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FEATURES

Use of Pesticides and Insecticides — An Organic Agricultural Point of View

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In this paper, which is particularly relevant to our Special Section on the 'Environment', the writer maintains that as each nation analyzes its future food-producing potential, and takes into account long-range environmental and energy factors, more attention must be given to recycling nutrients through the composting of wastes, and other physical and cultural systems within the discipline of biological agriculture. The Less Developed Countries in particular, he emphasises, must address themselves more to the realism and practicability of integrated pest management systems in which ecological conditions would be the primary determining factors. Karunairajan serves on the Co-ordinating Committee of International Federation of Organic Agriculture Movements (IFOAM) which is an organisation of groups and individuals from around the world, "united in their work to develop and encourage an agriculture that is ecologically, economically and socially sustainable."

The FAO defines a pest as an insect, mite, tick, nematode, fungus, bacteria, weed, rodent, bird, mollusc, crustacea or virus that hurts or damages the animals and plants that human beings use for their food and fibres. These are known to destroy and damage huge quantities of food and farming land. Any natural method or synthetic chemical substance that can get rid of these pests would be called a pesticide, and this term incorporates insecticides, herbicides, and other similar combatants.

Every organism, given the food and space, has an unlimited capacity for reproduction, and could multiply without restraint. But on this crowded planet plant species compete among themselves for water, light and soil nutrients; animal species for food and territory and both are beset by predators and parasites. Besides these competitive and combative relationships, there are also many co-operative ones. Bacteria aid plants by converting nitrogen from air into nutrient salts; animals and insects pollinate many plants and enrich the soil with their excretions and subsequently with their bodies; and many predators are kept in check by predation.

During the last two centuries there has been a wide dispersal of plants throughout the world. They have been taken from their natural homes and introduced into new areas. The United States Office of Plant Introduction alone has imported nearly 200,000 varieties of plants, and along with these about half the major insect enemies found in that country today. Such pests often cause more havoc in a new territory, having been freed from their natural enemies in their native lands. The long migration of the Colorado Beetle, almost unknown before 1850 and now found all over the North American continent is a classic example. It has even established itself in Western Europe. The spread of the cultivated potato gave this beetle not only an abundant supply of food but a means of transport as well, from its small beginnings in the Rocky Mountains.

Cash Crops

Modern agriculture has also intensified its own pest problems by the simplification of diversified natural communities to a dangerous extreme by opting for single-crop farming. This is not only true of the American prairies where millions of acres are devoted to wheat, and California with its vast citrus plantations, but also of Less Developed Countries (LDCs) where Multinational Corporations (MNCs) in general have successfully appropriated the plantation sectors for the production of cash crops. These crops are either non-edible industrial raw materials such as cotton and rubber, or edible (with or without food value) foodcrops such as sugar, bananas, peanuts, pineapples, and wheat. Tea and coffee too belong to this category.

It will be seen that the people of these LDCs are as a matter of fact subsidizing the food, garments, automobiles, tyres etc., of the people of the affluent nations with their cheap labour, while at the same time subjecting their lands to environmental disorders and destruction in the process. This so-called cash-cropping not only demands much time, space, effort and energy in the poorer countries but is also done at the expense of meeting their own basic food needs. It appears that the economic systems of the LDCs have been adapted to the 'vampirical' needs of the Developed Countries (DCs).

Cash crops occupy enormous areas of the best available lands. About 55% of the cropland in the Philippines and over 80% in Mauritius used for cash-crops are two good examples in this respect. Even worse, such export-oriented crops also take priority for irrigation, fertilizers, pesticides, and machinery. Cash crops are what the LDCs mainly produce and they need massive doses of chemical fertilizers and pesticides, which they can hardly afford.

. . . and Pests

Cash crops no doubt encourage the multiplication of pests caused by the reduction of various organisms, insects, and animals beneficial to farming communities. The pests that remain suffer less competition, have fewer natural enemies, a lavish supply of food, and are therefore liable to build up their population to catastrophic levels, than they would be on uncultivated territory or multi-crop plantations.

The farmer's main weapon against pests and weeds during the last three or four decades has so far been chemistry. The modern pesticide industry began during the Second World War with the discovery of the insecticidal properties of DHT (*Dichlorodiphenyltrichloroethane*) and BHC (*Benzene Hexachloride*). Since then, chemical

laboratories have provided farmers with a stream of powerful insect poisons, most of them either organochlorophines like DDT and BHC, or organophosphates which are toxic compounds related to the nerve gases. Various herbicides are also being marketed but they have been shown to have alarming side-effects. These laboratory creations are so unlike any natural molecules of life, and they escape attack by soil bacteria resulting in their accumulation in the soil. Their effects on plant, animal life, water resources, and the environment are indiscriminate and unpredictable. Another problem is the eventual production of a completely resistent stock of the pests through natural selection. In 1958, the World Health Organization listed 26 resistant insect species of importance to public health, including carriers of malaria, yellow fever, plague and filariasis. This list had grown to nearly 100 by 1968.

The increasing interest amongst agriculturalists in biological control has no doubt been caused by the consequences of the accidental transport of pests, the simplification of environments by modern agriculture, and the short comings of chemical pest control. Biological principles of pest control are implicit in such ancient farming practices as crop rotation, cover cropping, green manuring, applying composted manure and the cultivation of mixed forests and crops.

In the past 30 years, it often seems that the only consistent interest in biological control of insects was expressed by organic farmers. The attention of scientists has been and continues even today to be lethargic in the field of chemical compounds, and research is not exactly leaping ahead in the domains of biological control. The reasons for this is obviously economic, since success in biological alternatives to chemical pesticides would seriously affect the future of the chemical industry. After all, it would be seen in mere economic terms, that the pesticide industry is geared to a monetary market demand, and not to the needs of the human beings.

The United States, generally credited with having one of the world's most efficient food production machines, is also the world's number-one dealer in pesticides. It is also evident that it is attempting to generalize its own agricultural systems in other countries, particularly in the LDCs. These may be efficient when it comes to food production in terms of quantity, but cost-wise beyond the reach of most of the nations of the world, environmentally destructive, and its social consequences could be disastrous.

If the entire world were suddenly to adopt American farming and food processing methods, increasing the diets of all four billion people to the American level, the energy consumed would exhaust the world's known petroleum reserves in 13 years, according to Dr. David Pimental, an Ecologist attached to Cornell University in the USA. It would therefore naturally follow that the hope of being able to feed everyone adequately and to keep up with the expanding human numbers is to adopt food production systems unlike those in the USA.

Furthermore, US-based Multinational Agribusiness wants to grow cheap, usually in the LDCs, and sell dear mainly in the Western markets that can afford to pay. The needs of the poor in the LDCs, who cannot become consumers of their own products, are of no concern to them.

The increasing interest amongst agriculturalists in biological control has no doubt been caused by the consequences of the accidental transportation of pests, the simplification of environments by modern agriculture and the shortcomings of chemical pest control.

Even the pesticide industry is related to this kind of exploitive agricultural production. If the uses of pesticides and fertilizers in the LDCs are examined in the context of their respective economc systemic, it will be seen that most of the meagre supply that is available to them is appropriated by the export-oriented cash-croppers. Strictly on the basis of availability in the LDCs, the situation for fertilizers is bad, and for pesticides it is disastrous. In 1970 the LDCs were able to obtain only 7% of all chemical compounds available, even though the poorer nations are planting more and more crops which need increasing applications of pesticides in order to prosper, and the economies of many LDCs are very much aligned to this kind of plantation industry.

Furthermore pesticides, like fertilizers, depend largely on petroleum products for their basic feedstocks and the current market situation is very tight in this respect. However increased petroleum prices are only a fraction of the story. Agri-chemicals are produced by perhaps the most research-intensive industry on earth. It has been pointed out by the industry's spokesmen that they now have to screen up to 10,000 compounds for every one that eventually reaches the market, and it will not reach the market before an average of eight years had elapsed.

Most LDCs do not have on hand sufficient supplies of the basic chemical products to make even the simplest compounds, and the more sophisticated products necessitating up to five different syntheses lie totally beyond their manufacturing reach.

In the entire world, there are only 30 to 35 research centres for the development of new pesticides, and this figure may well decrease in the future, since costs are increasing drastically. There are about 10 in the USA, 5 in West Germany and about 10 in the rest of Western Europe, and 5 in Japan. There are a few in Eastern Europe but their products are not marketed outside the area.

Agricultural research did not exist as such before the 19th century. It only got underway during the colonial period because settlers introducing cash crops into newly colonized areas found their plants being attacked by various diseases and pests in the new environments. Research stations sprang up throughout the colonial world, but predictably paid no attention whatever to local

foodcrops. This research lag between cash and food crops is, alas still with us.

In recent years the LDCs have been bombarded with the spirit and hopes of the Green Revolution Technology Package (GRTP). The public relations job to propagate this has been admirable. Technically speaking this means breeding plants that will bear more edible grains and thus increase yields without increasing cultivated crop areas. Traditional grains for reasons of natural selection tend to be tall on the stalk so that they can get more sunlight, grow higher than the surrounding weeds, and resist flooding when heavy rains come. And effort to produce increased grains meant that the plants had to be short and have tougher stalks. Certain dwarf varieties capable of producing spectacular yields under ideal conditions were bred and they are called the High Yielding Varieties (HYVs). The High Yielders present problems of not being disease-resistant, and they will not bear full fruit unless heavy doses of fertilizers are applied. They need plenty of chemical protection—pesticides and fungicides against disease and pests, and herbicides against weeds that also thrive on fertilizers.

If the High Yielders are denied of any one element needed for their cultivation, their production can sometimes be less than that of the traditional varieties. Furthermore repeated application of chemicals to control weeds has adverse effects on soil structure, leading to reduced water infiltration and increased risk of erosion.

Tragedy of Western Models

It is indeed a tragedy that the LDCs have been exposed to western models of farming techniques without having been provided with the kind of research needed to create a sound basis for the expansion of chemical weed and pest control and other applications of chemical substances for agricultural production, if these are necessary at all. LDCs also generally lack skilled personnel, and their educational systems still remain to a large extent oriented to the needs of a subject nation within a colonial set-up.

In the first place there is a need for basic research on the ecology and biochemistry of weeds, and clearly, the more that is known about the conditions that favour the growth of various species in different types of agriculture, the greater will be the possibility of designing cheaper and more effective methods for their control.

Secondly there is also a need for much more investigation into the practical aspects of the use of herbicides and other chemical compounds. Dr. Pimental has uncovered significant data in his entomology studies which relate to organic farming. In a paper written along with an Indonesian expert, Dr. I. N. Oka, titled "Herbicides (2, 4-D) Increases Insect and Pathogen Pests on Corn", a finding has been made that Corn Leaf Aphids, European Corn Borers, and Southern Corn Leaf Blight were more abundant on corn exposed to the 2,4-D herbicide than they were on unexposed corn. They also concluded that the results of their investigation demonstrated that increased risks of attacks by insects and diseases on corn may have resulted from herbicide treatment. Studies on other crop plants on which herbicides are used, on the basis of their findings, are likely to provide disturbing evidence of consequences as a result of herbicidal plant protection programmes.

Recent studies also indicate that the activity of micro-organisms in the vicinity of roots of food crops can lead to changes in structures associated with the selective uptake of mineral nutrients by the plants. Such changes in the pattern of nutrient uptake might be associated with differences in the nutritional quality of the product. It naturally follows that cultivation techniques are bound to affect or modify the chemical composition of plants.

Gone Chemically Overboard

Japan is a good example of a country that could be regarded as having gone chemically overboard. No doubt by trying desperately to sustain itself by directing its people's industriousness towards economic ends, it has achieved material wealth, but at what price! Daily foods full of additives, rivers in which fish cannot live, air which irritates the eyes and throat are the costs that have accompanied their material wealth. Certain experiments carried out in Japan by feeding monkeys on food commonly eaten by the humans have shown physical deformities caused no doubt by the chemically grown food.

The strictest factor, however, that confronts modern agriculture and threatens to limit the activity of the humankind to feed itself is of course the ever tightening situation as regards the availability of non-renewable energy sources.

Many of the pesticides and fertilizers on which successful agriculture in industrialized nations traditionally depends, are derived from fossil fuel energy sources. The search is now for more sensitive and less energy demanding agricultural technologies, than those usually practised in industrialized countries. The farming methods that have to be developed should therefore be designed to harmonize rather than conflict with the natural systems.

As each nation analyzes its future food-producing potential, and takes into account long-range environmental and energy factors, more attention must be given to recycling nutrients through the composting of wastes, and other physical and cultural systems within the discipline of biological agriculture.

Biological Agriculture

Biological agriculture develops 80% of its energy requirements right on the farm. In comparison modern agriculture develops only 5 to 7% of its requirements only. Biological agriculture can profit from the fertilization value of working the soil because of better texture, higher humus content, more bacterial action (e.g. nitrogen fixation) which modern farming tends to cancel out, necessitating energy intensive machinery and equipment instead. The fact is constantly repeated that after two or three years of biological farming the soils open themselves and become lighter.

It could be stated that on the basis of fertilizers and pesticides, biological agriculture consumes three to

four times less energy than modern agriculture.

Dr. Richard L. Ridgway, an entomologist with the US Department of Agriculture predicted not so long ago that natural biological controls in insect pest management will expand significantly, and the expansion rate would depend on any society's willingness to make financial and organizational adjustments favouring the use of biological controls. One approach is augmentation whereby sufficient numbers of beneficial insects are mass-reared and released. In the Soviet Union, a Leningrad factory is producing 50 million helpful insects a day, and biological insect control is now used on 9 million hectares as opposed to 120 million still treated chemically in that country. This emphasis on inhibition of mating, release of sterile insects and the like can be done, and on a considerable scale too.

According to a recent report from Israel, a farmer working on biological methods has had remarkable success in controlling the Leopard Moths that were attacking his olive plantations. This insect is also known to be highly destructive in apple and pear orchards. The same farmer also reported that other Israeli farmers have also indicated much success in controlling Leaf Aphids with fungi, as well as scales and other insects by natural methods.

Perhaps one of the best known examples was how the US Department of Agriculture controlled an insect called the Cottony Cushion Scale which was introduced into California from Australia via imported citrus plants. In Australia it was not an important pest, but unchecked by its natural enemies in the USA, it multiplied with such speed that within two decades (1868 to 1886) it became a major threat to the entire citrus industry of the Pacific coast. The citrus industry in this respect was saved by the introduction of a beetle called *Rodolia Cardinalis*, also from Australia. It not only quickly brought the Cottony Cushion Scale under control in the USA but has had equal success in many citrus-growing areas of the world as well. The factors behind the success of this beetle are probably its high rate of reproduction, its lack of hyper-parasites, and its great activity both as larva and adult.

Insects have also had some spectacular successes in controlling weeds. A little over a hundred years ago, a thorny shrub called lantona introduced into Hawaii as an ornamental plant from Mexico began to spread rapidly and was soon menacing the pasture lands. The introduction of several insects that fed on this plant from Mexico, quickly brought this under control.

In Australia within a period of 13 years nearly half of the 60 million acres of grazing lands infested with an American variety of prickly pear was reclaimed to agriculture by the effective use of several species of cactus-preying insect. Another plant that has yielded remarkably to insect predation is St. John's Wort, a hardy perennial from Eurasia.

However, there is no denying of the fact that the major task ahead for research is to develop less expensive methods to distribute parasites and predators. Already in the USA some 20 different beneficial insects are available commercially from about 25 firms. There is experimental evidence that a number of these beneficial insects can, when reared and released in large numbers, provide the desired level of pest control. Using of Green Lace Wings to control Mealy Bugs on pears, Bollworms on cotton, Aphid on greenhouse flowers and the egg parasite Trichogramma to control caterpillars on a number of crops with great success are just a few examples.

Plants can also combat diseases just as much as animals and humans can. The compounds called phytoalexins (from phyto—plant, and alexin—to ward off), either kill or inhibit further growth of the invading fungus or bacterium. A number of the more important phytoalexins include *Ipomeamarone* produced in sweet potatoes, *pisatin* produced by peas, and *phaseolin* produced by tomatoes and potatoes. The speculation that phytoalexins have potential as natural fungicides is supported increasingly by plant pathologists.

At Cornell University in the USA two scientists have made conclusive studies on certain dry bean plants that fend off some pests by arming themselves with sharp resilient, hooked hair-like structures that entangle, puncture and tear insect enemies. The microscopic outgrowths, known as *tsichome*, aretas effective in limiting insect attacks on beans as thorns and spines are in discouraging larger herbivores from devouring cacti and rose bushes.

Furthermore many organic farmers increasingly reported that the health, fertility and longevity of their animals improved and that veterinary bills decreased, after they introduced biological methods and grew their own feed.

"The widespread belief that it is not possible to hold pests in check by natural predators on an ecologically well-managed farm is no more valid. It is also an ecologically compatible alternative to the use of chemical pesticides to breed crop plants for genetic resistance to insect pests."

Today, even the basic premise that large-scale farming with all its capital and energy-intensive inputs is more efficient than small-scale farming since it is said to produce less expensive goods is also being challenged. It could be seen in evaluating the costs of large farms such items as research, energy, consumption and environmental damage in determining efficiency are often overlooked, aswell as the costs of welfare, unemployment, crime and urban decay resulting from displaced population.

Small farmers lack machinery for this kind of operation. If efforts are made to develop more suitable

machinery for their needs then they could become as technically efficient if not more, as the large farmers.

It is therefore vital that any public or private non-industry funds that can be found for research should go to the areas of biological, microbial, physical, cultural pest control systems, and appropriate technology development. Insects and weeds, soil, cultural practices, and manure are four fields that need much study and research in the LDCs. LDCs must also become conscious of the fact that many commonly used pesticides clearly can be categorized as capable of causing death or disease in alarming proportions apart from the havoc they cause to the environment. It takes extensive knowledge to deal with pests using insecticides. But what is unfortunate is the fact that agricultural extension personnel in the LDCs have not been oriented to biological agriculture, let alone their adequacy to understand the serious consequences of using chemical compounds as fertilizers and for pest control programmes.

Complex Considerations Must Be Thoroughly Understood

The complex considerations such as susceptibility of both crops and weeds to many insecticides, weather at and shortly after spraying, soil types, and contents of clay and humus in the soil need to be thoroughly understood. Infact, the action of herbicides is so much affected by plant species and environment, that sound recommendations for their use in any locality can usually be made on the basis of experimentation in that particular area only.

The LDCs in particular must address themselves more to the realism and practicability of integrated pest management (IPM) systems in which ecological conditions would be the primary determining factors. Insecticides then would be applied only in minimal amounts and only when needed and not according to predetermined spray schedules. This is already a growing concept in the USA, and agronomists, ecologists, economists, entomologists, plant pathologists and systems analysts are increasingly engaging themselves in this pursuit.

Methods of IPM would also include the release of natural enemies, crop rotations, and the use of disease organisms lethal to the pest, genetic manipulation of the pest population, and companion planting.

The only deterrent today to ecological management of pests is the small number of scientists working in this area as compared to the large numbers of globe-trotting chemical salesmen, mostly in the garbs of experts and volunteers.

Another new development in the field of agriculture is the application of computer technology and systems analysis to build models of crop ecosystems that can provide farmers with reliable information on controlling insect pests and other aspects of crop management.

In the field of soil biology, fertilizing of plants by by-passing the soil promotes the one-sided development of some soil organisms that propagate quickly and become pests. Similar reactions occur overground with nutrient supply that can lead to sickness and pest attacks of plants. For instance adding compost promotes a differentiated organism population with a species diversity, and hence an ecological equilibrium is possible. The soil organisms also loosen and mix the humus with minerals from deeper soil layers and therefore the soil need only be cultivated on the surface thereby making tremenduos saving on energy a possibility.

The task before us is to seek out simpler and better ways to improve the soil and the quality of food grown by using manure and wasted organic matter as fertilizers, and by finding natural substitutes for chemical pesticides. There is no doubt that in most cases biological agricultural methods can maintain yields while cutting down expenses for chemicals.

The hungriest countries in particular must aim to reduce their dependency on the west, and engage themselves more in the production of food crops and distribute them more equitably. Self-reliance must begin at the grassroots of these societies. This could be achieved by organizing small community co-operatives and credit unions and involving in joint educational and farming activities.

The role of organic matter in providing a supply of available plant nutrients was the foundation upon which agriculture developed for many thousands of years. It is, however, only in this century that we have been able to identify and tried to quantify the importance of some of the many complex mechanisms involved, and the sum of our knowledge is still an infinitesimal fraction of our ignorance particularly of the role of organic matter in its influence on the composition of soil populations with all that implies for soil fertility.

We are already several leagues behind, battling with the chemical and toxic by-products of the Second World War, while the genuine path towards peace in our time is in the direction of biological systems and in the pursuit of sustainable agriculture which is in harmony with the environment and the well-being of humanity.

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