MODUL I

ECOLOGICALLY BASED INTEGRATED PEST MANAGEMENT

TRAINING PRINCIPAL AND APPLICATION OF INTEGRATED PEST AND DISEASE MANAGEMENT IN THE TROPICS 29-30 APRIL 2021

PLANT PROTECTION DEPARTMENT

INDONESIAN CENTER OF AGRICULTURAL TRAINING

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Background

We need farms for a variety of reasons. People in the world always need a food which only can produce from farming. However, there are constraints in the cultivation of plants, one of which is the constraints of pests and plant diseases. Of all the regions where agriculture is practiced, the tropics are where novel production approaches are most urgently needed. This region has not benefited significantly from modern technologies which led to high agricultural productivity in the temperate regions. Abundant rainfall and high temperatures promote competition from weeds, pest outbreaks and nutrient leaching; constraints that constantly plague the large- scale plantations and annual crop monocultures that cover large areas in the tropics (Beets, 1990 in Altieri, 2004). In many tropical areas, agriculture is highly mechanized and has implied the simplification of the structure of the environment over vast areas, replacing nature's diversity with a small number of cultivated plants and domesticated animals. Genetically, monocultures are shockingly dependent on a handful of crop varieties. Researchers have repeatedly warned about the extreme vulnerability associated with this genetic uniformity, claiming that ecological homogeneity in agriculture is closely linked to pest invasions (Adams, Ellingbae and Rossineau, 1971; Robinson, 1996). Many scientists argue that the drastic narrowing of cultivated plant diversity has put tropical food production in greater peril. In vain, farmers have tried to overcome these biotic constraints typical of the less seasonal tropics by applying large amounts of chemical fertilizers and pesticides, but this approach has been limited by scarce and expensive fossil fuels, but mostly by ecological backlash in the form of significant environmental and health externalities (Conway, 1997). Searching for ways to develop a more sustainable agroecosystems, several researchers have posited that tropical agroecosystems should mimic the structure and function of natural communities, (a practice followed by thousands of indigenous farmers for centuries), as these systems exhibit tight nutrient cycling, resistance to pest invasion, vertical structure and preserve biodiversity (Ewel, 1986; Soule and Piper, 1992). If such ecological approach is used, it is important to ensure that promoted systems and technologies are suited to the specific environmental and socio-economic conditions of small farmers, without increasing risk or dependence on external inputs. Rather, agroecological development projects should feature resource-conserving yet highly productive systems such as polycultures, agroforestry and the integration of crops and livestock (Altieri, 1995). The ecological futility of promoting mechanized monocultures in tropical areas of overwhelming biotic intricacy where pests flourish year-round and nutrient leaching is a major constraint has been amply demonstrated (Browder, 1989). A more reasonable approach is to imitate natural cycles rather than struggle to impost horticultural simplicity in ecosystems that are inherently complex. Ewell (1986) argues that successional ecosystems can be particularly appropriate templates for the design of sustainable tropical agroecosystems. Building on this idea and the contributions of modern agroecology, we provide principles for agroecosystem design emphasizing the development of cropping systems that enhance nutrient capture, and confer associational resistance to pests, thus reducing agroecosystem vulnerability while providing biological stability and productivity. Integrated pest and diseases management is an ecosystem approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. *FAO definition:* **Integrated Pest Management (IPM)** means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms (FAO, 2020).

Pest and Plant Diseases Pest

Pest. The definition of a pest can be very subjective, varying according to many criteria; but in the widest sense any animal (or plant) causing harm or damage to man, his animals, his crops or possessions, even if just causing annoyance, qualifies for the term pest. From an agricultural point of view, an animal or plant out of context is regarded as a pest (individually) even though it may not belong to a pest species.

The concept of animal become pest

Population resurgence. The effect of most chemical pesticides is short-lived nowadays, and once the suppressive effect declines the pest population will naturally resurge, possibly up to the economic injury level again. There may also be resurgence of a secondary pest due to insecticidal destruction of natural enemies, or from some other ecological upset.

Migration. In northern temperate regions a number of pest species regularly migrate into the country in the spring and early summer from farther south where conditions are milder and warmer. In the national pest spectra of the UK, Fennoscandia, Japan, and Canada there are several (or more) quite important migratory species that do not survive the winter locally, but regularly immigrate into the country each year from farther south.

Monoculture. The growing of a single crop species over a large area provides an unlimited source of food for pest spe- cies, especially when the crop plant is particularly succulent. The present worldwide tendency is towards mechanized agriculture which requires larger fields and fewer hedgerows which traditionally delimited each field, and so the crop monoculture becomes even more extensive. This practice will encourage some insect species to become more abundant, and hence important as pests, as was observed about a century ago with Colorado Beetle on potatoes in the USA (see fig. 8). As well as monoculture becoming more extensive, some new crop varieties have become more specialized in their growing conditions, and there is a tendency to reduce the extent of crop rotation. As mentioned before, the taiga of northern Asia and

Continuous cropping. The plantation and orchard crops are all very long-term and because of this they suffer from particular pest problems, but in compensation their pests are to some extent controlled by natural enemies. Field crops are typically characterized by their short duration (an ephemeral habitat) as at most they are annuals, and sometimes by careful timing the crop may be grown before the pest population catches up.

Pest Damage

Direct effects of insect feeding

1. Biting insects may damage plants as follows.
    a. Reduce the amount of leaf assimilative tissue and hinder plant growth; examples are leaf-eaters, such as adults and nymphs of locusts and Epilachna and larvae of Plutella, Pieris, Plusia (Lepidoptera) and sawfly larvae.
    b. Tunnel in the stem and interrupt sap flow, often destroying the apical part of the plant; these are stem borers and shoot flies, such as Zeuzera in apple branches, Cephus in wheat, Ostrinia in maize, Atherigona in maize and sorghum.
    c. Ring-bark stems, for example some Cerambycidae.
    d. Destroy buds or growing points and cause subsequent distortion or proliferation, as with Fruit Bud Weevils (Anthonomus spp.) on shoots of apple, pear, etc.
    e. Cause premature fruit-fall, as with Cherry Fruit Fly, Codling Moth, Apple Sawfly.
    f. Attack flowers and reduce seed production, as with the blossom beetles (Meligethes spp.) and Japanese Beetle.
    g. Injure or destroy seeds completely, or reduce germination due to loss of food reserves; examples are Hazelnut Weevil, Maize Weevil, Pea and Bean Bruchids, Pea Pod Borers, and Bean Pod Borers.

h. Attack roots and cause loss of water and nutrient absorbing tissue, as with wireworms and various chafer larvae (Scarabaeidae) and other beetle larvae in the soil.
i. Remove stored food from tubers and corms, and affect next season's growth; examples are cutworms and wireworms in potato, and Potato Tuber Moth larvae.

2. Insects with piercing and sucking mouthparts may damage plants as follows

a. Cause loss of plant vigour due to removal of excessive quantities of sap, in extreme cases wilting and foliage distortion results, as in the stunting of cotton by Bemisia (Whitefly), and aphids on many plants.
b. Damage floral organs and reduce seed production, for example capsid bugs (Miridae) and other Heteroptera (Wheat Shield Bugs, Chinch Bugs, etc.).
c. Cause premature leaf-fall, as do many diaspidid scales.
d. Inject toxins into the plant body, causing distortion, proliferation (galls) or necrosis; examples are seen in capsid damage on bean leaves and shoots, and the stem necrosis on plants by Helopeltis and other Heteroptera.
e. Provide entry points for pathogenic fungi and bac- teria, as does Dysdercus on cotton bolls (for fungus Haemospora) and other bugs.

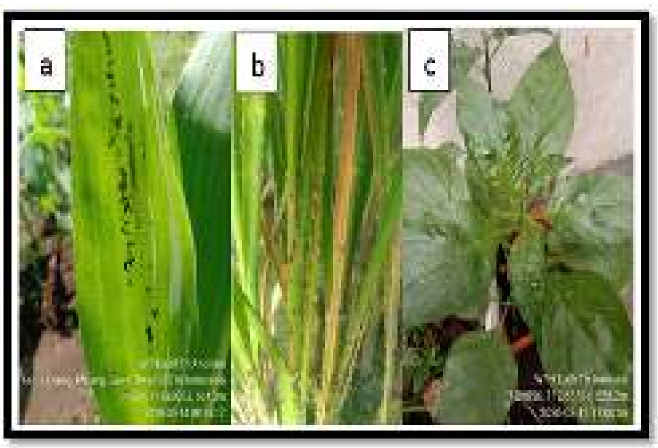


Figure 1. Pest Damage

Plant Diseases

Plant Disease is defined as the state of local or systemic abnormal physiological functioning of a plant, resulting from the continuous, prolonged "irritation" caused by phytopathogenic organism (infectious or biotic disease agent) and abiotic (lack of nutrients)

Concept of Plant Disease

In the history of plant diseases, there are several concepts of disease including:

A. The concept of disease triangle, which describes that plant diseases can occur if plants are susceptible to plant diseases, Disease-causing pathogens have high virulence, and an environment suitable for the growth of pathogens.
B. The concept of disease square which describes that plant diseases can occur if plants are susceptible to plant diseases, Disease-causing pathogens have high virulence, an environment suitable for the growth of pathogens, and human intervention (farmers who work on rice fields)
C. The concept of disease pyramide, which describes that plant diseases can occur if plants are susceptible to plant diseases, Disease-causing pathogens have high virulence, an environment suitable for the growth of pathogens, human intervention (farmers who work on rice fields) and time, this concept became the basis of epidemiological observations of plant diseases.

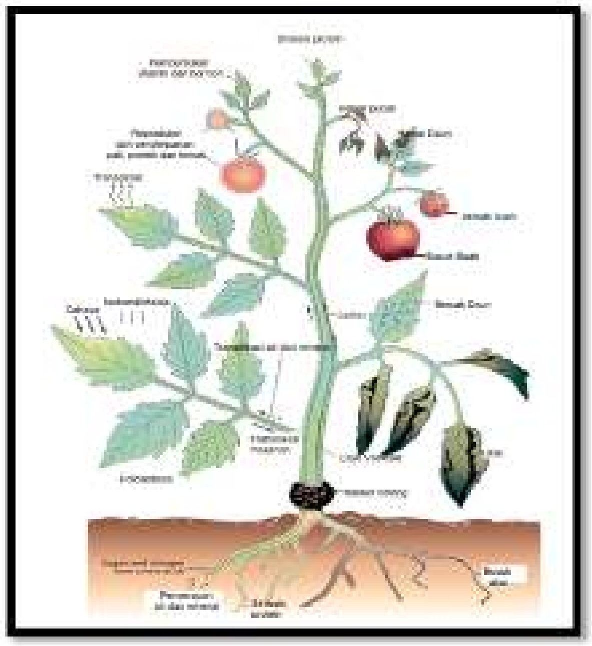
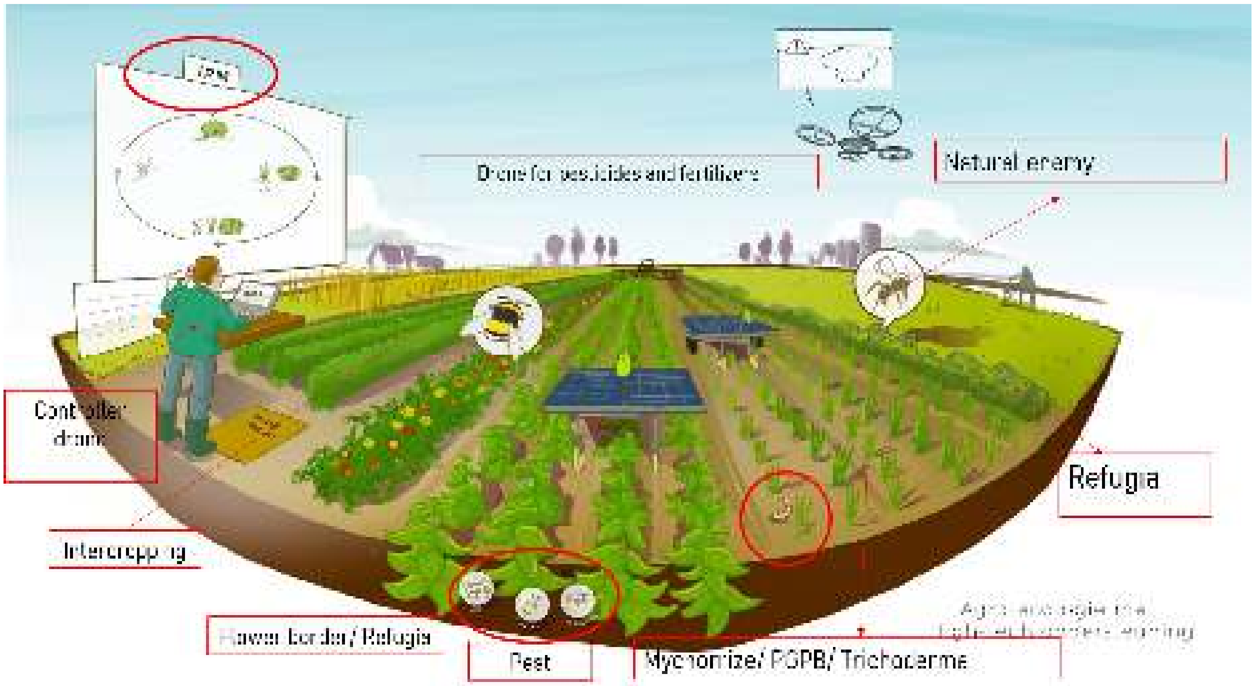


Figure 2. Schematic representation of the basic functions in a plant (left) and of the kinds of interference with these functions (right) caused by some common types of plant diseases.

Figure 3. Disease symptom

Ecological principles of IPM S

cientists began working out some of the basics of rice field ecology in the late 1970's and early 1980's. Their attention was generally focused on the brown planthopper (BPH), which at the time was ravaging rice fields across Southeast Asia. They discovered that BPH outbreaks were insecticide induced (P.E. Kenmore, 1980) and that breeding rice varieties resistant to BPH under continued pressure of insecticide use was futile (K.D. Gallagher, 1984). Researchers soon worked out an ecologically based means to BPH control (P.A.C. Ooi, 1988). Yet it was to take some time before the broader ecological approach became part of mainstream extension. Whereas the specific conditions critical for management decisions regarding inputs vary over a small spatial scale, agro ecosystems do have a general structure and dynamics that is reasonably consistent for the entire system. In essence, it is possible for us to think in terms of a general theory for the structure and dynamics of specific agricultural ecosystems. IPM is not a "theory" in a strict scientific sense; rather, it is merely a set of practical guidelines for how to best manage a specific crop. The existence of diverse populations of natural enemies, supported by abundant alternative food species, assures that populations of pests are consistently maintained at low levels. In effect, the structured biodiversity of arthropods in tropical irrigated rice functions to consistently suppress pest populations by denying pests refuge in time or space. All the key variables can be found in any rice ecosystem—only when the process is disrupted do pest populations explode, causing serious damage. Given this set of implications for rice, IPM practice can be determined. The use of insecticides disrupts and destabilises natural enemy populations. The use of insecticides is by far the most common cause of pest outbreaks, especially for pests such as the rice brown planthopper. These kinds of pest outbreaks are generally referred to as "pesticide-induced resurgence". Several factors combine to enable resurgence to occur: *Eggs of many pests, such as BPH, are not susceptible to chemical sprays.* *Insecticides create a refuge for the development of pest populations by reducing the abundance of natural enemies.* *Migratory abilities of pests are generally better and their generation many times faster than those of natural enemies.* Certain landscape designs can cause delays in the arrival of natural enemies after long dry fallow periods. In many tropical areas, the potential exists for year-round cultivation of rice. However, some areas—both by natural constraints or government design, are planted synchronously over thousands of hectares, and have long (3-4 month) dry fallow periods. These are the areas in which natural enemy populations are weakest and where pest outbreaks are most frequent (see Settle et al. 1996). After such a long dry spell, when the next season of rice is planted, it takes up to half a season to build up predator populations that would otherwise have been there from the beginning. Again, as pests are better recolonizers than natural enemies, the potential for outbreak is much higher in these synchronous, large-scale areas. Much attention has been given to the ideas of "synchronous planting" and "breaking the pest cycle with long dry fallow periods" to the point that these ideas have become ingrained almost as "fundamental principles" of IPM. However, a close look at the empirical data and experiments that purport to demonstrate these principles will show that the support is very weak. Soils, high in organic matter, are the foundation for a "healthy ecosystem". Soil organic matter is not emphasized as much for irrigated rice as for dry-land cropping systems because of the lesser need for good soil texture. However, as we have seen, soil organic matter is the foundation for energy cycles that ultimately support high populations of natural enemies.(FAO, 2021).


IPM
Drone for pesticides and fertilizers
Natural enemy
Controller drone
Intercropping
Refugia
Flower border/ Refugia
Pest
Mycorrhize/ PGPB/ Trichoderma

Reference

Altieri, M.A., Nicholls, C.I and Fritz, M. 2014. Manage Insect in Your Farm: A Guide to Ecological Strategies. Sustainable Agriculture Research and Education Publisher. US.

Dent, D. 2000. Insect Pest Management. CABi. UK.

FAO. 2020. Integrated Pest Management. Available at http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/scpi-home/managing-ecosystems/integrated-pest-management/ipm-what/en/

Rapisarda, C and Cocuzza, G.E.M. 2017. Integrated pest Management in Tropical Regions. CABI.

CROP	INTERCROP	PEST(S) REDUCED	MECHANISMS
Cauliflower	Corn spurry	Cabbage looper, flea beetle, aphid	Predators
	Lambsquarters	Imported cabbage butterfly	Predators
	White or red clover	Cabbage aphid, imported cabbage butterfly	Physical interference, predators
Corn	Wild parsnip, wild mustard, chickweed, shepherd's purse, and lady's thumb smartweed	Black cutworm	Parasitic wasps
	Pigweed	Fall armyworm	Uncertain
	Giant ragweed	European corn borer	Parasitic wasps
	Sweet potato	Leaf beetle	Attract pest to alternative plant
	Beans	Leafhoppers, leaf beetle, fall armyworm	Physical interference, Predators
	Beans, weeds	Fall armyworm	Predators
	Pigweed, Mexican tea, goldenrod, beggertick	Fall armyworm	Predators
	Soybean	Corn earworm	Predators
	Peanut	Corn borer	Visual masking
	Clover	Corn borer	Physical interference
Cow pea	Sorghum	Leaf beetle	Chemical repellent
Cucumber	Corn, broccoli	Striped cucumber beetle	Physical interference
Crucifers	Wild mustard	Cabbageworm	Parasitic wasps
Fruit trees	Rye, wheat, sorghum used as mulch	European red mite	Predators
	Alder, bramble	Red spider mite	Predators

Beneficial Microorganism The explanation of above and below ground

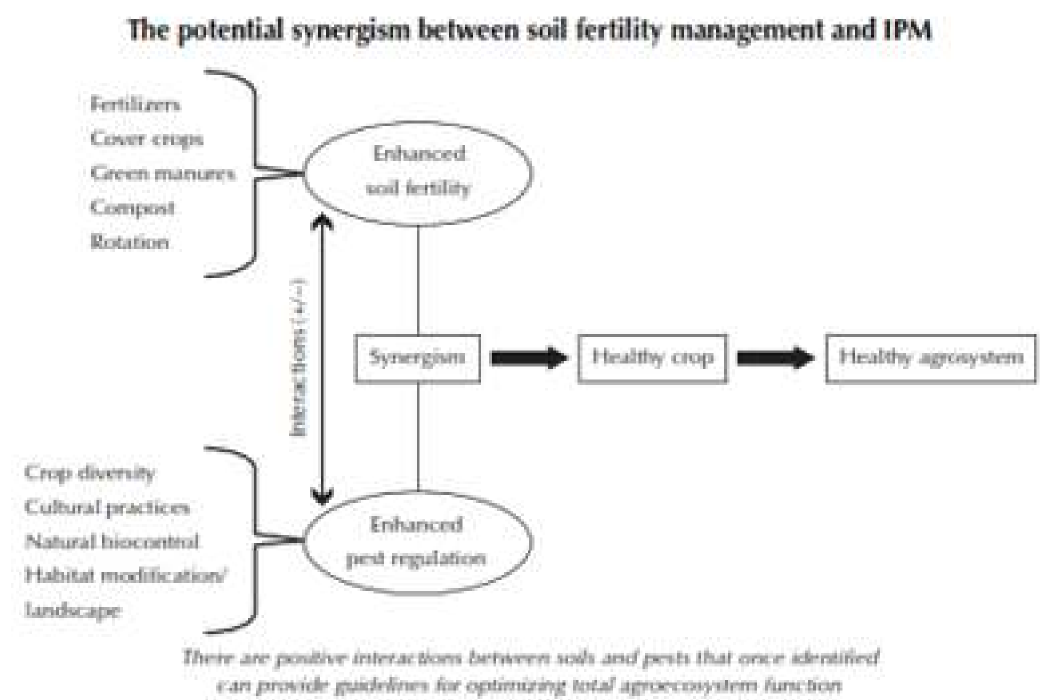


Fig. 8.9. Optimizing soil–pest interactions: a key pathway to achieving sugarcane agroecosystem health. (From Altieri and Nicholls, 2003.)