using questionnaire, verbal etc. and also on training venue, logistics etc,

PRA TOOLS

1. Brainstorming eg. snake and ladder
2. Focus Group on importance and need of Natural Farming vs Conventional Farming and prepare the priority grid
3. Transects / Maps to be done at village level to study the various crop patterns, AH, existing tools etc. Specifically, transect walks help to achieve the following**:**
   a) An appreciation of the biodiversity and the resource endowments of the specific farming community
   b) An understanding of the challenges and opportunities for Natural Farming development in that area.
   c) The Establishment of rapport with farmers and other key actors in that area.
   d) Resource Mapping and Crop Calendar
   e) SWOT Analysis including Stakeholder Analysis using Venn Diagrams
   f) Time Budget Analysis (Male and Female) and Gender Analysis: role of women vis a vis men
   g) Analysis of the Relations of Production

h) Trend Analysis of food habits and farming system

i) Role Play (dealer, farmer, NF extension worker)

j) Case Studies of well performing NF, conventional farmer expenses vs NF to be identified

k) Resource Flow (Expenditure flow of NF vs CF) for farming and other expenses

l) Comparison of availability of tools, equipment etc with NF as compared with CF

m) Crop Budgeting, role of market and credit

n) Report of the PRA findings to be prepared including action points

Checklist of tasks to be done before, during and after each training event:

❖ **Before the training:-**

- **Training Coordinators:-**
  - Mobilization Pictures
  - Planning of monitoring & time to time field visits
  - Sharing of Monitoring plan with their field staff and HO team
  - Conversation with their field staff and Trainer Farmers for training scheduling status
  - Trainees documents collection for new trainings
  - Training venue/location visit for the info about internet connectivity

- **Field Staff:-**
  - Confirmation phone calls to all the trainer farmers before 30 minutes of the training time
  - Conversation with their Trainer Farmers for training scheduling status
  - Update to their respective state coordinators for all started training session
  - Trainees documents collection for new trainings
  - Training venue/location visit for the info about internet connectivity
  - Connect with the person who will take the virtual online training

- **Trainer Farmer:-**
  - Phone calls to all trainees before the training timing on the daily basis.
  - Prepare the training's topic
  - Seating arrangement
  - Proper Branding (Banner)
  - Farmers documents collection for new batches and provide to field staff
  - Connect with the person who will take the virtual online training

❖ **During the training:-**

- **Training Coordinators:-**
  - Conversation with field staff regarding the training and photographs status
  - Conversation with Trainer farmers (randomly) through the audio or video call
  - Timely field visit (as per schedule)
  - Pin all the training locations on google map

- **Field Staff:-**
  - Conversation with Trainer farmers (randomly) through the audio or video call
  - Timely field visit (as per schedule)
  - Collection of the training photograph(starting timing pictures) and share with respective state coordinators
  - Pin all the training locations on the google map

- **Trainer farmers:-**
  - Take the training pictures of (starting and ending time) with notecam or time stamp on the daily basis
  - Make a training session video (Minimum 2 Min) on the daily basis and share with field staff.
  - Take feedback from trainees about the training session
  - Take a practical video or testimonials videos

❖ **After the training:-**

- **Training Coordinators:-**
  - Conversation with Field staff for the training session status, training photograph and videos
  - Collect and compile batch wise training photographs
  - Check the all training pictures (branding picture, session picture through notecam, practical picture, and videos) and upload on drive
  - Update to HO team for uploading the training pictures

- **Field Staff:-**
  - Conversation with trainer farmers regarding the training pictures and videos
  - Collect and check the training pictures and videos and share with respective state coordinator.
  - Collect the trainee's feedback about the training session

- **Trainer Farmer:-**
    - Share all training pictures (starting & ending timing) and videos to field staff on daily basis.
    - It is the responsibility of the trainer farmer to disseminate the knowledge gained in the training to the farmers whenever required.

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