Pest management: The art of mimicking nature

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This article presents a vision of how pest and disease problems in agriculture can be addressed. It is based on experiences in different semi-arid regions, mainly in India and West Africa. The principles which it looks at, though, are valid in any system and any climate zone. The title of the article refers to the conviction that sustainable farming needs to mimic nature in order to use ecological processes as the main method to manage pest and diseases, thus reducing the dependency on external inputs.

Nature and farming

Unlike in agriculture, in nature we seldom find massive destruction of vegetation by pests or diseases. We find high biodiversity of plants but also of animals, insects, bacteria and fungi. Nature is a system in which no component can easily dominate. Nature provides and promotes niches for diverse insects and animals competing with each other and living with each other. They die and decompose in the landscape where they lived. Nature recycles nutrients.

The introduction of permanent farming has, over the years, reduced biodiversity: moving from shifting cultivation to mixed cropping systems, then to mono-cropping systems with landraces of a relatively high genetic diversity, to improved varieties, to hybrids and to genetically modified crops. The latest developments mean that genetic diversity, even within the crop, has been very much reduced. Ecological logic suggests that, with decreasing biodiversity above the soil, biodiversity in the soil has also decreased. Attacks by pests and fungal diseases tend to increase over time, a process which is related to natural selection in an increasingly limited stock. Among the factors involved we have:

Imbalanced nutrition

Soil fertility decreases when the product is harvested. Farmers used to replenish fertility through the application of farmyard manure. But many farms have become too small to create sufficient manure. This has encouraged some farmers to resort to the easy solution of fertilizers. Unfortunately, an overdependence on chemical fertilizers has led to imbalanced plant nutrition: too much nitrogen in relation to all other macro- (P, K), meso- (e.g. Mg, S, Si) and micro-nutrients (e.g. Zn, B). Imbalanced plant nutrition leads to increased vulnerability to pests and diseases. There is ample evidence that very high levels of nitrogen attract sucking insects; that blast in rice is enhanced if the nitrogen/silicon ratio is wrong; that shortages of magnesium promote leaf-spot in groundnuts (on red soils); that zinc deficiencies lead to fungal diseases (in mango and finger millet).

Decreasing water-holding capacity of soils

The lack of organic matter in soils -caused by erosion, reduced application of farm yard manure and accelerating decomposition due to nitrogen application- leads to moisture stress, which also increases the susceptibility of plants to pests and diseases. For instance, thrips attack plants when they suffer moisture stress; groundnut shells crack due to water stress, which creates entry points for fungal diseases and subsequently aflatoxin problems.

Photo: Author

Nurturing healthy plants in Yavatmal, Maharashtra, India.

Monocropping and loss of natural vegetation in the landscape

The reduction of biodiversity in agricultural systems has also increased the relative abundance of insects that can live in such simple ecosystems. In the same way, harmful animals like rats and wild boars can easily survive; there is almost no niche for their predators (snakes, owls, wild cats). This can becompared with a supermarket where, because the food is so easily available, there are plenty of mice but the cats are absent.

Broad-spectrum pesticides

The use of broad spectrum pesticides has had a severe impact on the abundance of predators. The pest-predator ratio has been severely and negatively impacted. This applies to insects as well as to birds.

Irrigation

The introduction of irrigation also promotes harmful insects as the normal period of drought, and thus absence of a host plant, has disappeared. Host plants are present throughout the year and thus the pest population can survive. Crop selection by farmers aggravates the presence and persistence of harmful insects in irrigated systems. Farmers look at the earning capacity of a crop and rely on pesticides to control the pest that goes with the crop. There are many examples of farming systems that promote pests (for instance cotton bollworm in Guntur, Andhra Pradesh, India) through each and every crop grown during the year.

Prevention is better than cure: Back to nature

The main strategy for pest and disease management in LEISA farming systems is to reduce stress to the crop and strengthen ecological processes that control pests and diseases. This means ensuring that the crop is not:

- exposed to excessive drought or moisture;
- subjected to nutrient shortages and imbalances;
- facing excessive competition from other plants (for space, light, water or nutrients);
- exposed to extremely high or extremely low temperatures;
- grown as a monocrop in a landscape almost devoid of trees, shrubs, wild fauna and flora.

How can this be done? Organic matter in the soil is an important factor in improving growth conditions. It will improve soil structure and allow rainwater to infiltrate into the soil. This will reduce run-off and thus increase water availability, reduce water stagnation and provide better growing conditions for plants. It will also improve the water holding capacity of the soil, improve aeration and oxygen availability in the soil and it will also lower or increase the pH of the soils. All these are beneficial for the crop.

Systems for holding water can be created: pits dug in the field, dead-furrows, tied-ridges, vegetative bunds, earthen bunds with overflow structures, terraces. All these actions will help to reduce drought stress. Drainage of excess water is equally important: farmers growing ginger on flat soils face more bacterial wilt problems than those growing ginger on raised beds with a well designed water drainage structure, such as those seen in Sikkim and Kerala in India. Black cotton soils are notorious for water stagnation; their drainage is imperative. Farm ponds in the drainage system are a good strategy to use the water when long spells of drought occur.

Finding enough compost is a challenge for many faming families. It is possible in some farming systems, for example, by growing a green manure crop before the main crop. A one metre wide border crop of densely sown Sunn hemp (*Crotalaria* sp.), *Cassia siamea* or *Glyricidia* around the field can produce four tons of compost per acre after 3 years. Where animals are part of the system, it is important to make best use of their manure, collecting it where necessary.

Enhancing biodiversity

Many elements make up a farming system with high biodiversity – a main crop, border crop, trees, intercrop, and animals. Biodiversity can be enhanced further by introducing:

- trap crops (often crops with yellow flowers, like Indian mustard, sunflower, marigold, soybeans and French beans);
- crops that promote predators (e.g. pulses for the ladybird beetle, okra for the lace wing, coriander, sorghum, maize for *Trichogramma*);
- visual/physical barriers through densely sown border crops (e.g. the diamond backed moth needs to see cabbage).

After such interventions a field would have about 10 crops growing. It is thus becoming a fairly rich eco-system. The applied compost will provide feed for microbes in the soil which will enhance biodiversity, especially when micro-organisms have been added to the compost. The trees will encourage birds that will feed on boll worm or *Spodoptera,* for instance, but of course also on grains (the main reason why farmers want to remove trees). So it is not only vegetative biodiversity that will increase, but overall biodiversity.

Another possibility is to create patches of nature on community owned lands within a landscape. The best way to do that is to fence the areas temporarily and prohibit entry for a period of about 5 years. The nature that regenerates is highly diverse and suitable to the environment. These patches of nature can then be refuges for larger predators. Of course they are seen by many scientists also as source of pests and diseases. Only experiments will show who is right.

Crop management

Time tested local varieties should be preferred, unless it is clear that they are genetically degraded or that climate has significantly changed (onset of rains, end of rains and distribution). It would be recommendable to try and improve the varieties by selecting healthy and high yielding plants as the seed for next season. However, we should not be romantic: many crops and varieties have been introduced into farming systems relatively recently (1960s and 1970s). Though it is tempting to work with hybrids to improve yields, it would often be better to grow varieties that have good characteristics. They can be multiplied by farmers themselves, provided a good system of seed selection is implemented.

Timely planting, and choosing the right crop and variety are crucial. Often farmers will have to change varieties if they are forced to plant late due to late rains. Long term weather expectations are important in the choice of varieties or even crops. For years, farmers have observed nature's response to climate. Often they have found natural indicators for predicting good and bad rainy seasons (for example, in northern Ghana it was related to the fruiting pattern of *Acacia nilotica*). Such indicators can be correct, but in some cases they also might be wrong, so each case needs to be studied in detail. Attention needs to be paid to long term weather predictions, and possible alternative crops need to be discussed with farmers.

Plant density is an often overlooked factor in farming sytems. Too high or too low density can be found in many farmers' fields. Both situations can promote pest and disease attacks. Thus, it is important to maintain the optimal plant population. The densities depend on soil type, so it is wise to experiment and not just follow what researchers say.

When all these measures are taken, pests are usually kept at bay. However, there might still be problems emerging. It is possible to monitor these, and partially control them, by using sticky traps (bright yellow, light blue), light traps, pheromone traps and field observations. It is important to notice the onset of a pest problem, in order to manage it with relatively simple measures before it gets out of control. In many cases it is preferable to use anti-feedants like neem seed kernel extract, repellents like cow-urine, chilli or garlic sprays. Botanical pesticides are usually broad spectrum killers and lead to similar problems as broad spectrum chemical pesticides.

In conclusion, the best strategies for pest management are based on ensuring optimal conditions for plant growth: a soil rich in organic matter, balanced nutrition, good plant population and a high diversity of plants attracting, repelling harmful insects and promoting predators of all kind. It is necessary to look wider than at only one field: the whole cropping pattern of a farm and an area will promote or control pests and diseases. The natural environment too can contribute to controlling or promoting pest incidence. Only if we fully understand the ecology of pests and diseases, can we live in harmony with them instead of fighting them. ■

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