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Integrated Management of the Armyworm with Bio-Plant and Pro-Plant

Notes

1. Much of the information below comes from the article, "**Integrated Management of the Fall Armyworm on Maize"**at http://www.fao.org/3/I8665EN/i8665en.pdf .
2. AW = Armyworms.
3. These guidelines should be used in conjunction with using Bio-Plant to make compost, Pro-Plant to provide more than the full range of nutrients required by plants to grow healthily and abundantly; and recommended organic farming techniques, such as mulching, crop rotation, cover cropping, intercropping, etc.

1. Seed Preparation

- By soaking the seeds in a mixture of Bio-Plant (20 cc) and water (20 litres) or Bio-Plant (10 cc) and water (10 litres), the seeds will develop a strong immune system, which will help to protect the plants from pests.

2. Planting Dates

- Avoid late-planting and staggered planting (i.e. planting of fields at different dates in the same area), as this would continue to provide the favoured food of AW locally (i.e. young maize plants). This is one of the most important recommendations for smallholders.
- In line with this, in January 2018 some farmers in Kenya reported significant yield losses to AW on late-planted maize plots, compared to adjacent plots which were planted earlier.

3. Good Soil Health and Adequate Moisture are Critical

- Good soil health (by means of compost, for example) and adequate moisture (by means of mulching, for example) are essential to grow healthy plants, which can better withstand pest infestation and damage.
- Also, unbalanced inorganic fertilization of maize (especially excessive Nitrogen use) can increase oviposition by female AW. (Oviposition is the process of laying eggs.)

4. Plant Quality

- AW populations are affected by plant quality. An important factor, which affects AW populations, is the quality of the plant. The nutritional quality of plants affects not only plant growth and plant capacity to compensate for foliar damage by pests; but it also influences indirectly herbivore (i.e. AW) growth and mortality and infestation levels. Several studies have shown the effect of fertilization on AW larval growth and mortality. Several studies have shown a difference between chemical fertilizer and organic fertilizer (manures).
- The differences between the two types of fertilizers have been observed on:
  - AW larval growth.
  - Presence of natural enemies.
  - AW larval mortality.
  - Maize infestation levels (percentage of plants infested).
- In Brazil, chemical fertilizer resulted in significantly higher levels of AW infestation in maize than treatments with no fertilizer used, or with organic fertilizer.

5. Plant Diversity

- Another very important aspect of prevention of AW infestations is by maintaining plant diversity on farms. Diversity on a farm reduces AW infestation and supports natural enemies. Farmers in Central America have noticed that when they plant maize together with other crops, such as beans and squash, they have less pest attacks.
- Agro-ecologists have documented that poly-crops may be effective because of four main reasons or mechanisms:
  1. One possible explanation is that a diversity of plants in the same field confuses AW, and it is difficult for it to find its preferred host plant (maize), eating less or laying fewer eggs.
  2. Another reason is that the female AW moth does not "like" certain plants because of the chemicals they emit. These volatile compounds are the "push" effect in Push-Pull systems, which "push" pest species away from certain plants while they are "pulled" to others because the plant chemicals make them more attractive. So planting maize near other plants that "push" AW moths away is the first step in preventing AW infestation.
  3. A third possible explanation is that poly-cropping may provide natural enemies (parasitoids and predators) with resources, such as nectar, water, or a place to hide, and those natural enemies will control AW.
  4. A fourth rationale for the intercropping is that it increases soil organic matter, and in the case of legumes it increases Nitrogen, which improves plant health, making it more able to compensate for AW damage.
- We know that especially plants that bear flowers for a long period of time, such as many "weeds" or some medicinal or plants used as condiments, provide nectar to parasitoids and predators of AW.
- In Mesoamerica, plants such as Tagetes lucida, Coriandrum, Sonchus olerace, Ruta, and onions, attract beneficial insects, which eat AW.

6. AW Moths Prefer Maize to Lay Her Eggs

- In large monocultures of maize, the female AW moth just flies about, laying her eggs in a sea of maize. When maize is intercropped with other crops or there are other plants nearby that she does not like, she is more likely to move on, skipping maize plants that may be mixed in with the plants she does not like.

7. Push-Pull Technology

- Push-Pull is a habitat management strategy developed and implemented to manage pests such as stem borers and striga weed, and to address soil degradation, all of which are major constraints in maize production in Africa. The technology entails using a repellent intercrop (Desmodium as a "push") and an attractive trap plant (Napier/Brachiaria grass as a "pull").
- The Napier grass planted around the maize farm attracts stemborers and AW to lay eggs on it; but it does not allow larvae to develop on it due to poor nutrition; so very few larvae survive.
- At the same time, Desmodium, planted as an intercrop:
  - emits volatiles that repel stemborers or AW, and secretes root exudates that induce premature germination of striga seeds and kills the germinating striga; so this depletes seed banks of striga in maize farms over time; covers the ground surface between maize, thus smothering weeds; enriches the soil with Nitrogen, preserves soil moisture and protects the soil from erosion.
- "Push-Pull climate smart" (a combination of Desmodium Greenleaf and Bracharia cv Mulato II) is designed for dry and hot conditions to address the challenges posed by climate change.
- Brachiaria grass grows fast with less water, and has been found to tolerate dry conditions better than Napier grass.

- Push–Pull is an effective and efficient low-cost technology as it addresses some major constraints faced by smallholder farmers. The multiple benefits of this technology can result in an overall and significant improvement of farmer's food security and livelihoods.
- Observations on AW by at least 250 farmers who had adopted the climate-smart Push-Pull technology in drier areas of Kenya, Uganda and Tanzania indicated a reduction of AW larvae per plant and a subsequent reduction in plant damage. Further surveys on climate-smart Push-Pull and mono-cropped maize farms indicated 82.7% reduction in average number of larvae per plant and 86.7% reduction in plant damage per plot in climate-adapted Push-Pull compared to maize mono-crop plots.

8. Mechanical Control and Local Controls

- A very important management option for smallholder farmers in Africa, based on the experience of smallholders in the Americas, is to visit their fields regularly, and crush egg masses and young larvae (use your fingers, not pesticides).
- Farmers should visit fields twice a week during vegetative stage, especially in periods of heavy oviposition by AW, and once a week or every 15 days in later stages.
- Some smallholder farmers in the Americas report using ash, sand, sawdust or dirt into whorls to control AW larvae. Ash, sand and sawdust may desiccate young larvae.
- Smallholder maize farmers in Central America also report using lime, salt, oil and soaps as control tactics. Lime and ash are very alkaline. They also use local botanicals (neem, hot pepper, local plants) and some farmers report success.
- Some farmers report effectively pouring water in the maize whorl to drown the larvae.
- Other farmers in Central America and FFS farmers in Africa use sugary sprays, oil or lard, 'fish soup' or other material to attract ants and wasps to the maize plants. The predatory ants are attracted to the lard, oil, bits of fish parts, or sugar. Once on the maize plants, they also find and eat AW larvae.

9. Naturally-Occurring Bio-Control Agents

- Biological control agents include the following:
  1) predatory insects and mites, which eat their prey;
  2) parasitoids, which are insects with a free living adult stage and a larval stage that is parasitic on another insect; and
  3) parasites and microbial pathogens, such as nematodes, fungi, bacteria, viruses and protozoa, which cause lethal infections.

10. Parasitoids of the AW

- Parasitoids are organisms whose adults lay eggs inside or attached to a single host organism. For their development, the resultant larvae feed on the tissues of the host until they are fully grown and pupate.
- The larvae of parasitoids always kill their host as the outcome of their development.
- The majority of parasitoids known to be associated with the AW are wasps, and less frequently flies.

11. Ants

- Ants are often among the most important predators of AW larvae and pupae. Perfecto (1980) studied the interactions among ants, AW and pesticides in maize systems in Nicaragua. She found that ants are very important predators of AW in maize in Nicaragua and that pesticides dramatically reduced the presence and effectiveness of ants a natural biological control of AW. She placed AW pupae in the soil in maize fields and found that 92% of the pupae were

removed within 4 days in fields without insecticide treatments, compared with only 4% in fields with insecticidal treatments.

- Ants have already been seen attacking and killing AW larvae in maize fields in Africa.
- Some farmers have begun trying to apply lard or fish soup on their maize plants, to see if they can attract ants to their maize fields, so that they will then eat the AW larvae present.

12. Birds and Bats

- Birds and bats have been observed to prey on AW larvae. Studies in Central America have demonstrated significant impacts of birds on infestation levels of the AW.
- Presence of trees or bird perches in or near fields will help attract birds, which can prey on the AW and help control their population.

13. How to Favour the Presence of Natural Enemies in Fields?

- Farmers can take many actions to protect and favour populations of natural enemies in their fields. (This is called "conservation biological control"). Measures include:
  - avoiding overuse of synthetic insectides that can have detrimental effects on natural enemies. If pesticides are considered necessary, select products that are compatible with biological control.
  - ensuring diverse boundaries around fields, including open flowers and shrubs as a habitat or food for natural enemies;
  - trees or bird perches in or near fields.

14. Nematodes

- Nematodes are a biological control agent of armyworms, root weevil, black cutworm, grubs, Japanese beetles, ants, fleas, and over 250 other soil dwelling pests. When nematodes come into contact with their prey, they attack by entering through body openings or simply by boring through the body wall. Once inside, the nematode releases mutualistic bacteria from its gut that kills the host organism within 24-48 hours. Such nematodes will feed and reproduce before exiting in search of fresh prey.
- Beneficial soil nematodes are usually more abundant in crop management systems that include the use of compost, multiple crop sequences, reduced cultivation, and the addition of organic amendments.

15. Management That Decreases Microbial Populations

- Some fertilizers and agro-chemicals have a negative impact on soil microbes. Anhydrous ammonia, some nematicides, and ammonia-rich and sulfur-rich fertilizers can directly harm soil life or indirectly hamper their growth by decreasing soil pH (acidification).
- Increased pest and pathogen problems are often caused by insufficient rotation interval between crops. This is at least partially due to reduced biological diversity and weakened communities of beneficial organisms. If the soil microbes are not working for you they are more likely to work against you. Soil biota includes hundreds of pathogens, which are more likely to dominate the soil community if beneficial organisms have declined. When beneficials dominate the community, they suppress pathogens by competition and predation, and act as a physical protective barrier for plant roots.
- Tillage directly affects soil porosity and the placement of residues. Porosity determines the amount of air and water the soil can hold. Placement of residues affects the soil surface temperatures, rate of evaporation and water content, nutrient loading, and rate of decay. In other words, tillage collapses the pores and changes the water-holding, gas, and nutrient exchange capacity of the soil. Reducing soil disturbance increases the diversity and population

of soil organisms. These soils release nutrients gradually and have better soil structure than full width tillage systems.

16. Management That Increases Microbial Populations

- A more diverse soil community results in a more flexible soil. This means that a soil has the ability to successfully grow a number of crops, and is resilient in drought, low nutrient conditions and after a disturbance. Agricultural practices such as tillage, crop rotations and fertilizer inputs affect the numbers, diversity and functioning of the soil community (2).
- Organic matter from roots, plant biomass, manure, and compost provide the food energy to support the biological community. Cover crops and green manure crops increase the length of time that plants are actively growing in a soil, providing a steady influx of food for soil microbial populations. Cover crops also aid in reducing soil erosion. Diverse crop rotations can also help disrupt some pathogen cycles.

17. To Promote Soil Biodiversity

- Add organic matter regularly (cover crops, green and livestock manures) diversify the type of plants across the landscape (crop rotation, grass waterways, and CRP) maintain residue cover avoid excessive soil disturbance (intensive and secondary tillage, compaction, heavy use of pesticides).
- It is important to remember the general philosophy that beneficial soil organisms "need to be needed." That is, if the farm system depends on and supports their activities, more biomass and positive activities will develop. If the farm system depends solely on chemical inputs instead of biological inputs, beneficial biomass and activities will decline.

18. A Summary for Smallholder Farmers

PREVENT

Sustainable management of AW starts with prevention. There are actions that farmers can take before or when planting their fields to reduce infestation and impact of AW in their crops. Key first steps include:

- Use high quality seed. The seed should germinate well, be disease-free and be of the variety the farmer wants to plant. Good pest management depends on healthy plants.
- Avoid late-planting or staggered-planting (plots of different ages). When moths are looking for their favourite stage of maize to lay eggs on, if yours is the last-planted plot in an area, it will attract many female moths.
- Increase plant diversity in your plots. Maize mixed in plots with cassava or yams or other crops may be less attractive to female AW moths. Some plant species repel female AW moths. This is the basis of the ‘Push-Pull’ technology: including a plant species that ‘pushes’ AW away from maize and to plants that ‘pull’ them (attract them), where they can be easily controlled.
- Plant diversity can also increase the populations of farmers’ friends – those organisms that are naturally in the environment and can kill a high proportion of AW eggs and larvae. Predators (ants, earwigs, etc.), parasitoids (wasps that kill AW), and pathogens (virus, bacteria, fungi, etc. that kill AW) are in and around farmers’ fields. Plant diversity can keep them close to your maize so that they can find and kill the AW.

MONITOR

Farmers should visit their fields frequently to observe, learn, and take action. During the first 40 days after planting, they should walk through their fields every 3-4 days. While doing this, they should observe:

- **General Health of the Plants:** Do they have a nice dark green colour (indicating good nutrition)? Do they appear moisture-stressed? Are there signs of damage (from AW, other insects, or diseases)? If there is AW damage, is it current (look into the whorl and see if there are holes in the leaves in the whorl and fresh grass)? Are there AW egg masses present? Young larvae? Are there weeds (especially striga)? Are there farmers' friends present (ants, wasps, larvae killed by pathogens)?

KNOW

- **Maize plants can compensate for certain levels of foliar damage.** A low percentage of plants infested will not reduce maize yield dramatically.
- **Farmers' friends (the natural enemies of AW) can be very** important in naturally controlling AW – studies have found up to 56 percent of AW larvae naturally killed by farmers' friends. Key to good AW control is attracting and keeping farmers' friends in the fields. There are actions that can be taken to attract farmers' friends to their fields, keep them there, or harvest and use them.
- **Chemical insecticides are expensive and dangerous.** Their use is probably not economically justifiable for smallholder African maize farmers. Some also present high human health risks. Some older pesticides, which have been banned from use due to human health risks in many countries, are being used by smallholder maize farmers. Many pesticides kill farmers' friends.

ACT

- Effective and sustainable AW management requires action. Some of the actions prevent AW, others are required when something goes wrong in the system and there are high levels of AW infestation in the field.
- One of the simplest actions that farmers can take is mechanically killing AW eggs and young larvae. Eggs are laid in a mass, easily observed on maize leaves. These can be immediately crushed. Likewise, young larvae can be picked off the leaves, before they penetrate deep into the whorl.
- Many smallholder farmers try local solutions and report satisfaction with these local actions. In addition to the preventive actions, some farmers report success in:
  - **"Recycling" pathogens.** When larvae natural killed by virus, fungi or bacteria are observed in the field, they can be collected, taken home, ground (or put through a blender), strained. The liquid that strains through may be full or fungal spores, bacteria, or virus particles that can be diluted and sprayed back into infested plants. This is a free, effective natural bio-pesticide. Many farmers spray into the whorls of infested plants, so as not to waste the natural insecticide.
  - **Attract predators & parasitoids.** Ants have been observed to be important natural predators of AW larvae. They crawl up the plants, into the whorls, and find, and drag out AW larvae. Some farmers have found that they can attract ants to their maize fields by putting lard, grease from cooked meat, or old fish soup into their maize fields. These substances attract ants to their fields, and then they stay and find and kill AW larvae in the maize fields. Some farmers use sugar water to attract and feed the wasps that can eat or parasitize AW.
  - Other farmers try and report satisfaction with using a number of **local substances, applied directly to the whorl of infested plants**. Some of the substances that have been tried include: soil, ash, sand, lime, salt, soaps, oils, and extracts from local plants: hot peppers, Tephrosia, Marigold flowers, neem, etc. Farmers can try these and other local solutions and then compare and share the results, to see which work best under local conditions.