Ministry of Environment, Forest & Climate Change

NABARD

TRAINING MODULE- 4

EFFICIENT PEST CONTROL THROUGH INTEGRATED PEST MANAGEMENT

Funded by the Ministry of Environment, Forest and Climate Change, Government of India
Under the 'National Adaptation Fund for Climate Change (NAFCC)'

Government of Himachal Pradesh
Department of Environment, Science & Technology

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Sustainable livelihoods of agriculture-dependent rural communities in drought prone district through climate smart solutions in the state of Himachal Pradesh

An initiative under:

National Adaptation Fund for Climate Change (NAFCC)

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MODULE 4 | Efficient Pest Control through Integrated Pest Management

INTRODUCTION

The impacts of climate change on agriculture and horticulture are being witnessed almost in the entire country and more so in the state of Himachal Pradesh. The State has a high reliance on agriculture and thus it has direct bearing from climate variations. Increase in temperature, changing rainfall patterns will lead to water scarcity and drought. Plant diseases and pests negatively affect agriculture productivity; climatic parameters have a direct impact on disease occurrence, spread and intensity. Long-term changes in such parameters due to climate change will further aggravate the situation. It is projected that that there may be an all-round decrease in horticultural-agricultural production in the region in long-term and the farmers need to be sensitized with strategies related to drought mitigation, pest and disease control etc to make their crop withstand against climatic incidences.

For the purpose a Training Need Assessment exercise was undertaken and training gaps were identified as follows:

- ★ Inadequate knowledge of the farmers on pest management.
- ★ Regarding pest control measures less farmer consult government officials for efficiently use of pesticides and chemicals in their field.
- ★ Inadequate knowledge on application of fertilizer and pesticides.
- ★ Less knowledge on pest behavior due to adverse climatic condition.
- ★ Inadequate knowledge on ZBNF (Zero Budgeting Natural Farming)

Accordingly the main focus of the module 4 is to improve the knowledge and skill base of the participants for efficient pest control and its need and benefits in changing climatic conditions, IPM (integrated pest management) and zero budget natural farming to make their crop withstand against climate variation. Based on the above mentioned training gaps, under the module four sub sessions have been designed. They are as here under:

- ★ Impact of climate change on Insect pests, Pathogens and Nematodes.
- ★ Climatic requirements for disease outbreak in different Agri. and Horticulture Crops.
- ★ Integrated Pest Management Strategies for Climate Smart Agriculture.
- ★ ZBNF (Zero Budget Natural Farming).

For effective facilitation of sessions, materials like power point presentations, handouts, chart papers, white board and markers, activities sheets and reference materials will be used. As per suitability case study, video shows and interactive discussions will be organized as method of input delivery. Finally to assess the usefulness of the session's informal and formal feedback will be collected.

Moreover the learning of the participants will be assessed with the help of a set of key questions on different sub thematic areas along with the answer sheets.

MODULE OVERVIEW

Module 4 is designed to strengthen capacities of extension officials/ lead farmers to identify & implement an agricultural & agronomic practice that enhances resilience of farming communities well as develop facilitation skills so that they can effectively transfer knowledge and skills to follower farmers towards climate resilient agriculture.

OBJECTIVE

To understand the need and benefit for efficient pest control in changing climatic conditions and strengthen skills for integrated pest management and zero budget natural farming in the field.

SESSION DESIGN

Impact of climate change on Insect pests, Pathogens and Nematodes	Climatic requirements for disease outbreak in different Agri. and Horticulture Crops	Integrated Pest Management Strategies for Climate Smart Agriculture	ZBNF (Zero Budget Natural Farming)

• Introduction
• Why pest incidences are increasing
• Climate change/ Global warming impacts
  ▪ On Insects and mites
  ▪ Effect of moisture/ rain
  ▪ On insecticides
  ▪ On Pathogens
  ▪ On nematodes
  ▪ On weeds
S 1
	• Common pest occurrences and climatic trigger
	• Temperature and Precipitation
	• Carbon Dioxide (CO_2)
	• Insects
	• Some Plant Diseases Influenced by Climatic Variation
	S 2
		• Integrated Pest Management Strategies
		• Advantages of IPM
		• Knowing the problem
		• Major disease/ pest incidences in Agriculture and horticulture crops
		• Cultural and Biological Practices as Preventive Measures
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		  ▪ Cultural Practices
		  ▪ Biological Practices
		  ▪ Mechanical Practices
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		  ▪ Crop Stage-wise Integrated Pest Management Practices
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			• Zero Budget Natural Farming
			• Principles
			• Objectives
			• Jivamrita
			• Bijamrita
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			• Moisture / waaphasa
			• Other Important Methods of Zero Budget Natural Farming
			• Pest Control management under Zero Budget Natural Farming
			S 4

SESSION- 1 Impact of climate change on Insect pests, Pathogens and Nematodes

OBJECTIVE

- To understand the impact of climate change on the occurrence spread of insect pests and other pathogens

FACILITATION

STEP 1 Introduce handouts through a power point presentation. This would include the objective of the session and the process the facilitator will take to deliver the session.

STEP 2 Emphasize the importance of having a good understanding of climate change impact on insect pests, pathogens and weeds. Involve participants what they think and get an idea from their perception.

STEP 3 Discuss why the pest incidences are increasing in agriculture and horticulture crops. Describe how pest infestations often coincide with changes in climatic conditions, like early or late rains, drought, or increases in humidity, which can reduce yields also.

MATERIAL REQUIRED

PowerPoint presentation, relevant handouts, chart paper, markers, tape.

TIME

30 Minutes

CLIMATE IMPACT

S 1

Impact of climate change on Insect pests, Pathogens and Nematodes

INTRODUCTION

Agriculture and Horticulture is the main occupation of the people of Himachal Pradesh. It has an important place in the economy of the State. The agro-climatic conditions in the state are congenial for the production of cash crops like seed potato, off-season vegetables and ginger. One of the major factors contributing towards it is the prevalence of diseases which sometimes may lead to even zero harvest. In order to increase the production of crops, adoption of plant protection measures is of supreme importance. During each season, **campaigns are required to fight the threat of crop disease, insects and pest etc.**

Agriculture productivity is highly affected by the plant diseases. It is one of the important factors which have a direct impact on overall agricultural productivity and climate change will further aggravate the situation. **Worldwide approximately 20% yield reduction is caused by plant diseases** in the principal food and cash crops.

Climate models predict a gradual rise in CO_2 concentration and temperature all over the world, but are not precise in predicting future changes in local weather conditions. Local weather conditions such as rain, temperature, sunshine and wind in combination with locally **adapted plant varieties, cropping systems and soil conditions can maximize food production** as long as plant diseases can be controlled. However, all climate models predict that there will be more extreme weather conditions, with more droughts, heavy rainfall and storms in agricultural production regions. Such extreme weather events will influence where and when diseases will occur, and therefore enforce severe risks on crop failure.

Plant diseases are considered an important component of plant and environmental health and can be caused by infectious or biotic pathogens and non-infectious or abiotic factors. Biotic plant diseases are caused by organisms such as fungi, bacteria, viruses, nematodes, phytoplasmas, and parasitic plants. Abiotic diseases are associated with chemical and physical factors, such as temperature or moisture extremes, nutrient deficiencies, mineral toxicities, and pollution.

Why pest incidences are increasing:

The increase in pest population is attributed often to changing climatic conditions. **Higher temperatures and longer growing seasons** is resulting in increased population on insect pests, pathogens and nematodes as most pest species are favored with warm and humid conditions. Pest infestations often coincide with changes in climatic conditions, such as early or late rains, drought, or increases in humidity, which can reduce yields. **Pest outbreaks occur more frequently, particularly during extended periods of drought**, followed by heavy rainfall.

However there other significant reasons as well for increasing pest incidences in different crops like:

- Intensive mono-cropping
- Off season vegetable cultivation
- Emergence of pesticide resistance
- Loss of natural enemies due to indiscriminate use of insecticide

CLIMATE CHANGE/GLOBAL WARMING IMPACTS

➢ **On Insects and mites –**

They are cold blooded, higher temperature increases rate of development.

- Extension of geographical range of pests
- Increased risk of invasive migrant pests
- Reduced effect of crop protection technologies will increase pesticide consumption by 2.5 fold
- Increased probability of pest developing further resistance to pesticides
- Rising temperature extends growing season, reduces winter kill of insects there by increases pest population
- With increase in temp. The CO_2 level of atmosphere increases and soil moisture is depleted, which influences population dynamics of insects and there is significant crop loss
- This results in geographical expansion of the pest particularly sucking pests which in turn increase vector borne diseases
- In transgenic crop the production of Bt. toxin is reduced
- The overall temperature may influence crop pest interactions by speeding up pest growth rates which increases reproductive generations per crop cycle

➢ **Effect of moisture / rain**

- Drought changes the physiology of host species leading to change in behavior of insects that feed on them.
- Abnormally cool and wet condition brings in severe insect infestation.
- Flash rain or flash flood encourages outbreak of swarming caterpillar incidence in paddy.
- Sudden hail storm or precipitation results in outbreak of cutworm in groundnut, pulses and vegetables.
- Prolonged dry spell during monsoon season favours outbreak of BPH in paddy.
- Whether optimal, excessive or insufficient moisture/ precipitation are a key variable for pest outbreak.
- Cool and dry climate favours the incidence of sucking pests.

➢ **On insecticides**

- Pesticides like pyrethroids, organophosphates and bio-pesticides are highly thermo-unstable and degrade faster in high temperature Global warming may render many of these formulations

ineffective, there by necessitating frequent spraying for effective pest control.

- Hence there is increased probability of development of resistance in insects.

➢ **On Pathogens:**

- Higher temperature, humidity and greater precipitation results in spreading of plant diseases.
- Wet condition promotes germination of spores of fungi and bacteria. In wet condition, plant tissues exude bacterial masses that spread.
- Powdery mildew thrives in hot-dry climate as long as there is dew fall at night.
- Cereals are more susceptible in warm and humid climate.
- High temperature, elevates the CO_2 level which increases canopy size and density of plants, this is favorable for foliar pathogens.
- High C: N ratio of litter delays decomposition which increases pathogen survival in soil.
- Increased plant bio-mass, slower decomposition of litter and higher winter temperature could increase survival of pathogens in crop residues.
- Elevated CO_2 increases incidence of blast and sheath blight in paddy.
- High moisture increases LB of potato & tomato.
- Fog associated with low night temperature favours Powdery mildew, shooty mould, leaf blight in potato, tikka in Groundnut.
- Inflorescence blight in ornamentals increase with high humidity and frequent rain.

➢ **On nematodes**

- Nematode development is slower in cooler climate and faster in warmer climate.
- Increase in atmospheric temperature results in more no. of generations per season and expansion of geographic region.
- Drier temperature increases water stress in nematode affected plants.
- In banana, nematode population and root damage is more in high temperature.

➢ **On weeds**

- Weeds are benefitted due to climate change to a great extent since they have greater natural adaptation practices. Weeds are in a competitive advantage in changing climatic scenario for which it would be more cumbersome and expensive to suppress them.
- Elevated CO_2 influences weed flora as they have both C3 and C4 photosynthetic pathway. C3 weeds co-existing with crops may influence the crop greatly. .

SESSION- 2 Climatic requirements for disease outbreak in different Agriculture and Horticulture Crops

OBJECTIVE

- To enhance understanding of how various climatic conditions trigger disease/ pest outbreak and affect their spread and intensity

FACILITATION

STEP 1

Introduce handouts through an organized power point presentation. This would include the objective of the session and the process the facilitator will take to deliver the session.

STEP 2

Facilitator will explain what are climatic requirements for disease outbreak in different agriculture and horticulture crops.How rise in temperature and changes in rainfall pattern affects soil moisture and leads to expansion of pathogens.

STEP 3

To sum up the session, facilitator will mention the common diseases in agriculture and horticulture crops and how climate change is projected to have a direct impact on the occurrence and severity of diseases in crops.

MATERIAL REQUIRED

PowerPoint presentation, relevant handouts, chart paper, markers, tape, Activity Sheet S-1

TIME

30 Minutes

CLIMATIC TRIGGER

S 2

Climatic requirements for disease outbreak in different Agriculture and Horticulture Crops

1. Common pest occurrences and climatic trigger

Climate change is projected to have a direct impact on the occurrence and severity of diseases in crops, which will seriously compromise our food security. **Rise in temperature and changes in rainfall pattern will have a varied effect on soil moisture and humidity**. Studies have shown that temperature increase causing geographic expansion of pathogen and vector distributions, bringing pathogens into contact with more potential hosts and providing new opportunities for pathogen hybridization.

2. Temperature and Precipitation

Changes in temperature and precipitation regimes due to climate change may alter the growth stage, development rate and pathogenicity of infectious agents, and the physiology and resistance of the host plant. The large population size and short generation time of plant pathogens are expected to make them the first organisms to show effects of climate change. According to scientific studies the consequences of warmer temperatures on host-pathogen interactions may be reflected in three ways:

- **increases in pathogen development rate, transmission, and generations per year**
- **Increases in overwintering of pathogens,**
- **Changes in host susceptibility to infection**

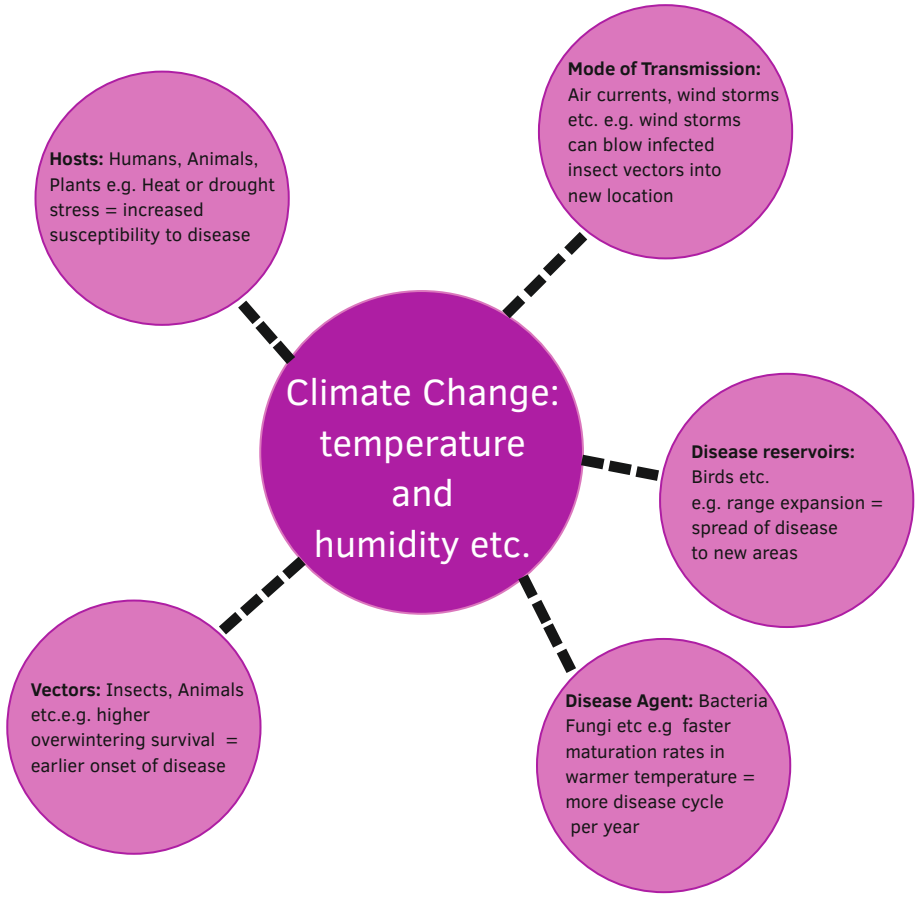
Moisture can impact both host plants and pathogens in various ways. Some pathogens such as apple scab, late blight and several vegetable root pathogens are more likely to infect plants with increased moisture content because forecast models for these diseases are based on leaf wetness, relative humidity and precipitation measurements. Other pathogens like the powdery mildew species tend to thrive under conditions with low moisture. **Pest outbreaks are more likely to occur if plants are stressed** (e.g., drought stress) because their defensive systems are compromised and resistance to pest infestation lower. Drought may become more frequent and severe in the future if increased evapo-transpiration rates associated with predicted higher temperatures are not compensated sufficiently by increases in precipitation.Drought stress has been found to affect the incidence and severity of viruses such as maize dwarf mosaic virus.

3. Carbon Dioxide (CO_2):

Normal soils may contain as much as 6-18% CO_2, depending on organic matter decomposition, microbial and root respiration, and other factors. Most soil-inhabiting fungi tolerate more than 10 to 20-fold increases in atmospheric CO_2 concentration. Some typicalsoilborne plant pathogens, such as species of Phytophthora, Aphanomyces, Sclerotium, and pathotypes of Fusarium Oxysporum multiply faster at high CO_2 levels.

4. Insects:

Insects are important vectors of many plant diseases. Low temperature extremes in winters significantly cause insect mortality, thereby reducing their population in the following season. However climate change is causing increase in winter temperatures especially min temperature. Predicted higher winter temperatures could increase the survival of many overwintering species. For example, aphid damage is expected to increase due to earlier aphid activity in the spring, increased development rate, and greater survival over winter. Already serious outbreaks of aphid vectored viruses have been observed following mild winters.



Climate Change Effect causing Diseases (direct and indirect)

Table 1: Some Plant Diseases Influenced by Climatic Variation

Disease	Pathogen	[1]Impact of climate change		[2]Time	[3]Remark	[4]Estimated effect
		Disease establishment	Disease progress			
Root rot	Phytophthoraspp	-	□	-	B/EK	-
Wilt	Erwinia spp.	□	□	□□□	C/GH	+
Powdery mildew	Oidiumspp.	□	□	□	BE	-
Angular leaf spot	Phaeoisariopsis spp.	□	□	-	BD/E	-
Early blight	Alternariaspp.	□	□	□	AB/EL	-
Late blight	Phytophthora spp	□	□	□	BD	-
Collar rot	Phytophthora spp	□	□	-	AB/KN	-
Apple scab	Venturia spp.	□	□	-	B/EM	-
Soft rot	Erwiniaspp.	-	□	-	AB/LM	+
Black rot	Botryoshpaeria spp.	□	□	-	B/EM	-
Bacterial blight	Xantomonasspp	-	-	-	D/EFM	0
White rot	Selerotium spp	-	□	-	A/EK	-
Common smut in corn	Ustilagospp	□	□	□□□□	FL	++
Ear rot in corn	Fusariumspp	□	□	□□□	B/FL	+
Grey leaf spot	Cercosporaspp	□	□	□□□	B/EM	+
Stalk rot in sweet corn	Fusariumspp	□	□	□□□	B/L	+
Bean yellow mosaic virus	Virus	□	□	-	C/HIO	++
Aster yellow in carrot	Phytoplasma	□	□	-	BC/GIJ	+
Basal rot in onion	Fusariumspp	□	□	-	A/F	+
Damping off in onion	Fusariumspp	□	□	-	ABC/G	+
Pink rot onion	Phomaspp	□	□	-	A/FGH	+
Verticillium wilt in potato	Verticilliumspp	□	□	□	A/G	+
Common scab on potato	Streptomyces sp	-	□	□	BD/K	+
Potato leaf roll virus	Virus	-	□	□	BC/HI	++
Cucumber mosaic virus	Virus	□	□	-	C/GHI	++
Powdery mildew in apple	Podosphaeraspp	□	□	-	B/FL	+
Powdery mildew in grape	Uncinulaspp	□	□	-	F	+
Powdery mildew in strawberries	Sphaerothecaspp	□	□	-	B/F	+
Root lesion in strawberries	Pratylenchusspp	-	□	-	A/G	+
Anthracnose in turf	Calletotrichum-spp	□	□	-	B/G	+
Brown patch in turf	Rizoctoniaspp	-	□	-	B/GF	+
Common rust	Pucciniaspp	□	□	-		+
Maize dwarf mosaic virus	Virus	□	□	□	P	++

1 "□" = Anticipated increase, "□"= decrease and "–"= no change.

2 Anticipated effect of increased growing season length on disease.

3 Reason(s) for anticipated effect:

4 Net anticipated effect on a particular plant disease. From a significant increase (++) to a significant decrease (--) in importance (--, -, o, +, ++).

A. Initial or primary inoculum is soil borne and expected to remain at the same levels, or possibly decrease, due to milder winters, longer growing season, and increased microbial competition.

B. Initial or primary inoculum is debris borne or survives on host and is expected to increase due to increased survival over milder winters.

C. Initial or primary inoculum is insect borne and is expected to increase due to increased survival of insect vectors.

D. Initial or primary inoculum is introduced each year from outside sources i.e., seed borne, airborne. The influence of climate change is difficult to assess without knowledge of the pathogen, host, and source of inoculum.

E. Warmer and/or drier growing season slows rate of disease progress.

F. Warmer and/or drier growing season increases rate of disease progress.

G. Increased severity of disease symptoms due to stress of drier and/or warmer summer growing conditions.

H. Increased survival of insect vectors due to milder winter.

I. Increased rate of development of insect vectors due to warmer temperatures.

J. Earlier introduction of vectors or pathogens from southern regions.

K. Reduced soil moisture due to increased evapo-transpiration, sporadic precipitation, etc., affects pathogen.

L. Increased wound sites on hosts due to increased extreme weather events (i.e., thunderstorms, high winds, hail) and /or increased insect damage increases infection sites.

M. Reduced disease development and spread due to decrease in rain and/or length of time of leaf wetness.

N. Fruiting bodies on trees have a longer active growth period in both fall and spring, hence more primary inoculum.

O. On non-woody perennials, pathogens have longer to grow on roots or overwintering leaves so more damage and perhaps increased primary inoculum in spring.

P. Due to drought stress.

Q. Due to increase rains in summer.

DISCUSSION POINT

What are the common pest occurrences in Agriculture and Horticulture crops and how participants relate it to climate change?.

SESSION- 3 Integrated Pest Management Strategies for Climate Smart Agriculture

OBJECTIVE

- To enhance understanding about Integrated Pest Management and its advantages
- To have better understanding of SOP to diagnose pest and diseases problems in the crops to take appropriate remedies

FACILITATION

STEP 1 Introduce handouts through an organized power point presentation. This would Include the objective of the session and the process the facilitator will take to deliver the session.

STEP 2 Empasize the importance of all participants of having common understanding of Integrated Pest Management (IPM). Facilitataor will ask participants if they use this practice.

STEP 3 Session will start with explaining about the Integrated Pest Management (IPM) and how useful it is for Agriculture and Horticulture crops.

STEP 4 Facilitator will discuss major diseases and pests in the crops and how to control them using Integrated Pest Management (IPM)

MATERIAL REQUIRED

PowerPoint presentation, relevant handouts, chart paper, markers, tape, projector to play videos

TIME

30 Minutes

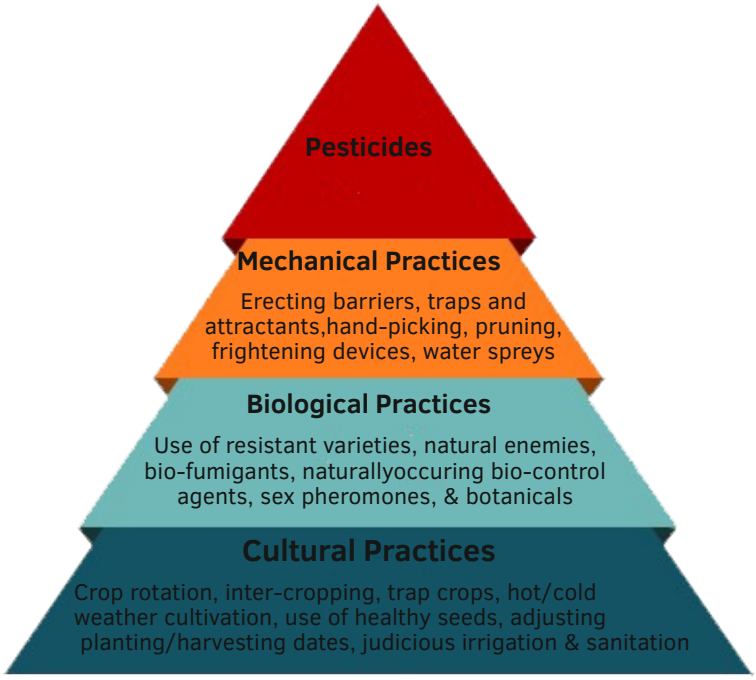
IPM STRATEGIES

S 3

Integrated Pest Management Strategies for Climate Smart Agriculture

What are the drought resilient varieties and cropping pattern and how these helps?

Integrated Pest Management (IPM) is an eco-friendly approach which aims at keeping pest population under control by using multiple methods and techniques available for pest control such as cultural, mechanical and biological with emphasis on use of bio-pesticides and pesticides of plant-origin like Neem formulations. The use of chemical pesticides is advised as a measure of last resort when pest population in the crop crosses economic threshold levels.



Integrated pest management approach

ADVANTAGES OF IPM

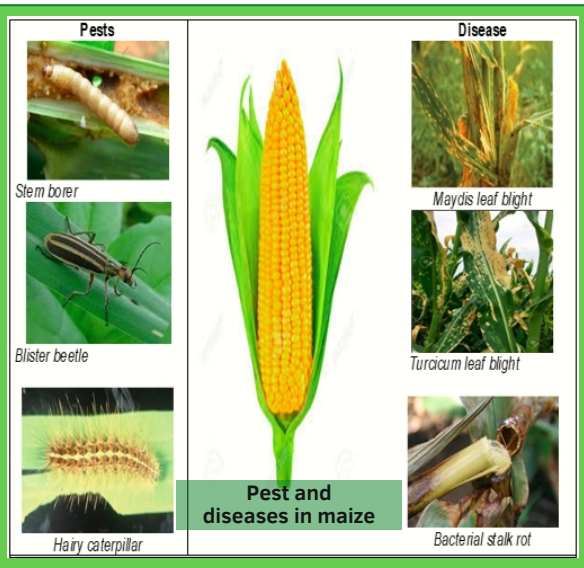
IPM was initially conceived as a response to world-wide pest problems due to excessive use of chemical pesticides and increasing rates of pest resistance to those chemicals. Thus, a major focus in IPM remains on the biological control measures for pest management, however lower costs of IPM, as compared with conventional pest control, are of economic significance both for marginal farmers and for countries where governments cores on pesticide subsidies. At the same time, health implications of excessive use of pesticide have been alarming. While the economic implications of IPM is yet to find its rightful place, IPM offers profound environmental significance for directly improving water and air quality for reducing pesticide use in agriculture. From the perspective of rural development, IPM can play an important role in the process of local (village) self-reliance.

KNOWING THE PROBLEM

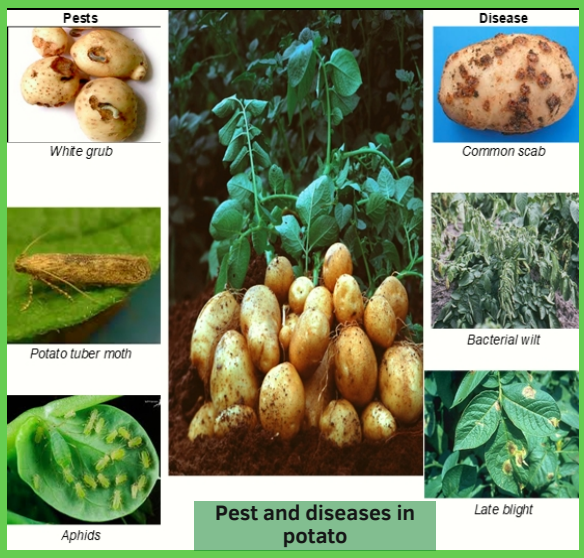
However before taking action to control pests and diseases it is very important to make sure that, the problem is correctly identified. Only then you can hope to succeed. Knowledge of pests and diseases will help you decide whether the problem is caused by a pest, a disease, a mineral deficiency in the soil or an environmental factor. Proper identification should be the first step in controlling the problem and more importantly, in preventing it from happening again.

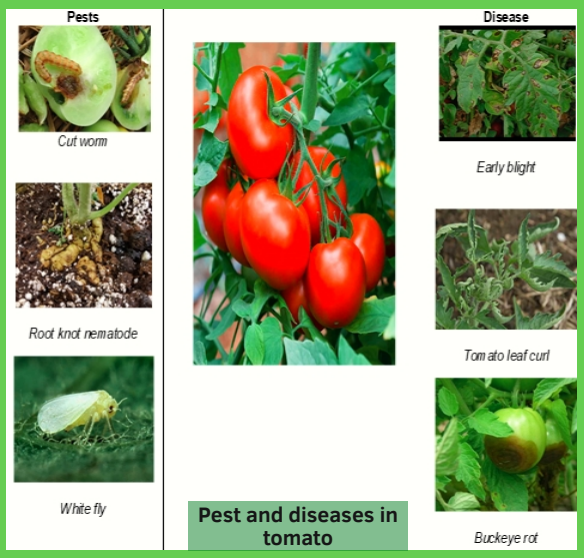
Crop	Major Disease	Major Insect Pest	Nematode	Weed
Maize	Brown stripe downy, bacterial stalk rot, brown spot, banded leaf and sheath blight, Turcicum leaf blight, Maydis leaf blight	Stem borer, Hairy caterpillar and Grass hopper, Cut worm and white grub and Blister beetle	Cyst nematode	
Wheat	Yellow rust, black rust, brown rust, karnal bunt, loose smut and covered smut, powdery mildew	Termite, leaf hoppers, wheat Aphid, army worm, pod borer, Pink stem borer		
Rice	leaf blast, neck blast, false smut sheath blight, brown spot, bacterial leaf blight, sheath discoloration, sheath rot etc -	leaf hopper, case worm, chaffer beetles, rice hispa, stem borer and leaf folder etc.		
Potato	Late and early blight of potato, pink rot, common scab, bacterial wilt, viral diseases -	White grub, cut worm, aphids, potato tuber moth, white fly, leaf hoppers		
Tomato	Early blight, late blight, tomato leaf curl, bacterial wilt, buckeye rot	Fruit borer, fruit flies, cut worm, root	knot nematode, white flies	
Apple	San Jose scale, wooly apple aphid, blossom thrips etc. - collar rot apple scab, sclerotius blight, crown gall , cankers or black rot etc.			

Table 2: Major disease/ pest incidences in field and horticulture crops


Pests
Disease
Stem borer
Blister beetle
Hairy caterpillar
Maydis leaf blight
Turcicum leaf blight
Bacterial stalk rot
Pest and diseases in maize


Pests
Disease
Leaf hopper
Pink stem borer
Army worm
Yellow rust
Karnal rust
Powdery mildew
Pest & Diseases in Wheat


Pests
Disease
White grub
Potato tuber moth
Aphids
Common scab
Bacterial wilt
Late blight
Pest and diseases in potato


Pests
Disease
Cut worm
Root knot nematode
White fly
Early blight
Tomato leaf curl
Buckeye rot
Pest and diseases in tomato


Pests
Disease
san joes scale
Codling moth
Woolly aphid
San jose scale
Codling moth
Woolly aphid
Pest and diseases in apples

CULTURAL & BIOLOGICAL PRACTICES AS PREVENTIVE MEASURES

1. General approach

The following is a general approach to natural pest and disease control with specific examples.

(I) A Healthy Soil

Crops grown on healthy soil will be much more resistant to pests and diseases. The soil should be managed to maintain its structure, fertility and soil microbes through regular input and recycling of organic residues in the form of animal manures and plant remains. Whilst **chemical fertilizers** appear to improve plant growth, their use can also **have negative effects**. A plant may look healthy but, because of the high content of nitrogen given by the chemical fertilizer, causing fast sappy growth, it is very attractive to pests. It has been observed that aphids lay double the number of eggs on plant grown with chemical fertilizers compared to organically grown plants.

(II) Good hygiene

If infected plant material, live or dead, is left lying around, pests and diseases can be passed on to future crops. Debris should be cleared up and disposed off. This can be done by composting the debris. The **composting process will kill some pests and diseases** and produce compost which is a good soil improver and fertilizer. However, some diseases may survive after being composted. If in doubt, the infected material should be burnt.

(III) Tolerant varieties and maintaining genetic diversity

Within a single crop there can be many differences among plants. Some may be able to tolerate particular disease and these plants are mostly in the traditional crops grown by farmers. These have been grown and selected over many centuries to meet the requirements of the farmer. Although many of these are being replaced by modern varieties, seeds are often still saved locally. Crops which have been bred by modern breeding methods tend to be very similar and if one plant is susceptible to a disease, all the other plants are as well. Although **some new modern varieties may be very tolerant to specific pest and diseases**, they are often less suited to the local climate and soil conditions than traditional varieties. It can, therefore, be dangerous to rely too much on them. A wide variety or "genetic diversity" between the plants within a single crop is important. This helps the crop to tolerate pests and diseases and acts as an insurance against crop failure in an unusual weather such as drought or flood.

(IV) Inter-cropping

Following good intercropping practices reduces the crop pest outbreaks by increasing the predator biodiversity. Also **avoiding mono cropping will control and manage the biological dispersal of pest organisms through the crop**. Intercropping systems for insect pest control includes the planting of a crop that has a repellent effect, an attractant effect, or a combination of the two, on a targeted insect in close proximity to a crop that has the potential to be attacked by the insect.

(V) Trap cropping

A system that uses an attractant crop planted close to the production crop is called trap cropping. The plant that is used as an intercrop (trap crop) is more attractive than the production crop to the insect, so the insect is drawn to the trap crop. In conventional systems, insecticides can be applied to the trap crop alone, reducing the need for pesticide use on all acres.

(VI) Crop rotation

Growing the same crops in the same site year after year can build up pests and diseases in the soil. These will transfer from one crop to the next. Crops should be planted in a different piece of land each year, and not return to the original site for several years. For vegetables a 3 to 4 year rotation is usually recommended as a minimum. **Crop rotation also helps a variety of natural predators to survive on the farm**. A typical four year rotation would include a cycle as follows; year one maize and beans; year two a cereal; year three a root crop and; year four either green manure or improved fallow.

(VII) Social prevention

It may be necessary to work with surrounding farmers to destroy a pest. For example, the variegated grasshopper (Zonocerus variegates), usually has 1 or 2 nests per hectare. These can be destroyed by raking out the eggs from the nest and leaving them in the sun to dry out and die. The nest could be on another farmer's farm but it could affect your crops. Joint action and cooperation between all farmers could considerably reduce infestation.

(VIII) Mechanical Practices

Traps and attractants

Many chemical and visual lures attract insects and can be used to monitor or directly reduce insect populations.There are several types of traps:

- Light traps attract nocturnal flying pest insects.
- Pitfalls catch creeping insects and slugs.
- Sticky traps, e.g. of a colour attracting a certain pest insect.
- Pheromone traps release a sex-hormone of the female insect, thus attracting the males which get stuck in the trap. and diseases, they are often less suited to the local climate and soil conditions than traditional varieties. It can, therefore, be dangerous to rely too much on them.

Crop	Major Disease	Major Insect Pest	Nematode	Weed
Maize	Brown stripe downy, bacterial stalk rot, brown spot, banded leaf and sheath blight, Turcicum leaf blight, Maydis leaf blight	Stem borer, Hairy caterpillar and Grass hopper, Cut worm and white grub and Blister beetle	Cyst nematode	

Table 3: Integrated Pest Management Package for Maize

2. Cultural Practices

These are practices that reduce pest establishment, reproduction, dispersal, and survival For example, changing irrigation practices can reduce pest problems, since too much water can increase root disease and weeds.

More cultural control practices are discussed below:

- Proper seed bed preparation, planting seed in warm, fairly moist soil
- Use certified seeds and eliminate light weight, chaffy, injured seeds
- Seed treatment with seed dressing insecticides to protect the seedlings at primary growth stage from sucking pests
- Pre pone or postpone of planting/sowing time of crop to minimize crop weed competition.
- Inter-cropping or mix cropping with legume reduces borer incidence. Maize-Mash, Maize-sorghum or late sown variety of wheat,Maize-Soybean/Maize-Cowpea/ Maize-Green gram are some of the good examples.
- Adoption of crop rotation practices
- Use of well decomposed farm yard manure reduces termite attack.
- Balanced use of fertilizers and supplement of micronutrient.
- Proper water management practices to avoid foot rot.
- Avoidance of moisture stress at the time of flowering to grain filling stage
- Use of pest resistant varieties

3. Biological Practices

This involves the use of predators, parasites and diseases of pests in a targeted way to suppress pest populations. Biological control agents like egg parasitoids, larval parasitoids and predators should be used regularly to keep the pest population under control. It's like matkakhad, Jivamrut / Leaf extracts etc. as per locally available resources which enhance the soil system and keeps pests at bay. More Biological Control practices are discussed below:

- Use certified seeds of recommended verities having built-in mechanisms for resistance of local pest problems.
- Soil application of neem cake for control of nematode and chaffer beetle
- Conservation of naturally occurring biocontrol agents such as Trichogrammachilonis Ishii., Cotesiaflavipes Cameron, Carabids, Coccinellids, Chrysoperla, spiders and wasps, etc. and by reducing chemical pesticides.

4. Mechanical Practices

These methods prevent the pest access to the host or area, or, if the pests are already present, physically removing them by some means. More mechanical control practices are discussed below

- Use of bird scarer prevents seed damage.
- Manual collection and destruction of white grub and chaffer beetle during adult emergenceperiod reduces the pest population
- Use of pheromone trap
- Set up light traps
- Stripping of 2 lower leaves along with leaf sheath
- Destroy infected plants & alternate host

5. Chemical control

Use of chemical pesticides is the last resort when all other methods fail to keep the pest population below economic loss. Use of pesticides should be need based, judicious, based on pest surveillance and economic threshold level (ETL). This helps minimize not only the cost involved, but also to reduce associated problems. While going for chemical control, we must understand thoroughly what to spray, when to spray, where to spray and how to spray, keeping in mind following points:

- Relatively safer pesticides e.g. neem based and bio-pesticides as judicious application of pesticides ismost important component of IPM.
- Seed treatment to minimize fungicide use at the later stage
- Foliar Spray- If pest is present in strips or isolated patches, whole field should not be sprayed.

6. Crop Stage-wise Integrated Pest Management Practices

Stage	Problem	Pest/ pathogen	Practices
Pre-sowing	Resting stage of insect, fungi, mycelia, conidia,thick walled sporangia & other resting spores	Pathogens like species of Fusarium, Rhizoctonia,Penicillium, Aspergillus,Pythium, Acremonium, Cephalosporium, Helminthosporium,white grub	● Adoption of crop rotation ● Clean plow down of crop debris and destruction of crop residue ● Deep summer ploughing followed by fallowing ● Selection of tolerant varieties ● Collection and destruction of white grub stages
Seed & Seedling	Seed & Seedling blight	Pathogenslike - pythium,Fusarium, Acremonium, Penicillum, Rhizoctonia,Macrophomina, Sclerotiumetc.	● Eliminate light weight, chaffy, injured seeds ● Use certified seeds ● Proper seed bed preparation, planting seed in warm, fairly moist soil ● Seed treatment
Vegetative & foliar Pest / Diseases	Stem borers, Aphids, Thrips,Termites, Turcicum leafblight, Maydis leafblight, Common rust,Brown spot	Pathogens like- Helminthosporium, Puccinia,Curvularia&Physoderma	● Removal and destruction of dead hearts ● Release of Trichogrammachilonis ● Granular application of Carbofuran
	Banded leaf sheath blight	Rhizoctoniasolanif. sp.sasakiiExner	● Stripping of 2 lower leaves along with leaf Sheath ● Seed treatment
	Commonrust,	Pucciniasp	● Spray of Mancozeb ● Three sprays of fungicide at 15 days interval, if needed
	Brown stripedowny mildew	Sclerophthorarayssiaevar. ZeaePayak andRenfro	● Planting before rainy season begins. ● Resistant varieties ● Seed treatment with fungicide
	Bacterial stalk rot	Erwiniachrysanthemip.v. eae(Sabet) Victoria,Arboleda& Munoz.	● Avoidance of water logging ● Field should have proper drainage ● Planting of the crop on ridges rather than flat soil ● Avoid use of sewage water for Irrigation
	CystNematode		● Deep summer ploughing ● Use of non-cereal crops like vegetables, oilseeds and pulses etc ● Use of resistant varieties ● Combined application of mustard cake and tobacco dust ● Application of neem cake

Table 4: Stage-wise Integrated Pest Management

7. Pest Resistant Varieties[2]

[2]*Refer to module 1 for pest resistant crop varieties*

SESSION- 4 Zero Budget Natural Farming

OBJECTIVE

- To understand the general principles of Zero Budget Natural Farming and major pest management methods under Zero Budget Natural Farming

FACILITATION

STEP 1 Introduce handouts through an organized power point presentation. This would include the objective of the session and the process the facilitator will take to deliver the session.

STEP 2 Emphasize the importance of all participants of having some understanding of Zero Budget Natural Farming and it's usefulness

STEP 3 Facilitator will describe what Zero Budget Natural Farming is. What are main components of Zero Budget Natural Farming. How it is used for pest management.

MATERIAL REQUIRED

Power point presentation, relevant handouts , chart paper, markers, tape

TIME

15 Minutes

ZERO BUDGET NATURAL FARMING

S 4

Zero Budget Natural Farming

Zero Budget Natural Farming means for all the crops production cost will be zero. In the Zero Budget Natural Farming we have not purchase anything from the outside, farming practice that believes in natural growth of crops without adding any fertilizers and pesticides or any other foreign elements. Our soil is prosperous-full of nutrients and all required things for the growth and development of the plant are available around the root of the plants, there is no need to add anything from outside. That means nature had supplied all the nutrients needed for the plant. The inputs used for seed treatments and other are locally available in the form of cow dung and cow urine. It is assumed that one Desi Cow is enough to enrich 20 acre of agriculture land.

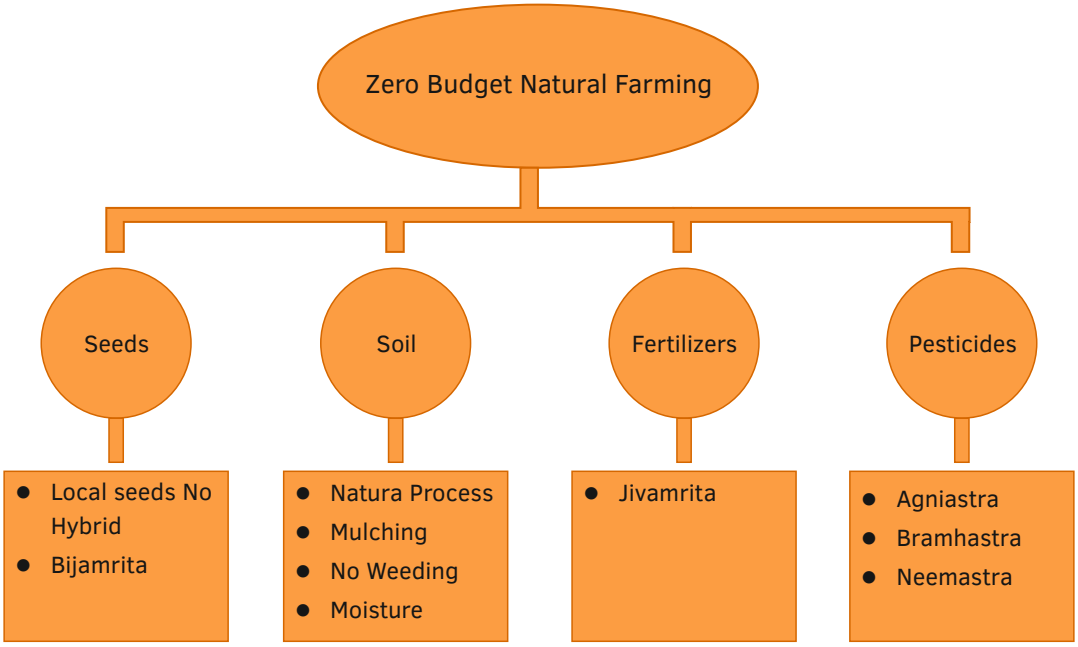
Application of ZBNF bringing down the cost of agriculture processing production, and producing of high yield sustainable zero agriculture practices. Such initiatives will develop win- win situation to the farmers.

1. Principles:

- No purchasing and pouring chemicals fertilizers, use natural fertilizers to make soil healthy initially
- No need to use hybrid seed and advance technology viz. heavy tractors.
- No need to use of pesticides and insecticides, use natural replacements for pesticides required.
- No flooding irrigation required under ZBNF
- Understand and use intercrop ecosystem to benefit from it

2. Objectives

- To promote climate resilient zero budgeting natural farming
- To double the agricultural productivity and incomes of small-scale farmers by reduce exposure to climate-related extreme disasters
- Ensure sustainable food production systems and implement resilient practices that increase productivity.
- To improve the soil fertility, soil porosity, water infiltration and water holding capacity.
- Minimizing release of hazardous chemicals into soil, water and air their impacts.



Components of ZBNF

3.Jivamrita

Jivamrita is a fermented microbial culture prepared from locally available natural resources for the purpose of being applied to the soils/plants at different stages of their growth. It provides nutrients, most importantly acts as a catalytic agent that promotes the activity of microorganisms in the soil, as well as increases earthworm activity. The 48 hour fermentation process multiplies aerobic and anaerobic bacteria present in the cow dung and urine, as they eat up organic ingredients, and a handful of undisturbed soil acts as inoculate of native species of microbes and organisms.

Preparation of Jivamrita

- Material Required

Water	40 liters
Local Cow (Desi Cow) dung	2 Kg
Cow Urine	1.5 Liter
Jaggery (a local type of brown sugar)	250 gram
Pulse flour (Baisan)	250 gram
Soil from farm (MeidhakiMiti)or forest	Handful (ekmuthi)

Table 5: Material required for1 Bigha land

- How to prepare jivamrita:

Put 40 liters of water in a tub; Add 2 Kg local cow dung and 1.5 ltrs.old cow urine; Add 250 gram of Jaggery (a local type of brown sugar), 250 gram of pulse flour (Baisan) and 1fist (ekmuthi) of soil. Stir the solution well and let it ferment for 72 hours in the shade. In the evening and morning for 2 -2 minutes stir slowly in one direction. Now Jivamrita is ready for application. 40 liters of Jivamritais sufficient for one Bigha of land

- Jivamritha Application

The application of Jivamrita acts as a preventive measure against fungal and bacterial diseases. It can be applied through irrigation water or through foliar spray. Jivamrita is only needed for the first 3 years of the transition, after that system becomes self-sustaining.

4.Bijamrita

The Bijamrita also prepared from locally available natural resources for the treatment for seeds, seedlings. The planting material needs to dip in the Bijamrita, take out for planting.It reduces the possibility of seed infestation by pests and protecting young roots from fungus and other soil-borne pathogens.

Preparation of Bijamrita

- Material Required

Water	4 liters
Local Cow (Desi Cow) Dung	1 Kg
Cow Urine	1 Liter
Lime (Chuna)	10 gram
Soil from farm (MeidhakiMiti) or forest	Handful (ekmuthi)

Table 6: Material Required for 20 Kg Seeds

- How to prepare Bijamrita:

Put 4 liters of water in a tub, add 1 Kg local cow dung and 1 kg of cow urine, 10 gram of Chunaand one handful of soil from ranch (MeidhakiMiti), stir the solution well and let it ferment for 24 hours in the shade. This is sufficient for 20 Kg of seeds.

- Bijamrita Application:

Add Bijamrita on the spread seeds of any crops, treat these seeds well by hands, dry it well and use for sowing.

5. Mulching

Mulching stops evaporation of soil water.Mulching reduces tillage, suppresses weeds, promotes humus formation and enhances thewater holding capacity of the soil. Mulching enhances the biological activity andreplenishes the nutrient base of the soil. Adequate mulching keeps the top and sub soilmoist and enhances the water holding capacity of the soil and also reduces water loss due to evaporation so that the crop will be better equipped to tide over drought conditions.

Mulching

There are three types of mulching methods which will help in enriching of soil components.

- Soil Mulching

This protects topsoil by avoiding tilling. It promotes aeration and improves water holding capacity of the soil, advised to avoid of deep ploughing

- Straw/Biomass Mulching

The straw material refers to waste dried biomass of previous crops left in the field.It can be composed of the dead material of any living being (plants & animals etc.). Through the activity of the soil biota and application of Jivamrit the dry organic material will lead to decomposition and humus formulation that will improve the soil fertility.

- Live Mulch (symbiotic intercrops and mixed crops)

It is important to develop multiple cropping and mix cropping systems by combining monocots (those seedlings with one seed leaf like rice and wheat) with dicots (those seedlings with two seed leaves like legumes) in the same field to supply all essential elements to the soil and crops. For instance, pulses helps in atmospheric nitrogen fixation however rice and wheat, Maize supplies other elements like potash, phosphate and sulphur.

6. Moisture / Waaphasa:

Moisture is the both air molecules and water molecules present in the soil, and roots need is water vapour.It analyses the rational that plants require more water and irrigation, rather, it calls for a drop in water usage and by saying "more crop per drop."

Moisture /Waaphasais that microclimate in the soil, by which the soil organisms and roots can live freely with availability of sufficient air and essential moisture. Moisture is the mixture of 50 % air and 50 % water vapours in the cavities between two soil particles. 92 % microorganisms and 88 to 95 % root hairs are working in the upper most 10 cm surface soil, so, the air must be circulating in this surface layer and vapour molecule must be available in this 10cm surface layer. This will happen when we give water outside the canopy of the plant. The outside shadow of the plant at 12 o'clock then only moisture willsbemaintained. The roots that take water are situated at the outer canopy.

7. Other Important Methods of Zero Budget Natural Farming

(I) Intercropping / Multi cropping/Mix Cropping

Intercropping, multi cropping or mixed cropping are the cultivation of two or more crops in proximity in the same field, during a growing season, to promote interaction between them. Natural farming enhances the use of the soil and its nutrients through these practices, for instance, long life-span species (viz. chikoo, coconut, and mango) with short life-span species (viz. various vegetables, leguminous, medicinal and aromatic plants) and medium life-span species (viz. banana, papaya). The diversification of crops has to be decided according to the area and agro-climatic conditions.

Multi cropping is a good way to minimize the risks for the farmer who could get yield throughout of the year. Supplementary advantages of intercropping are the limitation of outbreaks of crop pests (some plants act as natural pesticides against other crops' pests) however rotation protects against endemic pests, provide better and richer nutrition to the crops.Through mix cropping, cultivation of diverse species practice farmers can enhancing the income level.

(II) Contours and bunds

To preserve rainwater contours and bunds promote maximum efficacy for different crops.

(III) Local species of earthworms

Revival of local deep soil earthworms through increased organic matter.

(IV) Cow dung

Cow dung of Bosindicus(humped cow) is most beneficial and has the highest concentrations of micro-organisms as compared to European cow breeds such as Holstein. The entire ZBNF method is focused on the Indian cow, which historically has been part of Indian rural life.

8. Pest Control management under Zero Budget Natural Farming

Major pest management methods under ZBNF are given below:

S.No.	Name of Pest Management	Compositions	Controls
1.	Agniastra	Required 10(L) of Cow Urine, 1 kg Tobacco, 500g Green Chilli, 500 g Local Garlic, 5 kg Neem Leaves Pulp (crushed in cow urine), for spraying 2(L) Agriastra is taken in 100 (L)water	It is effective for the pest like Leaf Roller, Stem Borer, Fruit Borer, Pod Borer.
2.	Brahmastra	It is prepared by Neem Leaves, Custard Apple Leaves, LanternCamellia Leaves, Papaya Leaves, and White Dhatura Leaves crushed and boil in cow urine	It is used to control all the sucking pests. Pod borer, fruit borer etc.
3.	Neemastra	It is made up of local cow urine 5l,cow dung 5 kg, Neem Leaves and Neem Palp 5 kg fermented for 24 hours.	Used for sucking pests, Mealy Bugs etc.

Table 7: Name, Components, pest management

EXERCISE

1 Due to abnormally cold and wet conditions, the chances of insect infestation increases.

TRUE FALSE

2 Continuous application on pesticides will not lead to development of resistance to pastiche among the insects.

TRUE FALSE

3 Integrated Pest Management is

A. An eco friendly method of keeping the pest population under control
B. A method to emphasize on the use of Bio Pesticide
C. A method where chemical pesticides are used intensively
D. A Water retention technique

4 When should we use chemical pesticide?

A. when the population level of pest is very high
B. Never use it as it is harmful for the soil quality
C. None of the above
D. Both A and B

5 What are the ideal climatic requirements for the disease outbreak in different crops?

A. High moisture content
B. Warmer temperature
C. Increased Precipitation
D. All of them

EXERCISE

6 What is the major infestation causing pests for Wheat crop?

- **A** Termite
- **B** Cutworm
- **C** Army worm
- **D** Blister beetle

7 What is the major infestation causing pests for Maize crop?

- **A** Stem Borer
- **B** Leaf hopper
- **C** Cut worm
- **D** White fly

8 What are the mechanical practices that can be used for pest control?

- **A** Use of scarecrow to prevent seed damage
- **B** Set up light traps
- **C** Application of Neem Cake for nematode control
- **D** All of the above

9 Mulching helps in increasing the aeration and improve the water holding capacity in soil?

TRUE **TRUE**

10 To make Jivamrita to be used in one Bigha land following materials are required (quantity wise) Tick (□) the correct options.

- **A** Desi Cow dung (2kg)
- **B** Pulse flour (250g)
- **C** Cow Urine (3 L)
- **D** Base Flour, basen (400g)
- **D** 40 liters of Water

EXERCISE

11 The principles of Zero budget farming are-

A Usage of chemical fertilizers

B Using natural farming practice

C Using flood Irrigation system

D Not using heavy machinery such as tractors and hybrid seeds

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