Agro Ecological Farming System - Basic Concepts

Chapter 1: Introduction

The Green Revolution increased agricultural production for many famers in India and achieved significant gains in terms of food security. However, many of the small-farm holders in rain- fed and resource poor areas did not benefit much from Green Revolution Technology. Most of the small – farm holders who have been using chemical fertilizers and pesticides, many are caught in the debt trap due to the high cost of chemical inputs, lack of credit, poor access to markets, and lack of investible surplus, This has resulted in low profitability agriculture, Leading the smallholders to drop out of the sector. The spate of suicides among farmers in recent years has been an unfortunate consequence.

Every year it is seen that farmers have to invest more money for cultivation. Reasons are high rate of seeds, water resources, fertilizers. These costs are gradually increasing, whereas the production levels are gradually decreasing. There is decrease in ground water available for cultivation and this is an alarming situation. Ideally 2 – 3 crops have to be grown for the effective usage of ground water which is not seen currently. As a result of all the mentioned issues there is need to address Global warming. Due to the global warming there is temperature variation during day and night. For a farmer, to expect the yield is unpredictable till the last day of harvest. This risk is going to increase in the upcoming days. In order to get unaffected by all these issues he is in turn increasing the costs. Yet it doesn't confirm the higher yields for farmers.

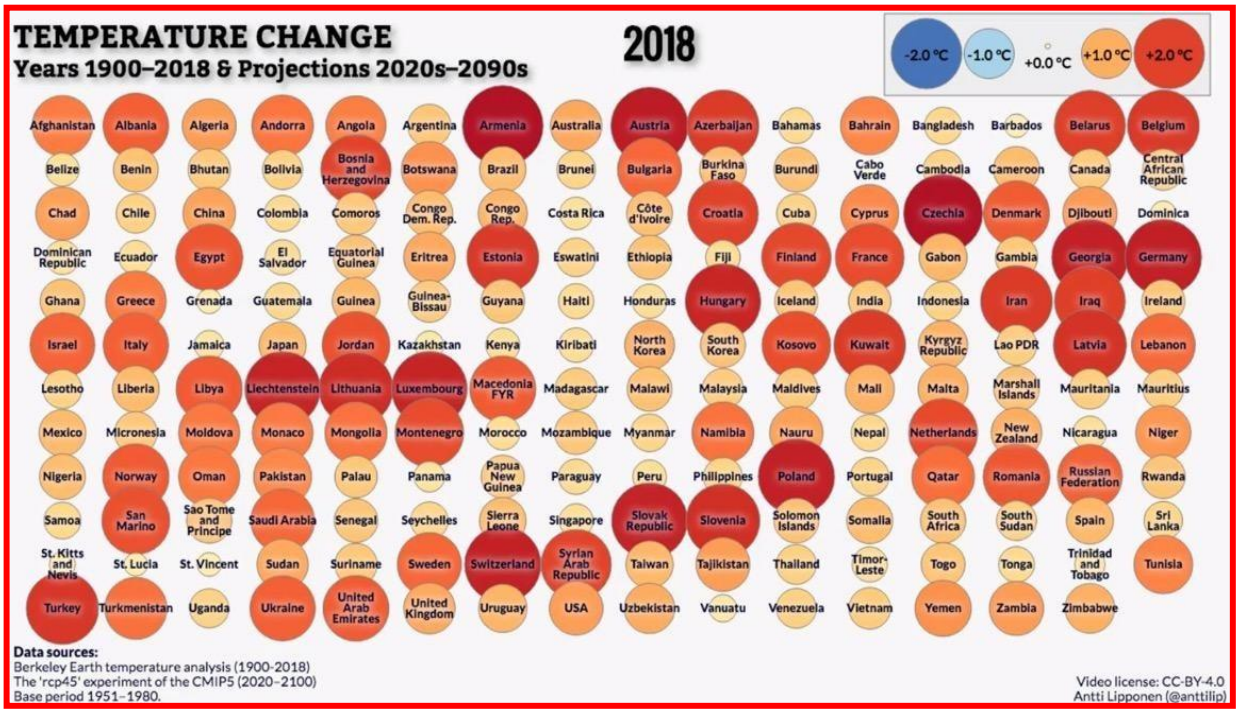
The next cause is the fertility of the soil which is decreasing. So initially usage of 1 bag of urea was enough but now the even with the increase of 5 – 10 times the yields are not commensurate. So the soil fertility (Organic carbon) is reduced. The soil fertility is lost due to lack of soil organic carbon (SOC) and soil biota. The major cause of this is continuous use of chemical inputs and unproductive agriculture practices. There is soil erosion with excess rainfall due to reduced humus content and porosity. The soil has lost its water withholding capacity. These issues are not temporary, but it's going to affect in the coming years. So farming has become not become viable livelihood.

Environmental crisis

Conventional farming is the main cause for the emission of Green House Gases (GHG). Out of total emissions 24% of GHG is due to excessive of chemical fertilisers and pesticides. It leads to **Global Warming**.

According to the IPCC reports released in Korea recently it has warned that if preventive measures are not taken we cannot escape from natural disasters and calamities which might occur within 12 – 15 years of time by when all the countries are to take up necessary actions to control this alarming situation.

Only 280 parts per million (ppm) was present in the atmosphere before industrialization. After the green revolution manpower was replaced by the machines, and as a result the carbon dioxide levels increases gradually and reached 411-412 ppm now. According to scientists 350 ppm was set as deadline. We have surpassed that digit long back. It is highly dangerous. Conference of Paris is held every year to understand the preventive measures taken by each country. All the countries are working to bring the emissions of Green house gases to zero.



All the countries are expected to take up necessary actions to mitigate GHG. 100 tonnes of carbons are emitted every year in to the atmosphere. With this, 3 ppm will increase to the current digit. So, we have to reduce the usage of fossil fuels and to encourage renewable resources such as solar, wind energy. We might not see the immediate results because there is already 411 ppm of carbon present in atmosphere which has 200 years of life span. A resolution has been adapted to take-up necessary actions for the upcoming generations.

What are all the human interventions contributing for the Global Warming, Pollution & Farmer distress?

The following are the important

- Since last century, the temperatures on Earth's surface have gone up till 0.74^0C +0.18^0C
- As per the reports given by IPCC, from the middle of 20^{th}century , the activity of drastic deforestation and increased usage of fossil fuels has further increased the Global warming. Similarly, the conventional, industrial agricultural practices, by using chemical fertilizers & pesticides, are emitting various greenhouse gases which are contributing for 24% in Global warming. Based on the recommendations of IPCC, The Federal Court of America has banned 26 out of 40 pesticides/ herbicides like Chloropyriphos / Glyphosate. Similarly Europe has banned 33 out of 39 and 18 in India.
- As per the UNO, around 2 lakh people are dying due to the usage of food grown under the chemical farming. Around 1.1 lakh people are committing suicides by consuming pesticides.
- As per the data given by FAO IN 2016-17 , the nutrition values in agricultural produce has gone down by 20% to 40% which is resulting in obesity in human beings.
- The Washington based Food policy research institute has recommended India to produce Chemical residue free and nutritious food by practicing Natural farming methods.
- After Industrial revolution the Global temperatures have been increasing drastically due to human activities.

Consumer/Health & Nutrition crisis:

Over the years it has been observed that 20-30% of the nutrients are lacking in the food that human is consuming. Abundant use of chemical fertilisers and pesticides which is causing nutrient imbalances, with surplus supply of N,P,K minerals and deficit supply of 34 types of elements like selenium. Broadly global disease load has increased exponentially and many experts attribute this to nutrient imbalance and other reasons. Serious ailments are reported to be caused by Weedicides like glyphosate etc. Vegetable samples drawn from the market and analysed by the labs are reported to be containing 18 types of pesticides residues much above tolerance limits. As a matter fact handling pesticides sprays without protective gear (Normal practice) is itself very hazardous activity.

Further accumulation of various heavy metals, through emissions by industries, application of fertilizers that too highly imbalanced to the farm lands has led to reduction of macro and micronutrients in the soil leading to disastrous health impact. According to WHO reports 50% of diseases are occurring due to such food that humans are consuming. It has been reported that pesticides are one of the reasons for causing cancer in the human beings.

To come out of these issues, natural farming (Agro-Ecological) is recognized as the alternative through which the cost of cultivation is minimised. Farmers are not relying on market dependant external inputs and are able to generate their inputs in *situ* on the farm. We are able to estimate the yields in AEFS and there is increase in the production. AEFS yields are on part with Non- AEFS if all practices are followed and are increasing over a period of time with increase of soil organic carbon. The land is rejuvenated, increase in the microbes and water holding capacity of the soil is enriched.

Natural farming encourages intercrop/poly crops over mono culture. Ideally a minimum of 8 – 20 crops will enable association of diverse microbes living in association with roots enhancing improved supply of nutrients, water and formation of humus. Further, poly cropping helps in reduction of leading for self- consumption improving health of the family. The plants are sturdy without succulence and withstand natural calamities and lodging.

Need of Agro Ecological Farming System (AEFS):

AEFS is a holistic alternative to the present paradigm of high cost chemical inputs-based agriculture. It is also very effective in addressing the negative and uncertain impacts of climate change. AEFS principles are in sync with the principles of Agro ecology, a worldwide movement. Its greatest strength is that it is based on the latest scientific discoveries in Agriculture, and, at the same time it is rooted in Indian tradition. UN- FAO has as recently as April 2018 urged all countries to move towards the adoption of Agro ecology to meet the twin goals of global food security and conservation of the environment.

AEFS encompasses agro ecological practices with emphasis on production of farm inputs, *in situ poly* cropping replacing mono cropping with poly cropping, rainwater and sunlight harvesting, elimination of fertilizer, pesticides and other agro chemicals empowering the farmer by using their knowledge, innovative skills, best practising farmers leading the farmer to farmer to extension model and taking support of women's organization(SHGs) networks for anchoring the programme.

This farming system significantly reduces the cost of cultivation,the need for large amounts of credit, and indebtedness. It also answers climate emergencies like global warming. AEFS is one of the methods of regenerative agriculture where the package of practices is made relevant to Indian farmers**.** These transformational changes are being achieved without any reduction in the productivity of the participating farmers and attracting especially young farmers back to agriculture. Initial results from AEFS in project area show a significantnet increase in farmers' incomes in addition to significan health and ecological benefits. AEFS has come up with strategies for permanent drought proofing through various resilient models which will give farmers a sustained income.

Chapter 2: Origin of AEFS and scaling up in Andhra Pradesh

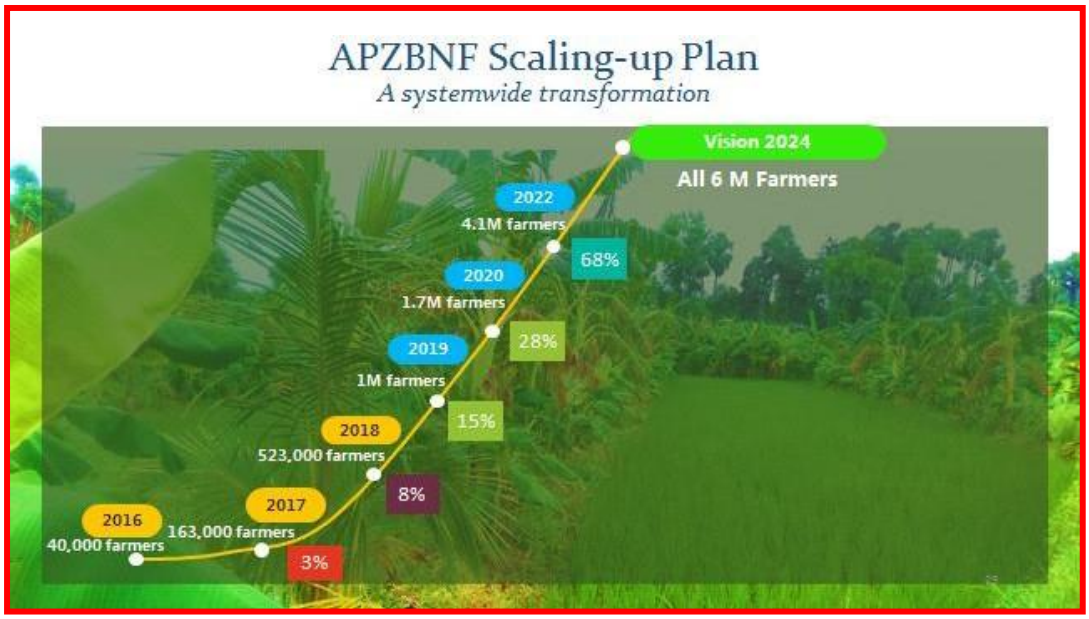
In the year 2000, Society for Elimination of Rural Poverty (SERP) was registered as a society under the MACS act. It aimed to support the self-help groups and empower to come out of poverty. During 2005-06, The Government of Andhra Pradesh started Non Pesticide Management (NPM) program to address the critical problems of agriculture i.e. the usage of fertilizers and pesticides. Also poor farmers (Small & Marginal Farmers) to adopt sustainable agriculture practices, to reduce the cost of cultivation and increase net incomes. The NPM program gradually transformed into NPM plus i.e., Community Managed Sustainable Agriculture (CMSA) taking additional components such as Rain water harvesting, Nutri gardens, 7 layer models (Sunlight harvesting), PoP (Poorest of the poor) half acre model and Integrated Farming System (IFS).The project provided support for community managed extension system rather than providing material inputs. Best practitioners are known as "Community Resource Persons (CRP)" were role models, who had adopted CMSA practicing farmers successfully in their fields and improved their net incomes, were acting as extension agents for last mile delivery.

The success of CMSA led to scaling up of Andhra Pradesh Agro Ecological Farming System (APAEFS) to a state-wide transformation of agricultural practices. The program implementation has commenced from Kharif 2016. The Ministry of Agriculture, Government of India and the Department of Agriculture, Government of AP are supporting the Program under the Rashtriya KrishiVikas Yojana (RKVY) and the Paramparagat KrishiVikas Yojana (PKVY). Azim Premji Philanthropic initiative is also supporting the program through one time grant.

AEFS Scaling up

Rythu Sadhikara Samstha (RySS) *(Farmer empowerment organization)*

Government of Andhra Pradesh (GoAP), Department of Agriculture (DoA) is implementing. Agro Ecological Farming System (AEFS) Program, through Rythu Sadhikara Samstha(RySS(*corporation for farmers'empowerment),non*-profit organization established by GoAP. The program has been initiated in 2015-environment.



Community Institutions

The AEFS approach is managed by community institutions, Self Help groups as the women found to favour the most and they saw the health benefits on themselves and on their children through this method. Further women's contribution to agriculture is 80% and it goes unnoticed mostly. This became a strong motivation and they were also able to convince their husbands. The most important factor in making this change to AEFS was this social capital of women. The second major force/ factor through which this huge transformation could occur are the farmers themselves, who were taking for alternative.

Community Resource Person

As mentioned earlier they are the driving force, of farmer led extension. In 3 – 5 years they will cover all farmers and cover 80 % of the total land extent. 2 – 3 CRPs are kept in charge of 1 cluster comprising 5 villages to achieve above objective. To start with project has selected best 10 CMSA clusters in each district and in subsequent years adjacent villages/ clusters are added on. They will further identify and groom Internal CRPs at the rate of 1 per every 100 – 150 farmers (10-15 SHGs) They together identify 1 to 2 lead farmers (at least 1 will be woman farmer per SHG) and they will be responsible for saturation of entire SHG. The CRP closely liaises with VOs at different levels and work in close coordination with CRPs of IB and other verticals. They will all report to community organizations at different levels.

One Assistant director of Agriculture is designated as the District Project Manager and will be in charge of the program at district level and liaising with the regular agriculture department.

RySS has set up a technical support unit to bring young pool of professionals called **Natural Farming Fellows (NFF)** who are graduates supported with Natural Farming fellowship, responsible to create awareness on AEFS, become a model farmer in the allotted clusters and to support Scientific studies establishing AEFS.

Strategy for Extension:

For delivery of extension services, cluster cadres bring together all the farmers by conducting Farmer field schools, Pico disseminations, Fort nightly meetings, Input Mass preparations.

- **FFS:** The community cadres engage farmer in the fields for identification of pests and learning different control measures for the pest. FAO is working closely with AEFS and running pilots in Guntur and Chittoor districts extending to entire State in a phased manner through NFFs.

✓ **PICO Dissemination:** Human mediated video disseminations are done with the help of PICO projector in the evenings on the day of FFS with SHG members and other farmers. CRPs anchor this program. The community video films are made in the fields of Local farmers' picturised, edited by trained Video resource persons. This is done with the support of an organization viz Digital Green Foundation. There are about 500 video films and few of them are shared with other states with subtitles in English.

✓ **NPM Shops:** Green input shops are being established to supply to those who cannot prepare on their own to sustain and expand the program. This is mostly run by SHG women. Efforts are made to include Custom hiring centre to supply small machinery in order to reduce drudgery and improve efficiency, to some of the successful NPM Shops.

✓ **Mass Preparations:** Engaging the community (SHG) in input preparation on a large scale.

✓ **Fortnightly meetings:** conducting meetings with SHG members on AEFS activities in the villages

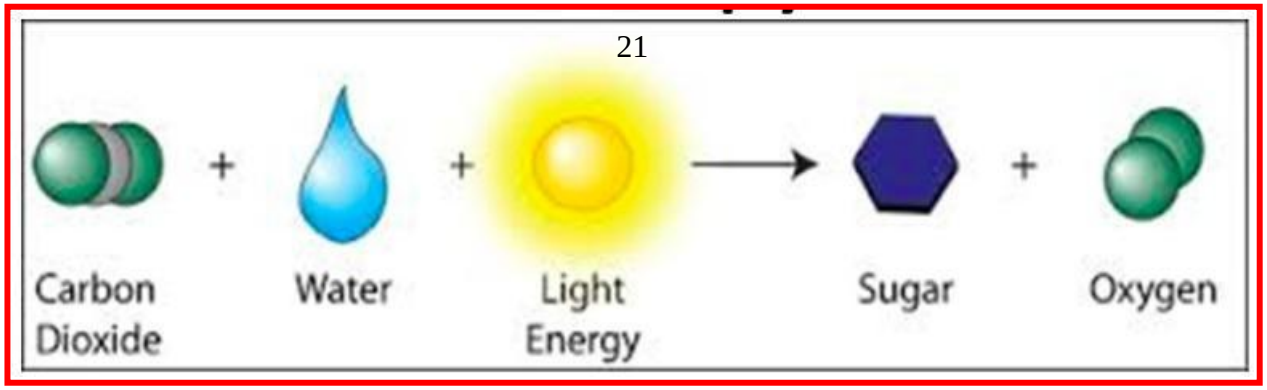
✓ The continuous capacity building is envisaged for ICRPs by organizing 2 day review cum training programs at sub district level (About 12 places in each district)

Chapter 3 - Soil Fertility, Four wheels, Science behind AEFS

Soil Carbon budget in a plant/ Role of Microbes:

Plants prepare their own food using sunlight, air and water by means of a process called Photosynthesis.

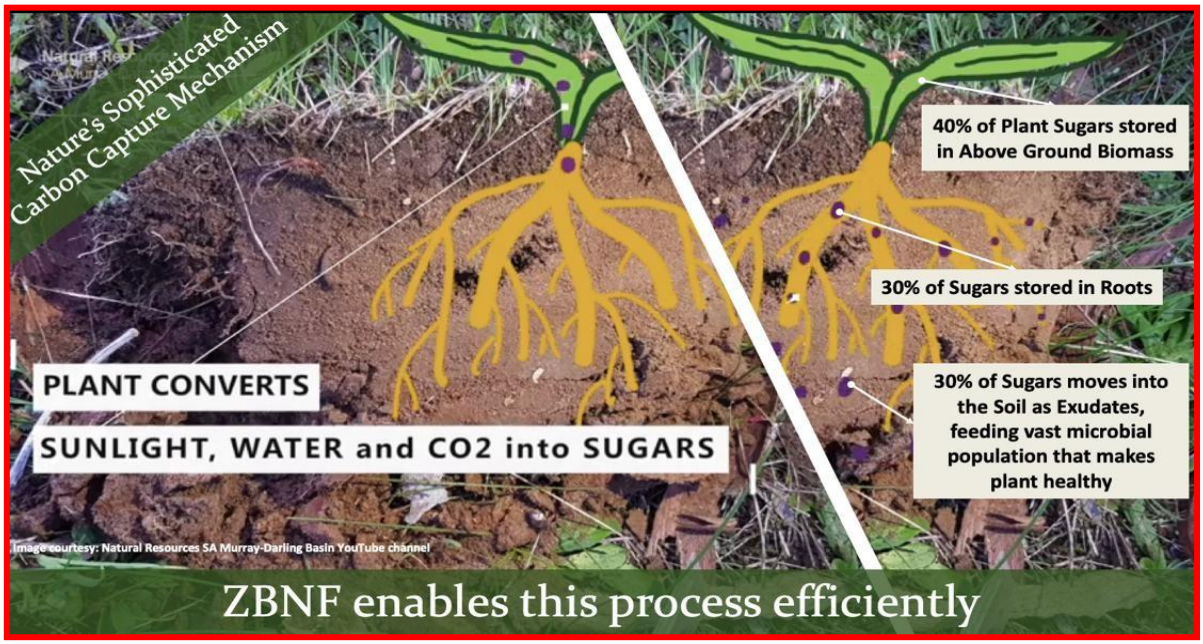
Figure 1 Photosynthesis phenomenon



The sugars (are carbon rich substances – soluble sugars, and other substances) prepared by plants are used for its own growth and also for the growth and development of other organisms. Herbivores eat plants, carnivores eat herbivores. Its how food web operates.

Figure 2 Budgeting sugars produced by plants

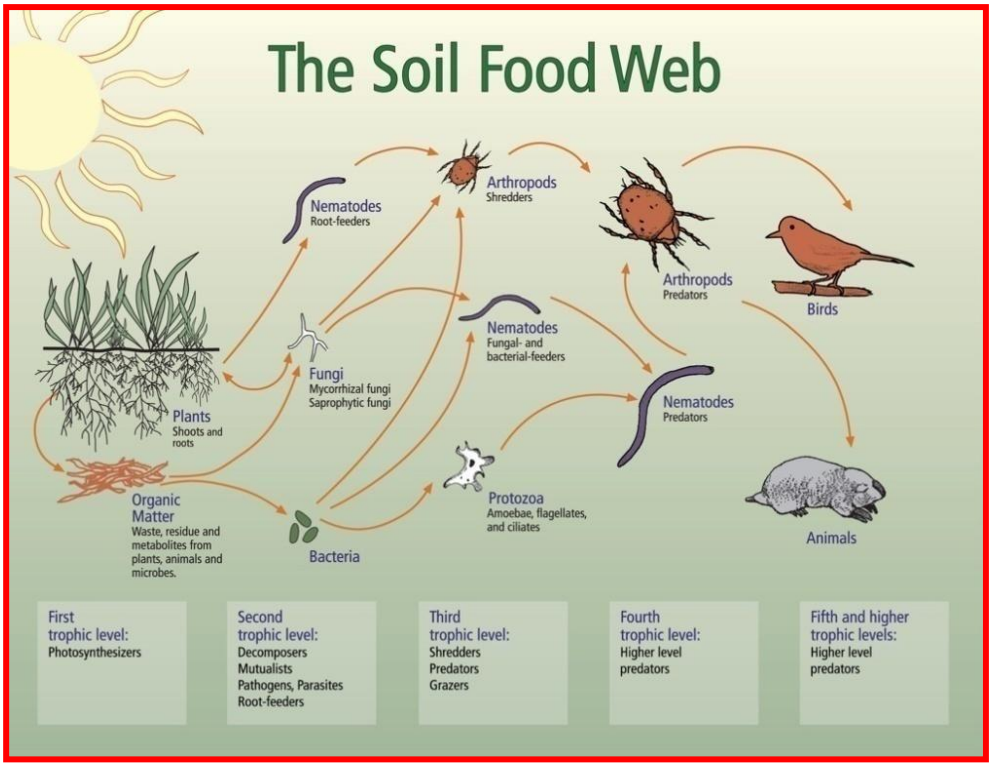
There is also an important process in which the "sugars" are actively fed to the soil microorganisms which is called root exudation.



Plant uses around 30% of the sugars produced by photosynthesis for its shoot development (development of new leaves, stems, branches, flowers, fruits, etc). Another 30% of it is used for the root system development (branching of roots, root elongation root hairs, etc). The remaining 40% of the sugars are released into the soil by the root system. The substances exuded by plant roots serve as food for the soil micro-organisms. The microorganisms increase in number and associate with the roots and help in humus formation in the soil. Different types of plants have different microbial associations. One spoonful of soil contains as many as 7 billion microorganisms. The above ground diversity in plants ensures the below ground diversity of microbes. The life below the ground is very huge and important and they depend on each other represented in the figure below "soil food web[1]" (predator-prey relationship).

Cow dung and urine contain millions of microbes which can be used for seed coating and application to soil for enriching microbial diversity after proper treatment. This is naturally occurring and low cost option. Scientific evidence has shown that only 2-10% of naturally occurring microbes can be cultivated in lab.

Figure 3 Soil Food Web



1. **FIRST WHEEL (Beejamrutham)**:

Beejamrutham we use as a coating of beneficial microbes (bacteria and fungi) which protect the seeds from infections. The local and improved seeds have good affinity with bacteria and fungi. Where as GMO and hybrid seeds cannot have good association with fungi and they might take decades for the affinity to develop with microbes. So Beejamrutham provides protection through beneficial microbes while the roots are tender and vulnerable.

Ingredients

- Water : 20 litres
- Cow dung : 5 kg
- Cow urine : 5 litres
- Lime : 50 g
- Soil : handful of soil from the ant hill or the bund

Method of preparation:

- Pack 5 kg dung in a cloth and suspend it in 20 litres of water
- Add cow urine and lime.
- Leave it for 12 hours
- Stir occasionally

Usage:

- Sprinkle beejamrutham on the seeds that are ready for sowing
- Shade dry it for some time and sow the seeds

Other planting material like suckers of banana and nodes of sugarcane etc need to be immersed in beejamrutham before sowing. For vegetables and paddy, their root systems of seedlingshould be immersed in beejamrutham before sowing.

SECOND WHEEL (Jeevavamrutam):

Both Solid (Ghanajeevamrutam) and Liquid (Dhravajeevamrutam) jeevamrutam are capable of supporting soil microbes. The microbes in soil have been suppressed by continuous usage of harmful chemical fertilizers/pesticides/Weedicides. In a healthy system, the weight of microbes will be 8-10 times the weight of the plant root biomass.

Year after year, crops mine a lot of nutrients from the soil and not giving back to the soil. If soil is healthy under the good management practices that align with natural processes, even after raising crops for 100 years, nutrients will be recycled and supplied to the crops. 1 cubic meter of soil has 25000 kilometres long fungal hyphae. The fungal hyphae form a network[2] and function as extended roots in transferring nutrients and water. Under natural farming practices, in the presence of soil microbes there is a formation of humus.

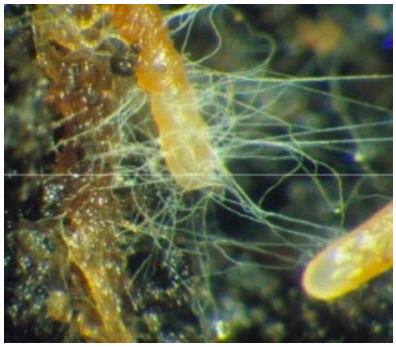


Figure 4

Fungi associated with roots aggregate

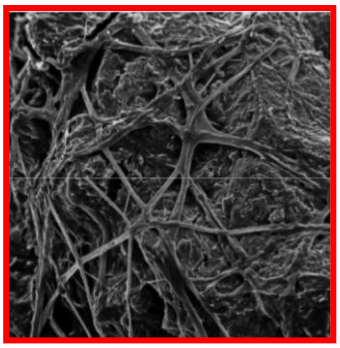


Figure 5

Fungal mycelia stabilising soil

The advantage of humus is that it's half-life of humus is around 500 to 2000 years.So humus is a very good sink for Carbon. Humus is a very stable form of carbon. 1 gram of carbon can hold with 8 grams of water. The development of humus happens with the help of exudates. The fungi surround soil particles and help in the formation of micro soil aggregates. Soil consists of "mineral matter" and "soil life". The microbial biomass debris has cell walls which act as cementing substances. They help in aggregation of soil particles.

Important benefit from humus is that the naturally produced foods are tasty. The tastiness, shelf-life, colour are important traits of naturally grown products. The tastiness is due to the presence of trace elements. In conventional (dead) soil system, the plant roots absorb whatever is present in the soil without any filtering system. In such situations, there is danger of plants absorbing toxic heavy metals also. But the membrane of fungal hyphae acts as an intelligent sensor and filters out unwanted elements while selectively allowing required elements as per required quantity. This is the reason why AEFS products are healthy and are nutritious too. Lack of humus in soils is the reason why nutritive values are low in conventionally grown products. That is how ***AEFS links with health.***

Jeevamrutham

Dosage: 200 litres is applied per acre through irrigation water or soil spray

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Required Material:

- Cow dung : 10 kg
- Cow urine : 10 Litres
- Black Jaggery : 1 kg
- Pulse powder (except soya bean and groundnut) : 1 kg
- Plastic drum : 200 Litres Capacity.
- Fistful of ant hill soil

Method of Preparation:

Take 200 litres of water in a drum, add 10 kgs of cow dung and 10 litres of cow urine. Mix thoroughly. Then add 1 kg of Jaggery and 1 kg of pulse powder and add fist full of soil from ant hill/ bund. Thoroughly stir it in clock wise direction for 4 days. It is ready for use from 5^{th} day onwards. This preparation can be used for 15 days from the day of preparation.

Usage:

- It enhances the activity of soil microbe and soil fertility status be improved.
- Availability of nutrient is made easy to the plant
- It develops pest and disease resistance to the crop

Ghana Jeevamrutham

Required material:

- Dung : 100 kg
- Cattle urine : required amount
- Jaggery : 1 kgs
- Pulse flour : 1 kgs
- Virgin soil : fistful

Preparation:

Mix all materials by adding urine. Keep this mixture under shade for seven days. After drying store in gunny bags upto six months.

Application:

Take 100 to 400 kgs of Ghana jeevamrutham apply in the field.

Use:

- It enhances the activity of soil microbe and soil fertility status will be improved
- Availability of nutrients is made easy to the plant
- It develops pest and disease resistance to the crop

THIRD WHEEL (Mulching):

Mulching is of 2 types, **Dead Mulch** & **Live Mulch**. Mulching is the method of covering the surface of the soil with any decomposable material (grass, hay, paper, kitchen wastes, leaves, twigs, and plant residues) so that the soil is not exposed to the drying action of the sun or the desiccating action of the wind.

Benefits of mulching:

- Soil does not get dried out as it is not exposed to the sun
- Soil retains moisture for a longer time
- Prevents soil erosion
- Improves soil life
- Mulch provides nutrient rich humus on decomposition
- Improves drainage of the soil
- Improves soil quality

Soil moisture conservation can be done by various methods.

Mulching with crop residues: on the soil surface will help prevent excessive evaporation during early crop growth. The amount of water conserved in this way is directly related to the amount of residue present on the soil surface. Increased infiltration of rainfall also occurs when crop residue remains at or near the soil surface. For better soil moisture management, crop residue left at the soil surface is essential.

Live mulchin is covering the soil 365 days or as long as possible with diversified crop plants so that symbiosis sets in, plant nutrition is taken care, pests and disease load is less, weed growth is minimised, diverse microbial populations are associated with increased humus generation around living roots in the soil. It also gives economic returns to the farmer. This is being attempted in the model 365 days green cover which is discussed in the subsequent pages.

WAPHSA:

Soil aeration is possible in well aggregated soil. If aeration is around 60%, the soil is considered to be well aggregated. 1) Soil aggregation results in better infiltration 2) water binds with root hair/humus 3) the water vapour in the air absorbed by humus and enter soil made available for plant roots.

Additional practices for soil fertility management namely NADEP is also essential for improving the soil fertility , at initial stages mulching may not be possible hence apply NADEP 2500 (For Details see in Annexure 1)

Chapter 4: AEFS Innovative Models
365 days/Pre monsoon Dry Sowing (PMDS) / Dry Sowing):-

- As per the reports generated by FAO, It takes 1000 years to build 3 cms of top soil and if the current rates of degradation continue all of the world's top soil could be gone within 60 years.
- By using chemical fertilizers, pesticides, herbicides and cutting down the forests results in killing of pollinators. The pollinator's population is drastically reducing.
- Resources like water, power are getting reduced due to less rainfall which is leading to distress in farming community.
- To answer the above issues, the farmers have to adopt the methods of arresting the soil degradation, increasing the biodiversity and harnessing water from the Atmosphere. The water vapor present in the Atmosphere is almost 10 times of the entire fresh water present in all the rivers in the world together. To address the above issues AEFS has created this PMDS model.

In order to convert the soils into living soils or fertile soils within short period, we need to maintain green cover throughout the year. Taking the advantages of Waaphsa mechanism, established by natural farming practices, the plants absorb water even under drought conditions. In the early hours, the plants, live mulch crops, straw mulch and even bare soil absorbs atmospheric water vapour which is sufficient for the growth. Soil microorganisms grow well under such aerated moisture (Waaphsa) conditions and utilize plant root exudates. The symbiotic and free-living bacteria and mycorrhizal hyphae supply nutrients to plants while enjoying Waaphasa condition. The plants absorb and sync atmospheric carbon into soil very rapidly. So that the soil organic carbon becomes available within short period. The mulching practice and continuous growth of plants enhances the soil organic matter.

Under these favourable conditions, when Ghana and Drava Jeevamrutham applied, soil micro-organisms increase their diversity and number. Ghanajeevamrutham absorbs the moisture and enables the seed germination even under scanty rainfall coupled with Dravajeevamrutam sprays. Continuous sprays of Dravajeevamrutam will help sustained growth coupled with intermittent rains. On the whole the soil becomes fertile and ultimately turned as **LIVING SOIL**. The only thing is, we have to maintain roots to grow in the soil continuously. For this we should grow crops, cover crops, plants throughout the year i.e. **365 days green cover** on the land.

In the monsoon seasons, it is common practice to cultivate crops, but in the summer or before summer farmers usually leave the soil fallow. In the absence of rains, farmers do not sow seeds. To maintain 365 Days Green Cover in the fields, there is urgent need to cultivate 15-20 variety crops between crops seasons. The option is pre-monsoon sowing and dry sowing to bridge the gap period between major crop seasons. Some important strategies to be followed to maintain 365 Days Green Cover are;

- Plan for pre-monsoon sowing (with Navadhanya method or Dabholkar method or any natural farming practice to cover the land with green plants/trees). The sowing method can be broadcasting and row method. Seed pelletisation may be an option for uniform sowing of the diversified seed.
- Maintain diversified cropping system by using all types of seeds (preferably desi seeds) for seasonal crops in kharif and rabi.
- Maintain poly cropping models (with inter crops, relay crops), so that farmer cultivate crops throughout the years (at least 9 months, rest of 3 months with pre-monsoon sowing) and cover the soil with green cover for 365 days. This system provides food and nutritional security to the family, fodder for cattle and facilitates microbes to survive in the soil and also creates the humus.
- Increase the number of 5-layer models.
- Convert existing orchards into multi-layer models.

Pre-monsoon sowing is such practice that seed are sown during the May month to catch the rains of thunder showers or summer showers (pre-monsoon rains). The crop passes through germination and early vegetative stage during the pre-monsoon season. After the monsoon season rains, the crop grows healthy without any pest and diseases incidence. During the dry spell of summer, soil retains moisture due to application of Ghanajeevamrutham and mulching material. The recommended dose of Ghanajeevamrutham is 400kg/acre. Mulch material should be covered in a thickness of 4 cm. Different mulch materials prove to be useful like Groundnut shell, Paddy straw and any other locally available mulch material (Crop residues may also be used). Paddy husks prove to be non- effective. This practice maintains soil biodiversity and insect biodiversity. Prevent the soil from wind erosion during uncultivated season, and also prevent from excess expose to sunlight.

Multi Layer Model:-

The concept of Multi Layer Model is built based on the natural forests which have various layers of trees living together without competing for sunlight, nutrients and water. In the forests, the five layers naturally exist with Big trees, Medium trees, Bushes, Small plants, Creepers and Tubers.

Based on the plants' photosynthesis capacity, entire vegetation is divided into three groups viz.,

1) Highly photosynthetic plants
2) Mild photosynthetic plants and
3) Photo sensitive plants

Highly Photosynthetic plants:

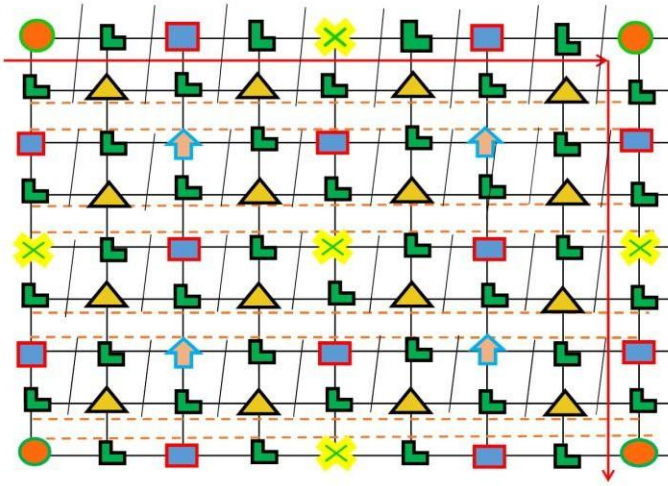
Highly photosynthetic vegetation requires intensive sunlight for their photosynthesis. The full intensity of solar light is between 8000 to 12000 foot-candles.

In this group all big trees and huge trees are present which include Mango, Tamarind, Cashew, Sapota, Coconut, Teak, Jackfruit, Bel, Jamun, oil palm, date, Rubber (Monocot crops like Gramineae family viz Sugarcane, Paddy, Maize, Millets and Grasses are also included in this group). They can manufacture food 10 hours per day. But high photosynthesis occurs during 10.30 am to 3.30 pm. Under the shadow they cannot prepare food. Under such conditions, stomata of leaves are closed by guard cell. Even dancing shadow is not enough to prepare food.

Mild Photosynthetic plants:

All types of medium trees, bushes, all types of pulses, oil seeds, vegetables, flower crops are part of this group. These plants manage with dancing shadow. The leaves of medium trees, bushes, and plants that fall under this category require the solar energy between 5000 to 7000 foot-candles (medium intensity sunlight). Naturally, in the rainy season, clouds create dancing shadow. In the winter, intensity of sunlight is less. So, we need to arrange shade vegetation to cover these crops from higher sunlight during summer season.

Photo sensitive plants: All types of spices, ginger, turmeric, black pepper, beetle wine, and tubers are grouped under this category. The leaves of these plants do not require full sunlight or dancing shadow, they grow well under the shadow. The leaves utilize 3700 to 5000 foot-candles of sunlight. Considering the family's food and nutritional security as well as economic point of view Multi Layer model has been designed with the inclusion of Big Trees, Medium trees, Bushes, Small plants, Creepers and Tubers.The basic units of any Multi Layer Model is; 36' X 36'models - Coconut group/ mango group of 36' X 36'. Few medium trees are; nutmeg, orange, desi drumstick, sweet orange, lemon, kinnow, guava, amla, apple, cocoa, areca nut, papaya, cloves, and other medium trees. Bushes are; custard apple, banana, drumstick, pomegranate, curry leaf, cinnamon and other small bushes.



Layer no.	Symbol	Plant	per block	per acre
Layer-1		Mango	1	33
Layer-2		Acid Lime	3	99
Layer-3/1		Drumstick	8	264
Layer-3/2		Papaya	16	528
Layer-3/3		Gliricedia	4	132
Layer-3/4		Perennial Redgram	32	1056
Layer-4		Turmeric	288	9504
Layer-5		Beera, Sora etc (Creeper)	32	1056

FORMULAS TO FIND NUMBER OF PLANTS IN EACH LAYER IN A GIVEN LAND :-
L1 = ((Breadth/36) X (Length/36) X 1) + (Breadth/36) + (Lengh/36) + 1
L2= ((Breadth/36) X (Length/36) X 3) + (Breadth/36) X 1 + (Length/36) X 1
L3 = ((Breadth/36) X (Length/36) X 60) + (Breath/36) X 6 + (Length/36) X 6

Instructions:

- The plot planned for Multi Layer Model may be over laid with 365 DGC for enhancement of soil fertility, and carbon sequestration. All around the plot trenches, in between conservation furrow, swales across the slope and farm pond at bottom of slope to harvest rainwater is ideal species and spacious as indicated in the above diagram.
- This can be combined over all watershed planning. Some components can be done in convergence with MGNREGA.
- Lot of higher end experiment are planned with National & International scientific organizations which are appended with wide annexure 3

CHAPTER 5 - NON NEGOTIABLES

SEED & SEEDLING TREATMENT:

Different methods discussed Seed treatment chapter

When: Before Sowings
Why: Prevent seed borne pests and diseases
How: Beejamrutham or any other botanical extract recommended for seed treatment

CLIPPING OF THE TIPS (ONLY PADDY)

Clipping of rice seedling tips at the time of transplantation to minimize carryover of rice Hispa case worm and stem borer infestation from bed to the transplanted fields

When: Just before transplanting

Why: To prevent stem borer attack

How: Cut the tips of the plants

ALLEYS (ONLY PADDY)

Leaving 20 cm path at every 2 mts interval in East–West direction in Khariff and North South direction during Rabi Season will reduce attack of Brown plant Hoppers and sheath blight

When: During transplanting

Why: Prevent Brown plant hopper infestation

How: 20 cm path at every 2 mts interval in East –West direction

WHITE AND YELLOW STICKY TRAPS

Arrange 15-20 Yellow and White sticky traps per acre. Green leaf hoppers and thrips stick to these traps.

Clean these traps once in two days and add sticky material to traps for effective trapping. Height of these traps should be the same with the plant height

When: After transplantation

Why: Reduce sucking pests, also to identify the intensity of sucking pests.

How: Paste glue or castor oil on white and yellow plates keep them at plant height

BLUESTICKY TRAPS

Blue sticky traps may be kept in chilli and Tomato crop to monitor the thrips attack.

BIRD PERCHES

Arrange 10-15 bird perches per acre immediately after transplanting and remove these at grain filling stage (60 days after transplanting).Bird perches will attract birds and birds will eat pests. Broad costing of yellow rice will attract more birds. Height of bird perches should be more than the height of plants

When: 10 -15 days after transplantation

Why: Birds will sits on the perches and will eat larvae
How: Place 10 -15 perches per acre above the plant height

PHEROMONE TRAPS

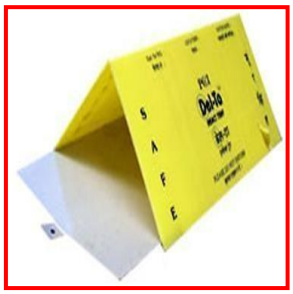
Keeping 5-10 Pheromone traps in zigzag way to mass trapping of Lepidoptera's pests. Lure has to be changed once in a month or afterthe expiry date

When: Fifteen day after transplantation in paddy and 30 days in other crops
Why: To prevent stem borer
How: Place5-6 pheromone traps per acre above the plant height

A pheromone Trap: Is a type of insect trap that uses pheromones to lure insects. Sex pheromones and aggregating pheromones are the most common **documentation and evaluation of traditional** types used. A pheromone - impregnated lure, as the red rubber septa in the picture, is encased in a conventional trap such as a Delta trap, water-pan trap, or funnel trap.

Types Traps:

Coco Trap (trapping Red Palm Weevil and Rhinoceros Beetle)



Del-Ta

(moths, fruit

flies, etc.)

Fero-T

Fligh t (For Tapping melonfly & Furit fly)

Types of lures:

1. Pink Bollworm (Cotton)
2. Rice Yellow Stem Borer (Paddy)
3. Rhinoceros Beetle (Coconut)
4. Spiny Bollworm (Cotton)
5. Spotted Bollworm (Bhendi)
6. Tobacco Caterpiller (All crops)
7. Helicoverpa (All crops)
8. Brinjal Fruit & Shoot Borer (Brinjals)
9. Diamond Back Moth (Cabbage and cauliflower)
10. Melon FruitFly (all creeper vegetables and fruits)
11. Sugarcane Early Shoot Borer (Sugarcane)
12. Sugarcane Internode Borer (sugarcane)
13. Sugarcane White Topshoot Borer (Sugarcane)
14. Coffee White Stem Borer (Coffee)
    Red Palm Weevil (palms PinkBollworm(Cotton)
15. Rice Yellow Stem Borer (Paddy)
16. Rhinoceros Beetle (Coconut)
17. Spiny Bollworm (Cotton)
18. Spotted Bollworm (Bhendi)
19. Tobacco Caterpiller (All crops)
    Helicoverpa (All crops Pink Bollworm (Cotton)
20. Rice Yellow Stem Borer(Paddy)
21. Rhinoceros Beetle (Coconut)
22. Spiny Bollworm (Cotton)
23. Spotted Bollworm (Bhendi)
24. Tobacco Caterpiller (Allcrops)
    Helicoverpa (Allcrops)
25. Brinjal Fruit & ShootBorer (Brinjals Groundnut
    Leaf webber (along with Delta trap) (Groundnut)

26. Diaond BackMoth(Cabbage and cauliflower)
27. Melon FruitFly (all creeper vegetables and fruits)
28. Sugarcane Early ShootBorer (Sugarcane)
29. Sugarcane Internode Borer (sugarcane)
30. Sugarcane White Top shootBorer (Sugarcane)
31. Coffee White Stem Borer (Coffee)
32. Red Palm Weevil (palms)

AZOLLA:

When: 15 days after transplantation

Why: Supplies Nitrogen, Control weed and water evaporation

How: Apply 10 kg Azolla into main field and within 15 days it will spread to entire field. Then incorporate Azolla with the help of Weeder.

TRAP CROPS:

Grow yellow flower Marigold (tall growing plants are preferred) and Cast or around field, ensure flowering before main crop completes vegetative stage

When: Along with main crop sowings

Why: To attract pests – these plants will provide space for laying eggs

How: Crisscross – cover entire field Marigold plants will attract gram pod borer, also it controls effect of nematodes. Castor plants will attract spodoptera (Tobacco Caterpiller)

BORDER CROP:

Sow 3 row soft all growing Jowaror, Bajraor, Maize, Thulasi, Caster (without any gap in the row). This will provide enabling environment for friendly insects and it also prevents sucking pest complex.

When: Along with main crop sowings

Why: To attract friendly insects, prevent pesticide drift from neighbouring fields

How: Two rows around the field

APPLICATION OF BOTANICAL EXTRACTS:

If all the above mentioned principles are followed religiously, there will not be any need to apply botanical extracts. How ever list of pests and botanical extracts discussed in Botanical extracts chapter.

OTHER METHODS

LIGHT TRAP:

Light traps can be used to monitor and trap adult insects, there by reducing their population. Some form a light traps that could be used are electric bulbs, hurricane lamps and bonfires. Water mixed with kerosene is filled in a large plate or vessel and kept near the light. The trap should be fixed 2–3 ft above the crop canopy and setup in the field between 6 and 9pm. (If it is kept beyond 9pm, there are chances that the

beneficial insects will also get trapped and killed.) The adult moths, which get attracted by the bright light, fall into the water in the vessel and perish.

ROPE METHOD:

The field should be filled with water up to a height of 5cm. One litre of kerosene should be mixed with 25kg of sand and stre wn in the field. Later, a string should be dragged over the surface of the leaves vigorously so that the caterpillars fall into the water. The caterpillars are killed by the kerosene present in the water .Later, the water should be drained to remove the dead caterpillars. The field should be dried and then freshly irrigated.






USE OF EFFIGIES

A human-like figure,made of paddy straw and wearing a whitedress (@ two effigies per hectare) kept in the field at milky to grain filling stage, will scare away the birds.

KEEPING BUNDS CLEAN

Field and field bunds are the favourite egg laying spots of most pests. Hence, wild grasses and weeds found in the field and on the bunds should be periodically removed.

PLASTERING OF BUNDS

Weeds found on the bunds should be removed and the bunds should be plastered. By doing this, rat holes found near the bunds can be sealed and rodent damage controlled. Such a procedure also prevents water leakage.


French Bean


Marie Gold


Sunflower


Mustard


Maize


Castor

GOOD INSECTARY PLANTS BELONGING TO COMPOSITAE, LEGUMINACEAE, UMBELLIFERAE, BRASSICACEAE ETC. FAMILIES

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