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Alternatives to Insecticides

THE ICAC RECORDER, June 1993

Alternatives to Insecticides

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It was not long ago when insecticide use was advocated to the extent that it was heavily subsidized by governments. While insecticides are still on the list of many cotton producing countries as an important subsidized agricultural input, others are trying to eliminate them. There is no doubt that insecticides are the most efficient and effective means of controlling insects. Insects must be controlled and insecticides will continue to be used unless feasible alternatives to insecticides are found and adopted. No emphasis is needed on the fact that insecticides are harmful to beneficial insects, pollute the environment, create resistance problems and also are very expensive, out of reach for small farmers in many cotton producing countries.

Those who started using insecticides earlier than others are now leading the way to end the use of these toxic compounds. The objective is to protect the crop not with insecticides, but with chemicals and materials which are safer to use and have equally high efficacy. Such promising alternatives will be discussed in this paper.

In the US, studies by the National Academy of Sciences, the Natural Resources Defense Council and others concluded that farmers could substitute up to 50% of their pesticides with off-the-shelf, non-toxic alternatives without affecting their crop yield. Pesticide reduction plans in the Netherlands, Denmark and Sweden call for a 50% reduction in insecticide use by the year 2000. The current trend of gradually increasing regulations for registering new insecticides and, in certain cases, re-registering insecticides is causing a decline in the market for these products. Safer ways and means of control need to be explored and economically utilized against insect pests and diseases.

Varietal resistance and biological control of insects have long been recognized as means to decrease the use of insecticides. They have been used extensively, but were unable to eliminate insecticide use completely. Similarly, other components of integrated pest management, some of which are easy to apply, have only contributed in decreasing the use of pesticides. I will concentrate on those means of insect control which have the potential to take the place of insecticides.

Plant Materials

Neem-based Pesticides

Neem has long been known to have insecticidal effect. The neem leaves have been used in different forms to prevent infections. Although based on hypothetical considerations, neem has shown results and its use has continued. It has also been used as an insecticide on cotton in the absence of resources to buy expensive insecticides or due to psychological opposition to insecticides. Now the use of neem for making insecticides has been commercialized. W.R. Grace & Co. of Florida, USA, and P.J. Margo Private Limited based in Karnataka, India, have announced the founding of the world’s first commercial-scale facility specially designed for neem-based, natural pesticide production. Initial capacity of the plant is 20 tons per day. The extracts of the Indian neem tree include the pesticide Azadirachtin which is capable of attacking over 200 types of insect pests, as well as some species of mites and nematodes. Presently, the neem-based products marketed as Margosan-O and BioNeem have extensive use in horticulture, but carry a great potential to be used commercially on cotton. The neem-based extracts are harmless to birds, mammals and beneficial insects.

Biosoap

Whitefly is a worldwide pest of cotton with the potential ability to develop resistance to insecticides. The importance of this pest has increased worldwide in the last decade, particularly in the US. In the US, a sudden shift in the population from "A" to "B" biotype enhanced the host range, providing more opportunities to multiply at a higher rate. Looking at the large scale losses in vegetables, fruits and cotton crops during 1991 in Arizona, California, Florida and Texas, the US Government has prepared a Five Year Research and Action Plan for management and control methodology of whitefly. The Nursery Crops Laboratory in Maryland, USA, has developed a product called Biosoap which has great potential as an insecticide against whitefly. Biosoap is made form the extracts of tobacco plants and is environmentally safe. It successfully killed sweetpotato whitefly in the green house and small scale field trials. Biosoap kills an immature whitefly by weakening the waxy protective coating on its body covering, causing it to dry out and ultimately die. While Biosoap killed all the whiteflies in the green house, it killed 94% of the whiteflies in one trial and 78% in another trial under field conditions compared to un-sprayed control plots. The additional advantages of Biosoap include safety to beneficial insects and delayed resistance to insecticides.

Vegetable Oils

Vegetable oils are used as alternatives to neuro-toxic insecticides. There are tremendous advantages to the use of this type of control agent: There are few human hazards; it is simple to use and generally inexpensive; and insects and mites do not develop resistance to oils. Oils primarily act by physical action, but also as behavior modifiers in the control of insects. Efficacy of an oil for combined activities of behavior modification and lethal effect has to be ascertained before it is used as an insecticide. Variation in the physio-chemical properties of the base oil, or the mode by which the oil is formulated, determines a marked difference in its performance. Moreover, chemical characteristics of the base-oil, such as unsaturation and fatty acid composition, can be related to the bioactivity and chemical stability of the crop oil. Optimization of the formulation application is a prerequisite for consistency of field performance. The International Cotton Advisory Committee has recently approved a project for consideration by the Common Fund which will work along the above lines to develop novel insecticides for the control of whitefly. The principle products considered will be vegetable oils; however, detergents will also be tried.

Microbial Insecticides

Bacteria, fungi, nematodes, protozoa and viruses can be used as insecticides to control selected target insect pests. Viruses, bacteria and nematodes have been used extensively in a number of countries. Registered bioinsecticides for commercial use are available, though not popular for cotton.

Viruses

The insecticidal effect of viruses is well known, but it has not been fully utilized. Among the naturally occurring insect pathogenic viruses, baculoviruses have shown the greatest potential from the point of view of safety and effectiveness. The pathogenic viruses have been found to attack more than 12 major insect pests of cotton. The only mode of infection is host ingestion, followed by incorporation in mid-gut cells and later by other susceptible cells causing lysis, liberation of viral products and eventually organ disruption, leading to death of the insects. The virus impregnated larvae/insects continue feeding and moving until they die. A baculovirus Elcar was developed in the early 1980s and showed effective control against *Heliothis* on cotton in many countries, which favored its registration as a commercial product. Unfortunately, the release of Elcar coincided with the introduction of pyrethroid insecticides, which were certainly much more efficient and effective compared with Elcar. As a result, Elcar could not gain a market share and had to be withdrawn. Problems with the baculoviruses include the condition of ingestion by the target host, a slow rate of effect, rapid inactivation by ultraviolet light, long term storage disadvantages and sometimes higher cost of production. These problems have to be overcome if these entomopathogens are to be used as insecticides on a commercial scale.

The interest in controlling insects with entomopathogens has grown in the last few years. Among viruses, nuclear polyhedrosis viruses (NPV) and granulosis viruses have the unique characteristic of producing a large pseudo-crystalline protein matrix known as the inclusion body. The mature viruses are embedded in the inclusion body which provides shelter in the field until the viruses are ingested by the host. The baculoviruses have been tried in as many as 19 countries, mainly against lepidoptera. They have been found to be more effective against *H. zea* and *H. virescens* in the US. In Australia, *H. armigera* has been controlled successfully. In China, NPV has been extensively used to control cotton bollworm, *H. armigera*. But the most successful use of baculovirus against cotton pests has been in Colombia where the application of NPV was so effective in controlling *Trichoplusia ni* larvae that it replaced all other pest control measures.

NPVs have been successfully used against *Spodoptera* spp. in Egypt. Attempts to use viruses against pink bollworm, *Pectinophora gossypiella*, have not been very successful. Probably more research is required to identify suitable viruses or other types of biopesticides for the control of this insect.

The concept of multi-pest killing viruses is also becoming popular. Recently it has been confirmed that the celery looper virus could be purified, packed and sold as a new, environmentally safe insecticide against a variety of insects on cotton, alfalfa, tomato and other vegetable, Sandoz, with the collaboration of the USDA, has upcoming experiments for controlling insects in cotton, in addition to broccoli, cabbage, tomatoes, alfalfa and soybeans. Improving the marketability of viral insecticides is a big challenge for researchers and a crucial point for the companies involved in this business. Extensive work is also going on at the USDA laboratories and American Cyanamid Company to develop compounds which could bolster the deadly effects of insect viruses. Preliminary results show that the addition of certain chemicals can enhance the effectiveness of the viruses by 100 to 1000 times.

Bacteria

The only bacteria used for insect pest control belong to the group *Bacilli*. Within this group, the main species used is *Bacillus thuringiensis*. This group contains a protein crystal in the bacterial spores which provides the insecticidal properties for this microbe. Upon ingestion, the protein crystals are released in the midgut cells of the insect causing paralysis and ultimately death. Unlike the viruses, the effect is immediate and soon after ingestion of the bacterial spores, the insect stops feeding, hence the damage to the plant is stopped soon after treatment.

Most bacteria are lethal to lepidoptera insects, but recently species of bacteria which attack other varieties of insects have bee identified. *B. thuringiensis* has been reported to kill 21 species of insects and is used in 19 countries. Low efficacy against some important groups of insects like *Spodoptera* limits its extensive use. Although the overall use of this microbe constitutes 80-90% of the microbial insecticides, new species lethal to a wide range of insect species could be identified, produced and used on cotton. Large scale use of *B. thuringiensis* has been reported in the Central Asian Republics of the Commonwealth of Independent States. It is also registered in the US for control of *Heliothis* spp. on cotton.

Fungus

In the US during 1991, whitefly caused huge yield losses in vegetables and fruits, in addition to deterioration in cotton quality. The pest appeared late at almost boll opening stage of cotton, yet the losses to agricultural crops were estimated at over 200 million US dollars in the affected states. As it was feared that the whitefly might cause damage in 1992, the whitefly wasp, *Eretmocerus mundus* was released in abundance in September 1992 to control the pest. The whitefly population remained under control, and there have been no reports of any significant damage. Recently, it has been observed that a fungus epidemic may also provide a solution to the whitefly problem. Scientists at the USDA in Weslaco, Texas, noticed a natural outbreak of a fuzzy white fungus in broccoli fields. Entomologists claim that the fungus could be a promising new way to control whiteflies. The fungus, *Paecilomyces farinosus*, was noticed causing damage to whitefly in 1991, but this time it occurred in epidemic form at the right time in farmers' fields in Texas.

The fungus, upon contact with the whitefly, penetrates its body and starts producing spores inside the pest. Thus, the infection is spread throughout the body, resulting ultimately in death of the insect in four to five days. The fungus has the capability to enter and kill adults as well as nymphs of whiteflies. It is known to attack whitefly in cabbage, cantaloupe and cotton fields. It is said to be safe to humans and wildlife, but its effects on other insects are not yet known. USDA researchers are planning to undertake joint studies with the private company Mycotech Corporation to test the fungus' potential as a natural, non-chemical method of whitefly control.

Sex Pheromones

Sex pheromones are chemicals which are used to influence the behavior of organisms. They produce a scent similar to that produced by females to attract males for the purpose of mating. The scent is produced in such a large quantity in the field that the males are confused and unable to locate females for mating. Thus, mating is disturbed resulting in reduced multiplication of the population. The pheromones have been successfully used in cotton on a number of insect pests in many cotton producing countries. They are very species specific and safe for beneficial insects. Pheromones have the following three main uses:

- Monitoring the insect population with pheromone baited traps
- Controlling insect population by using traps on a large scale
- Confusing the males and disturbing the mating process to check multiplication of the insect

Pheromones are available in several formulations. Hollow fibers and laminate flakes have to be applied with glue in special applicators to ensure adherence to the cotton leaves. Microcapsules are water-based suspensions and can be sprayed with conventional applicators. Pheromones in the form of twist-tie and PVC dispensers are labor intensive as they must be individually tied to the plant stem by hand. The important advantage of pheromones is their long lasting effect; they are applied only once each season.

Pheromones have generally been successful against pink bollworm, perhaps because of much greater persistence of twist-tie PVC resin formulations. Pheromones have been used in the US since 1978 in Arizona and southern California. Results have shown that pheromones can reduce insecticide use by almost 40%. The limiting factor in their use is hand application, which offsets part of the lower cost of insecticides.

Pheromones have also been tried in China, Egypt, India, Israel and Pakistan. Pheromone treated fields gave comparable yields and preserved beneficial insects. The use of pheromones has remained restricted due to high cost of the product, labor intensive method of application, persistence for a shorter time and prevalence of more than one species of insects at the same time. The problem of higher persistency has been overcome, but still only those countries in which labor cost is low can afford hand application. Use on a larger area and on pests with limited migratory habits best shows the impact of pheromones. It is generally concluded that pheromones can be successfully integrated with broad spectrum insecticides to have season-long control of insects. However, if pheromones are used on large areas continuously for years, they have the potential to eliminate the need for insecticides. The impact of the pheromones is evident, but that is required is an increase in the spectrum, so that one product can be used against a variety of insects, and improved application methodology, so that they could be sprayed like conventional insecticides and only once for the crop period. Other uses of pheromones, particularly trap monitoring, could be expanded to improve the correlation of trap catches with field infestation.