UNITE for the Environment

Sustainable Agriculture

Weed, Pest and Disease Control

2nd Term Teacher Training

2018

Training objectives; By the end of the training,

- Participants will justify the use of organic means to control pests, diseases and weeds in farming.
- Participants will be able to prepare an organic pesticide/medicine to use in sustainable agriculture.
- Participants will be able to come up with teaching activities that are focused on enabling more student interaction and critical thinking.

Introduction

Disease, pest and weed control in sustainable agriculture usually involves management.

Management is long term and focuses on keeping existing pest populations, weeds and diseases low. Regular monitoring of pests, diseases and weeds is one of the bases for effective management. The management approach in sustainable agriculture is to deal with the causes of a problem rather than waiting to treat the symptoms.

Control is a short term activity and focuses on killing pests, weeds and treating diseases.

Both management and control include biological, mechanical, cultural and chemical methods and some of the activities support each other.

There are different methods used to control pests, diseases and weeds. These are:

Cultural control means changing the environment. Cultural control methods include crop rotation, managing the soil for optimum soil health, and choosing resistant varieties to pests and diseases.

Mechanical control means physical objects such as traps, machines, and our hands. Plowing and tillage of the soil, uprooting, might be used to control pests and diseases. Traps are also used for monitoring insects and catching pests.

Biological controls are natural enemies of the pests, such as animals and other creatures. In agriculture, that can be predators like lady beetles and lacewings, or parasites like wasps can help especially in managing pests. Growing cover crops can help reduce weeds.

Chemical controls are poisonous to the pests, diseases and weeds, such as sprays, dusts, and baits. Pesticides are sometimes used to control various pests to crops while herbicides are commonly used to control weeds.

ACTIVITY: IDENTIFYING THE ISSUE AFFECTING A CROP

Introduction

When crops are affected by pests, diseases or weeds, they do not look like those which are healthy (free from pests, diseases and weeds). In addition, crops affected by weeds, pests and diseases may not look the same and even crops affected by different pests and diseases have different symptoms.

When addressing different issues, different approaches can be used.

Procedure

1. Divide participants into 14 groups and distribute to each group a picture of a crop.

- Affected by a pest e.g. cutworm
- Affected by a pest e.g Banana Weavil
- Affected by a fungal disease e.g. leaf blight
- Affected by a mammal e.g. a goat, cow, rat
- Affected by a viral disease e.g. tomato mosaic
- Affected by bacteria e.g. bacterial wilt
- Which is normal/ healthy

Note: Every two groups will have a similar picture

2. Ask each group to observe the crop in their photo and tell what plant is in their photo and whether it is healthy or not.
3. If the crop is not healthy, ask the group to discuss and list the signs and symptoms observed and identify what the issue is what might have caused this? Is it a pest or a disease, is it a fungal, viral or bacterial disease (they may be given tips if they get stuck)
4. Ask the group to discuss what control methods can be used to address the issue.
5. Have groups share their ideas and observations.

Discussion

- Different groups will most likely have different control methods. As a group discuss which methods suit sustainable agriculture and which ones may not.
- Introduce and discuss the pros and cons of using organic control methods vs inorganic/chemical methods.

These may include:

- Organic methods do not cause human diseases as opposed to chemical methods which can cause nervous system diseases, reproductive problems and cancer.
- Organic methods preserve the soil while most chemical methods can damage the agricultural land by harming the beneficial insect species, the soil microorganisms, and the

worms which naturally maintain the soil fertility and health. They also reduce the concentrations of plant nutrients in the soil such as nitrogen and phosphorous.

- Organic methods are environmentally friendly while agrochemicals contain toxic substances, which when released into our environment can kill living things. They kill plants, insects, fungus, rodents and others. For example agrochemicals kill bees, butterflies and other insects which play an important role in the plant cycles and evolution especially through pollination.
- Chemical methods weaken the plant root systems and the immune systems.
- Most agrochemicals especially herbicides cause human poisoning through ingestion, inhalation and dermal absorption. Symptoms vary according to the substance, but include skin irritations and gastrointestinal discomfort.
- Organic methods such as mechanical techniques are very selective and therefore non targeted species (those one does not wish to harm) are not affected while most chemicals especially herbicides are non-selective. This means they kill all types of vegetation, not just weeds.
- Most organic methods do not have lasting effects on the soil and environment in general as opposed to agrochemicals which persist in the soil long after they are applied. This can cause lasting effects on future vegetation growth.
- Rain or irrigation can carry agrochemicals into unintended areas. This is problematic when they enter waterways. These can have harmful effects on humans, fish, amphibians and other aquatic life.
- Repeated use of specific herbicides can create weed resistance to the chemical. If resistant, the weeds will no longer respond to the herbicide's active properties which is not common with organic methods.
- Using organic methods especially like weeding doesn't clear the entire vegetation since it is the weeds which are removed however; most herbicides clear the soil's vegetation hence leaving it loose and bare. This exposes the soil to erosion.

Therefore, when practicing sustainable agriculture, controlling pests, diseases and weeds, agrochemical use should be avoided.

ACTIVITY: COMMON WATER (ADAPTED FROM COMMON WATER PROJECT-WET)

Introduction

Water is one of the resources that is affected by use of agrochemicals. It is a limited resource with unlimited demands upon it as it can be used by different people for different purposes. The

purpose of this activity is to illustrate how multiple users of water resources can affect water quality and quantity. The activity also examines the complexities of providing water for all water users. This activity helps students recognize that it is vital for water users to consider each other's needs and to share this limited and valuable resource.

Materials needed

- 1 big container e.g. a basin or an open jerry-can filled with water
- 5 small buckets up to 3 liters (Each bucket should have materials that will influence color e.g. soil once the water is poured)
- 12 labeled water bottles for drawing water

Procedure

1. Ask participants to list major water users in their community and how they use water. After, they may arrange the water users, from those who they think use the most water to those who use the least.
2. Ask the participants what happens when the number of water users increases.
3. Ask participants where they think water goes after it has been used by different people.
4. Select participants to take part in three rounds of simulations to understand evolving demands on the common water supply (If it is a relatively small class, all participants should take part).

The large basin/container of water for each group represents water stored in a reservoir, pond or lake. During each 1 minute round, the participants will distribute water from the container to their own buckets using labeled plastic bottles.

Round 1

It is 100 years ago. A small village is located in the watershed and they use water for domestic use and the farm.

- 1 participant representing an organic farm draws 250 mls
- 1 participant representing domestic use draws 500 mls.

Round 2

It is now 50 years. The size of the village has increased. The population has doubled; additionally there is a hospital and a school.

- 2 participants representing organic farm draws 250 mls each.
- 2 participants representing domestic use draw 500 mls each.
- 1 participant representing a school draws 1 litre.

Round 3

It is the present. The population of the village continues to grow and has once doubled. In addition people have started to use agrochemicals and there is a washing bay.

- 4 participants representing organic farm draw 250 mls each.
- 4 participants representing domestic use draw 500 mls each.
- 1 participant representing agrochemical farm draws 750 mls.
- 2 participants representing a school draw 1 litre each.
- 1 participant representing a washing bay draws 1.5 liters.

Have each group pour half of the collected water in the basin (you may ask the group what they think this means) and observe.

Discussion questions

- At what round was the water quality and quantity affected more and how?
- Are water users in their own community represented by the characters in the simulation?
- Were there any groups who used too much water or did not get enough?
- Were there any groups whose signs (of pollution) were more visible after when half the water in each of the buckets was poured in the basin?
- How do you compare water now and when the activity was starting?
- What is likely to happen in the future?

Link this to how we use water and highlight that once we use chemicals, most of these again end up in the water, which is then consumed by different people and other living organisms from different areas.

Build on this to start a discussion on general organic pest, disease and weed control methods.

PEST ATTACKS ON CROPS

Monitoring is a very important component of sustainable agriculture. Through this, one can quickly know if their crops are affected by pests. It is important to timely notice any pest infestations on the farm as these may cause a very big negative impact in a short period of time. Most crop pests belong to the insects, mites and nematodes. However, in our communities, rats, birds and other animals can also sometimes damage crops.

Insect damage can be categorized by biting and chewing (e.g. caterpillars, weevils), piercing and sucking (e.g. aphids, psyllids) and boring (e.g. borer, leaf miner) species. Some pests are slow moving (e.g. caterpillars), fast moving (e.g. fruit flies), hidden (e.g. stem borer), or easy to observe (e.g. caterpillars, weevils).

Signs of pest attacks on crops

Pest damage is often species-specific. Leaves with holes or missing parts is an indication of caterpillar or weevil damage; curled leaves is an indication of aphids; damaged or rotten fruits are often caused by larvae of fruit flies; withering plants can also be caused by larvae of noctuids (army worms) or the stem borer; and branches or trunks with holes may be an attack by lignivorous insects (Insects that feed on wood).

Colour change: Some pest attacks cause changes in the plant color for example if mites are present on plants, leaves and fruits become yellowish. Mites are very small and cannot be seen with the naked eye. However, some mite species (spider mites) weave a typical tissue on attacked plant parts and can, therefore, easily be detected. Nematodes also cause color change in plants as they mostly attack plant roots; plants become yellow, wither and die. Nematodes are also very small and therefore, they are not easy to observe with the naked eye.

Example of a common pest - Cabbage looper

As the name suggests, this pest attacks cabbage but it can be found on other greens such as broccoli, kale, turnip, mustard, cauliflower, and Brussels sprout. It is tiny and light green with silver markings or ridges and makes a loop when moving because it has only two pairs of legs. It affects crops in the larval form (caterpillar or grub) and also in the adult form (butterfly). It feeds on the leaves, causing ragged holes and other damages that lead to the loss of the crop.

Cabbage looper can be managed through mechanical and physical methods such as crop rotation, squashing the butterfly eggs, and picking off the caterpillars. Concerning crop rotation, introducing lettuce after cabbage can eliminate the pest from the garden.

CROP DISEASES

Most crop diseases are caused by fungi, bacteria or viruses.

Fungal diseases

Fungi cause the great majority, estimated at two-thirds of infectious plant diseases. They include all white and true rusts, smuts, needle casts, leaf curls, mildew, sooty moulds and anthracnose. In addition, they are responsible for most leaf, fruit, and flower spots, cankers, blights, wilts, scabs, and root, stem, fruit, wood rots among many others. They can cause parts of plants or the total crop plant to wither and die.

Example of common fungal disease - Leaf blight /early blight

Common on tomato and potato plants, early blight is caused by the fungus *Alternaria solani*. Symptoms first appear on the lower, older leaves as small brown spots with concentric rings. As the disease matures, it spreads outward on the leaf surface causing it to turn yellow, wither and die. Eventually the stem, fruit and upper portion of the plant will become infected. Crops can be severely damaged.

Leaf blight can be managed by pruning plants to improve air circulation and reduce fungal problems, disinfecting your pruning scissors after each cut, keeping the soil under plants clean and free of garden debris and adding a layer of organic compost to prevent the spores from splashing back up onto vegetation.

Other management methods include, removing and destroying all garden debris after harvest and practicing crop rotation.

Do *NOT* compost infected plants, instead burn them.

Bacterial diseases

Bacteria cause different problems. Some bacteria produce enzymes that breakdown the cell walls of plants anywhere in the plant. This causes parts of the plant to start rotting (known as ‘rot’). Some bacteria produce toxins that are generally damaging to plant tissues, usually causing early death of the plant. Others produce large amounts of very sticky sugars; as they travel through the plant, they block the narrow channels preventing water getting from the plant roots up to the shoots and leaves, again causing rapid death of the plant. Finally, other bacteria produce proteins that mimic plant hormones. These lead to overgrowth of plant tissue and form tumors.

Example of common bacterial disease - Bacteria Wilt

Bacterial Wilt is caused by the pathogen bacterium Ralstonia Solanacearum and is quite common in the moist environments. This bacterium lives in the soil and will work its way quickly through the roots and up the stem of the plants.

Bacterial wilt often happens where plants have been cut, injured or weakened by insects or simply by cultivation. The bacterium clogs up the stem, preventing water and nutrients from reaching the leaves and the plant dies.

The first symptoms are wilting of the youngest leaves, usually during the hottest part of the day. This can easily go unnoticed because the leaves stay green but eventually the entire plant wilts and dies.

Bacterial wilt can be managed in different ways.

When the plants die, the pathogen is released into the soil, so it's imperative that you remove diseased plants immediately. Do not compost the diseased plants.

Also running water can spread the disease to other parts of the garden so practice crop rotation away from host plants which could include all of the nightshades (tomatoes, peppers and eggplants), and potatoes.

Try raised beds to improve drainage and control root knot nematodes that weaken plants, leaving them more susceptible to disease.

Space plants far enough apart to provide good air circulation.

Wash your hands after handling infected plants and sterilize any gardening tool that could have been used in infected soil.

Viral Diseases

Viruses mostly cause systemic diseases. Generally, leaves show chlorosis (change in colour of leaves and other green parts). Light green or yellow patches of various shades, shapes and sizes appear in affected leaves. These patches may form characteristic mosaic patterns resulting in general reduction in growth and vigor of the plant.

Careful and continuous monitoring of pest and disease levels during critical times of growth of a crop is the key to successful management. This can be done through regular scouting of the field by the farmer. It helps the farmer to intervene early enough before the pest and/or disease cause significant damage.

Example of a common viral Disease - Tomato Mosaic

Tomato mosaic virus is a serious and extremely contagious disease. Tomato mosaic virus symptoms can be found at any stage of growth and all parts of the plant may be infected. When the plant is severely affected, leaves may look akin to ferns with raised dark green regions. Leaves may also become stunted

Infected plants may have a severe reduction in fruit set and those that do set may be dotted with yellow blotches and necrotic spots while the interior of the fruit is brown. Stems, petioles, leaves and fruit may all show signs of infection.

The disease is spread into the plant through small wounds caused by mechanical injury, insect chewing, and grafting. Leftover plant debris is the most common infection. Tomato mosaic virus of tomatoes can exist in the soil or plant debris for up to two years, and can be spread just by touch –

a gardener who touches or even brushes up against an infected plant can carry the infection for the rest of the day.

In managing tomato mosaic, you should wash your hands with soap and disinfect tools after handling tomato plants to keep the disease from spreading. Treating mosaic virus is difficult and there are no chemical controls, although some varieties of tomato are resistant to the disease. Sanitation is the most important application to practice when controlling the disease. Destroy any seedlings that appear stunted or distorted and then decontaminate tools and hands. Keep the area around the tomatoes weeded and free of plant detritus to minimize areas the disease can harbor. Control insects as well to lessen the chances of contamination. If you spot the disease in your garden, you should immediately dig up and burn infected plants. Don't plant tomatoes, cucumbers or other plants that are susceptible to mosaic virus in that same area again.

GENERAL PEST AND DISEASE MANAGEMENT AND CONTROL PRACTICES IN SUSTAINABLE AGRICULTURE

Ensuring plant health: Farmers practicing sustainable agriculture should create conditions which keep their plants healthy. A healthy plant is less vulnerable to pest and disease infestation. Plant's health is more at risk in monocultures while on-farm diversification provides a balanced interaction between different plants and pests and predators.

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

Compost teas and herbal teas are tools that can be made on the farm to enhance plant health and fertility, and to inoculate the leaves and roots with soluble nutrients, beneficial microorganisms, and beneficial metabolites (products that aid in the growth and development of plants).

Growing of adapted, resistant varieties and safe seeds: It is important to choose varieties which are well adapted to the local environmental conditions (temperature, nutrient supply, pests and disease pressure), as it allows them to grow healthy and makes them stronger against infections of pests and diseases.

It is very important to use planting material from safe sources. Therefore use safe seeds which have been inspected for pathogens and weeds at all stages of production.

Use of suitable cropping systems: For example mixed cropping systems can limit pest and disease pressure as the pest has less host plants to feed on and more beneficial insect life in a diverse system. Crop rotation reduces the chances of soil borne diseases and increases soil fertility.

Green manures and cover crops increase the biological activity in the soil and can enhance the presence of beneficial organisms.

Use of balanced nutrient management and organic matter: Moderate fertilization helps plants to grow steadily and makes them less vulnerable to infection. Too much fertilization may result in salt damage to roots, opening the way for secondary infections. Balanced potassium supply contributes to the prevention of fungi and bacterial infections.

Organic matter increases micro-organism density and activity in the soil, thus decreasing population densities of pathogenic and soil borne fungi. It also stabilizes soil structure and thus improves aeration and infiltration of water. Organic matter also supplies substances which strengthen the plant‘s own protection mechanisms.

Use of good water management: Water logging should be avoided as it causes stress to the plant, which encourages pathogens infections. Avoid water collecting on the leaves, as water borne disease spread with droplets and fungal disease germinate in water.

Selection of optimum planting time and spacing: Most pests or diseases attack the plant only in a certain life stage; therefore it’s crucial that this vulnerable life stage doesn’t correspond with the period of high pest density and thus that the optimal planting time is chosen. Sufficient distance between the plants reduces the spread of a disease. Good aeration of the plants allows leaves to dry off faster, which hinders pathogen development and infection.

Use of proper sanitation measures: Remove infected plant parts (leaves, fruits) from the ground to prevent the disease from spreading. Eliminate residues of infected plants after harvesting.

Promoting natural enemies: The natural enemies of pests are other organisms (fungi, bacteria, viruses, insect predators, and insect parasitoids) which kill pests. Therefore, the organic farmer should try to conserve natural enemies already present in the crop environment and enhance their impact. This can be achieved by minimizing the application of natural pesticides (chemical pesticides are not permitted in organic farming), allowing some pests to live in the field which will serve as food or host for natural enemies, establishing a diverse cropping system (e.g. mixed cropping), and including host plants providing food or shelter for natural enemies (e.g. flowers which adult beneficial insects feed on).

Hedges and flower strips: Most indigenous flowering shrub species are known to attract predators and parasitoids by offering nectar and pollen.

Three to five native flowering plant species can be sown in well-prepared seed beds, arranged in strips of 1 to 3 m on the boundary of the crop field. After flowering, seeds can be collected to renew the strip or create new ones.

Beetle banks: Strips of grass in the neighborhood of crop fields harbor different natural pest enemy groups like carabids, staphylinid beetles and spiders. In order to lower the risk of weeds and plants known as host plants of crop pests and diseases, one to three native grass species can be sown in strips of 1 to 3 m.

Companion plants: Natural pest enemies can also be attracted by companion plants within a crop. These companion plant species can be the same as used in the flower strips. A few (1 or 2 per 10 m^2) flowering companion plants within a crop serve as a 'service station' for natural pest enemies.

Use of natural pesticides: The preparation and use of natural pesticides require some know-how, but not much material and infrastructures. It's a common practice under many traditional sustainable agricultural systems. Some commonly used botanicals are:

- Neem: Neem derived from the neem tree (*Azadiracta indica*) of arid tropical regions, contains several insecticidal compounds. The main active ingredient is azadiractin, which deters and kills many species of caterpillars, thrips and whitefly. Both seeds and leaves can be used to prepare the neem solution. Neem seeds contain a higher amount of neem oil, but leaves are available all year. A neem solution loses its effectiveness within about 8 hours after preparation, and when exposed to direct sunlight. It is most effective to apply neem in the evening, directly after preparation, under humid conditions or when the plants and insects are damp. There exist different recipes for the preparation of a neem solution. Neem seed kernel extract has been tested on cabbage and results have shown very good repelling effect on diamondback moth (*Plutella xylostella*). Pound 30 g neem kernels (the seed of which the seed coat has been removed) and mix it in 1 L of water. Leave it overnight. The next morning, filter the solution through a fine cloth and use it immediately for spraying. It should not be further diluted. Neem cake (ground neem seed or neem kernel powder) has also a considerable potential as a fertilizer and at the same time it will hinder nematode attacks of the crop roots (e.g. tomato). Put neem cake in the planting pit (200g per m2) and mix it with substrate. The neem cake will repel and even kill nematodes and other root pests. Insecticidal agents (azadirachtin) will be translocated to above-ground parts of the plant and help to get rid of pests there.

- Pyrethrum: Pyrethrum is a daisy-like flowering plant. The flower heads are processed into a powder to make a dust (Pyrethrins). This dust can be used directly or infused into water to make a spray. Pyrethrins cause immediate paralysis to most insects. Low doses do not kill but have a “knock down” effect. Stronger doses kill. Pyrethrins break down very quickly in sunlight so they should be stored in darkness. Liquid formulations are stable in storage but powders may lose up to 20% of their effectiveness in one year.
  Pyrethrum powder is made with dried ground flowers. Use pure or mix with a carrier such as talc, lime or diatomaceous earth and sprinkle over infested plants. To make liquid pyrethrum extract (mix 20 g pyrethrum powder with 10 L of water) add soap to make the substance more effective. Strain and apply immediately as a spray. For best effects this should be applied in the evening.
- Chilli pepper: Chillies and capsicum pepper have both repellent and insecticidal effects. To make the chilli extract grind 200 g of chillies into a fine dust, boil it in 4 L water, add another 4 L of water and a few drops of liquid soap. This mixture can be sprayed against aphids, ants, small caterpillars and snails.
- Garlic: Garlic has antifeedant (insect stop feeding), insecticidal, nematicidal and repellent properties. Garlic is reportedly effective against a wide range of insects at different stages in their life cycle (egg, larvae, adult). This includes ants, aphids, armyworms, diamondback moth, whitefly, wireworm and termites. However, garlic is non-selective, has a broad-spectrum effect and can kill beneficial insects as well. Therefore, it should be used with caution. To make the garlic extract, grind or chop 100 g garlic into 0,5 L of water. Allow mixture to stand for 24 hours, add 0,5 L of water and stir in liquid soap. Dilute at 1:20 with water and spray in the evening. To improve efficacy, chilli extract can be added. There are many other extracts of plants known to have insecticidal effects like tobacco (*Nicotiana tabacum*), yellow root (*Xanthorhiza simplicissima*), fish bean (*Tephrosia vogelii*), violet tree (*Securidaca longepedunculata*), and nasturtium (*Nasturtium trapaeolum*) which are traditionally used to control pests in our communities. Anise, chillies, chives, garlic, coriander, nasturtium, spearmint and marigold are known to have a repellent effect on different pest insects (aphids, moths, root flies, etc.) and can be grown as intercrop or at the border of crop fields. Marigold is especially known to deter root nematodes, while neem cake is known to deter mice.

Many plant extracts are known to have fungicidal effects. Onion and garlic are effective against many diseases such as mildew and fungal and bacterial diseases. Mexican and African marigold

act as a crop “strengthener” to help potatoes, beans, tomatoes and peas resist fungal diseases such as mildew. The leaves of pawpaw (*Carica papaya*) and sweet basil have a general fungicidal effect. Many other plant species are known to have fungicidal effects. Traditional knowledge might be of help to amend the range of plant extracts in each region

Besides extractions of plants, there are some other natural pesticides, which are allowed in sustainable organic farming. Although some of these products have limited selectivity and are not fully biodegradable, there are situations, when their use is justified. However, in most cases, the desired effect is best reached in combination with preventive crop protection methods. Some examples are:

- Wood ashes from fire places can be efficient against ants, leaf miners, stem borers, termites and potato moths. Ash should be dusted directly on pest colonies and infested plant parts. The ash will dehydrate the soft bodied pests. Wood ashes are often used when storing grains to deter storage pests such as weevils. In addition, ashes are used against soil borne diseases.
- Acidic clays have a fungicidal effect due to aluminium oxide or aluminium sulphate as active agents. They are used as an alternative to copper products but, are often less efficient.
- Milk has also been used against blights, mildew, mosaic viruses and other fungal and viral diseases. Spraying every 10 days with a mixture of 1 L of milk to 10 to 15 L of water is effective.

WEED MANAGEMENT IN SUSTAINABLE AGRICULTURE

In sustainable agriculture, the management practices aim at keeping the weed population at a level that does not result in economic loss of the crop or harm its quality. The goal is not to completely eradicate all weeds, as they also have a role to play on the farm.

Roles of weeds on a farm include providing cover that reduces soil erosion, maintaining biological diversity in our crop fields, providing habitat for beneficial biocontrol insects and mycorrhiza fungi, serving as a valuable instrument in controlling pests and food for farm animals.

However, weeds may also alter the environment of the crop in a negative way. This is through:

- Competing for food, nutrients and light with grown crops
- Harboring pests
- Building environments which are ideal for easy spread of diseases
- Negatively affecting the quality of harvest

As already discussed, a basic working principle in sustainable agriculture is to prevent problems, rather than to cure them. This applies equally to weed management.

In sustainable agriculture, good weed management includes creating conditions which hinder weeds from growing at the wrong time and in the wrong place and then becoming a serious problem for the crop cultivation.

Competition by weeds doesn't harm the crop throughout the whole cultivation period in the same way. The most sensitive phase of a crop to weed competition is in its early growth stage. A young plant is vulnerable and depends highly on an ideal nutrient, light, and water supply for a good development. If it has to compete with weeds at this stage, the crop may grow weak, which also makes it more vulnerable to pest and disease infections.

Weed competition later in the cultivation period is less harmful. However, some weeds may cause harvesting problems and reduce the crop yield in that way. Therefore, weeds should not be completely ignored after the most critical growth period of the crop, but in general, they become less important.

These considerations should influence the selection and timing of weed management measures. In general, such measures aim at keeping the weed population at a level which doesn't result in economic loss of the crop cultivation or harm its quality.

Several preventive measures may be applied at the same time. The importance and effectiveness of the different methods depend to a large extent on the weed species and the environmental conditions. However, some methods are very effective for a wide range of weeds and are therefore regularly used:

Choice of crops and varieties: Tall crops and varieties with broader leaves will compete better with late occurring weeds than small varieties with narrow leaves. Some varieties will inhibit and suppress weeds while others will tolerate them. For example, there are witch weed (Striga) resistant maize and cowpea cultivars in many countries of Africa, which give better performance at the same level of weeds where other varieties are more affected.

Mulching: The weeds find it difficult to receive enough light to grow and may not be able to pass through the mulch layer. Dry, hardy material, that decomposes slowly, keeps its effect longer than fresh mulch material.

Living green cover: The cover competes successfully against the weeds for light, nutrients, and water and therefore helps to prevent weed growth by winning the competition for resources. The cover crops usually used are legumes, which improves soil fertility on top of suppressing weeds. For example, a ground cover of desmodium (*Desmodium uncinatum*) or silver leaf, inter-seeded among maize, reduces striga weed and fixes nitrogen at the same time.

Crop rotation: Rotation of crops is the most efficient measure to regulate seed and root weeds. Changing the conditions of the crop interrupts the living conditions of the weeds thus inhibiting their growth and spread.

Intercropping (mixed cropping and under-sowing): Intercropping with fast growing weed-suppressive species ("smoother crop" or "living mulch") between rows of main crop species is effective in weed control for example, sowing cowpeas or pumpkins as intercrops in cassava to reduce weed occurrence.

Sowing time and density: Optimum growing conditions enhance the optimum crop plant development and their ability to compete against weeds. Proper crop spacing will ensure that minimum space is available for the growth of weeds and will minimize competition with weeds. This will effectively restrict weed development. In order to apply this approach, the limiting weeds must be known and the seasons in which they occur. A weed calendar of the area or region, if available, might be of help. It will be used to manage weeds in a targeted fashion with proper timing and effect.

Balanced fertilization: This can support an ideal growth of the crop, which promotes the growth of the crop over the weeds.

Soil cultivation methods: This can influence the total weed pressure as well as the composition of weeds. For example, minimum-tillage systems can increase the weed pressure. Because weed seeds can germinate between soil cultivation and sowing of the crop, weed cures before sowing can be effective at reducing weed pressure.

Manual weeding is probably the most important way to reduce weeds. There are different tools to dig, cut and uproot the weeds. On small scale farming, hands can be used while on commercial/ large scale farming, ox-drawn and tractor-drawn tools can be used. Using the right tool can increase work efficiency significantly.

Pasturing: in perennial crops like coffee, mangoes, avocadoes or cocoa, the use of sheep and goats to reduce rampant weed growth is becoming common. In case of cattle, broadleaf weeds tend to predominate due to the cattle preference for grasses. Therefore, it is necessary to rotate with sheep and goats which prefer broadleaves to overcome this selective grazing.

Weeds can be minimized by preventing dissemination of weeds by eliminating them before seed dispersal and preventing insemination of crops by weeds by avoiding the introduction of weed seeds into the fields through tools or animals; and by using only weed free seed material.

With the necessary preventive measures, weed density can be reduced, but it will hardly be enough during the critical periods of the crop at the beginning of cultivation. Therefore, mechanical methods remain an important part of weed management.

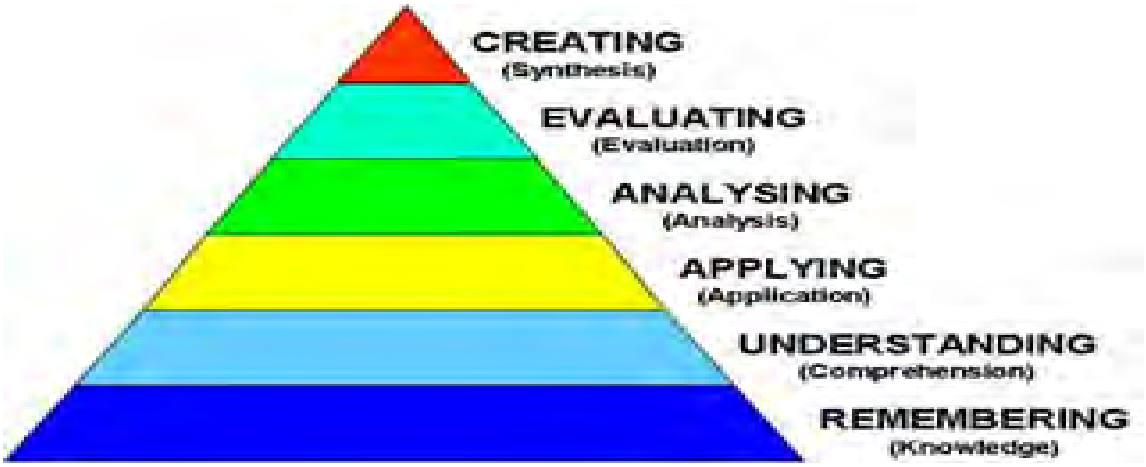
USING HIGH END OF THE BLOOMS TAXONOMY IN CONDUCTING ACTIVITIES

Introduction

Most teachers prefer to use low order teaching which involves teaching within established parameters, without students doing critical examination, challenging or changing the values and assumptions. Low order teaching/learning does not question the 'things', the activities and the assumptions which lead to those activities.

Much as high order learning presents more of a challenge for individual learners and sometimes teachers because it requires them to 'step back' and think about 'how' they are learning as well as the implications of 'what' they are learning, it is known and researched as the best way of learning. This is because it involves critical examination, challenging and sometimes changing values and assumptions. As a result it generates an awareness and understanding that goes beyond knowledge. It is also more likely to create permanent learning and greater retention of ideas.

In Bloom's taxonomy, "analyzing", "evaluating" and "creating" are thought to be of a higher order, requiring different learning and teaching methods, "applying" is viewed as a transitional step from lower level to higher level of level of learning while "remembering", "understanding" are thought to be of a lower order of learning.



1. Remembering/ Knowledge: The individual is able to remember ideas, facts, and theories. No change in behavior occurs at this level as it simply indicates the ability of the individual to remember information he/she was presented in the training. Example The individual can

recite back the specific model learned on how to manage conflict. Activity examples: define, list, repeat, recall, duplicate, recognize.

2. Understanding/comprehension: The individual can comprehend the meaning of the material presented and predict consequences or effects from it. No change in behavior occurs at this level as the individual is able to describe their understanding of what is presented and discuss how the new material learned may or may not work in their own environment. The individual is able to explain the specific model learned on how to manage conflict in his/her own words. Activity examples: describe, discuss, explain, identify, review, and translate.
3. Applying: The individual can use the material he/she learned in new situations, applying concepts, principles, methods, and theories effectively. At this level, the individual demonstrates his/her ability to apply the new material they learned in the form of a measurable activity. This is the start in a change in behavior. For example, conducting an effective negotiation session or conflict management via role plays. The individual is able to apply the conflict model as learned in a role play situation. Activity examples: apply, demonstrate, interpret, practice, solve, use, illustrate.
4. Analyzing: The individual can break down the material learned into smaller elements or components so that its organizational structure is understood. At this level, the individual demonstrates his/her ability to analyze a situation using the knowledge learned by applying it to a case study. The individual will use his/her newly learned skills to understand the situation of the case study, determine cause and effect, and develop a solution to the problem. The individual demonstrates his/her knowledge by taking a systematic approach to analyzing the situation and developing a solution based on the analysis. Activity examples: analyze, compare/contrast, distinguish, experiment, examine, and differentiate.
5. Evaluating: The individual is accomplished at judging the value of material learned for a given purpose and those judgments are based on defined criteria. At this level, the individual is able to take a multi-disciplinary assessment of a situation. He/she works from a defined set of criteria to make judgments about information presented in a case study, whether or not a solution is valid and the quality of a particular solution. At this level, the individual has mastered the new skill/knowledge. The individual is able to assess options and select the most effective conflict model (make changes to the conflict model) to utilize depending on a given conflict situation. He/she is able to assess a conflict situation to judge the best model to use for solving the conflict. Activity examples: appraise, assess, defend, judge, support, evaluate, value, and argue.

6. Creating: The individual builds a structure or pattern from diverse elements, puts parts together to form a whole, with emphasis on creating a new meaning or structure. Examples: Write a company operations or process manual. Design a machine to perform a specific task. Integrates training from several sources to solve a problem. Revises and process to improve the outcome. Activity examples: categorize, combine, compile, compose, create, devise, design, generate, modify, organize, plan, rearrange, reconstruct, relate, reorganize, revise, rewrite, summarize.

ACTIVITY

1. As a group, discuss the key verbs that relate to each level of blooms taxonomy with the facilitator guiding the discussion.

Level	Sample verbs
Remembering	Define, identify, label, list, name, recall, record, repeat, state etc
Understanding	Classify, compile, discuss, describe, give examples, translate
Applying	Apply, calculate, develop, interpret, locate, predict, report, use, present
Analyzing	Analyze, categorize, classify, compare, contrast, examine, test
Evaluating	Critique, decide, determine, establish, justify, recommend, rate, judge
Creating	Arrange, assemble, compose, construct, design, develop , diagnose, organize, manage, plan etc

2. Divide the participants in groups of 6.
3. Assign a verb that falls under applying, analyzing, evaluating and creating to each group.
4. Allow each group come up with an objective under the given verb. Highlight that a clear learning objective identifies a desired outcome of the educational offering/activity.
5. Ask each group to give a short explanation on how they will meet their objective through teaching an activity about sustainable agriculture. The activity should be clear e.g making kitchen garden, compost, etc.

6. Groups can share in which subjects and topics can their activities be integrated in the routine teaching and how they can link the activity to general environmental conservation.
7. After each presentation, spend 3 to 4 minutes to critique the presentations.