

## COMBATING INSECT PESTS\*

**C**ROP production is a very keen contest between nature and man. A farmer runs a race with soil, climate and enemies of crops, and it is but very rarely that an Indian farmer wins the race. It may be claimed that, with efforts, he can mould the soil for his purpose, and be independent of heaven's mercy for water where facilities for irrigation exist, but climate is beyond his control and the gods of seasons are rarely kind to him. He lives perpetually in terror of dust-storm, drought, excessive and untimely rain, hail storm, frost, and so on, and in addition to these, diseases and pests threaten his crops. The enemies of crops are indeed numerous and range from the ultra-microscopic viruses, which pass through the finest filter, to elephants. The most numerous and the most tenacious of all these are the insects which cause our farmers untold losses.

Nature has endowed these animals of small size an organization most suited for rapid increase in numbers and there is hardly any matter of animal or plant origin living, dead or decaying, which does not provide food for some insects, and there is hardly a habitat in which insects are not found. Some insects feed even on opium and there is a fly the larvae of which live in pools of kerosene oil.

Such creatures man has helped to flourish. Man has cleared vast tracts of natural vegetation and brought under irrigation extensive arid regions, and on the land thus made fit for his use, he grows his crops, or in other words crowds together an enormous number of plants of the same type. He thus provides certain insects with immense quantities of easily available nutritious food.

Besides, man conserves animal and human food of every description : to this insects have free access, and they find conditions most suitable for their rapid increase. Near human habitation accumulate immense heaps of refuse, consisting of decaying organic matter, which provides certain insects with abundant food. Man has introduced plants of one country to another and with these he has brought in insect pests. India has given to the world a number of such insects and the compliment has been returned in the form of San José Scale, Woolly Aphis and Potato Tuber moth, to mention but a few. With his merchandise man has taken insects from one country to another and these enemies of man have thus crossed unsurmountable barriers without effort. Quick means of transport : railways, motor cars, steam-ships and now aeroplanes, all help in the spread of insect pests. Under natural conditions insects had numerous enemies, which checked their rapid increase ; unfortunately through his lack of foresight man has destroyed the abodes and actually killed off these maintainers of balance in nature. Numerous birds and reptiles

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and other animals, which fed mainly on insects, man has reduced to a condition of impotency. In short, man's system of crop production—cultivation, irrigation, growing, harvesting and storing crops, disposal of crop remnants and refuse, has produced conditions which enable certain insects to escape the rigours of climate and attacks of their enemies and find abundant supply of easily available food. No animal has interfered with nature to the extent that man has done and in doing so he has helped his most virile competitors—the insects, to multiply unchecked. The punishment imposed by nature upon man for this interference is also very heavy. It has been estimated that in the United States of America, in spite of her most advanced pest control organization, insects cause a loss of 2 billion dollars annually. Fletcher estimates that in India the annual loss to sugar-cane, from bores alone is not less than Rs. 300 millions per year. During 1905 it was through the ravages of a single insect—the Spotted Bollworm of cotton—that the Punjab cotton growers suffered a loss which has been estimated at 5 crores of rupees. San Jôsé Scale is responsible for the destruction of thousands of fruit trees in Kashmir and the fate of this industry depends directly on the effort put in to check this pest. It has been stated that, at a very conservative estimate, the Indian farmers and fruit-growers pay their insect conquerors a tribute which is not less than Rs. 1,95,00,00,000, a year. As our population increases and our needs grow greater, we come more and more in conflict with insects, and therefore the fight is becoming keener and more intensified every day, and at every stage insects defy man's efforts for mastery over the resources of the globe. There is nothing to show that man's victory over insects is either near, or sure.

Since prehistoric times man has waged war against insects and has evolved varied methods to save his crops and crop-products from depredation by these foes. Some of these methods in their natural simplicity appear most crude, while others based on the highest scientific knowledge and mechanical skill are most ingenious.

The simplest and natural method of "hand-picking", which monkeys and human beings employ to get at the body-louse, has survived up to the present day because of its efficacy. A number of our important pests, for example, the Red Pumpkin beetle and the Egg-plant Lady-bird beetle can be effectively controlled, over small areas, by this method. Where childish enthusiasm can be directed into useful channels, or the cultivators have spare time, this simple method may yield results of value even over larger areas. Sugarcane Top Borer moths and caterpillars of Lemon Butterfly have been successfully hand-picked. What is captured may be crushed, but a more elegant procedure is to drop the catch into a receptacle—for example an old cigarette tin suitably stringed—containing water with a layer of kerosene oil.

Some insects when disturbed fall down from a tree and may be collected in sheets or umbrellas. Some beetle pests can be effectively controlled by this method.

A number of our serious crop pests lay eggs in clusters, and it is possible to crush such egg clusters *in situ*, or to hand-collect and destroy them. Such insects as the Sugarcane Pyrilla, Sugarcane Moth Borers, Hairy Caterpillars often yield to this treatment. Collection of eggs is one of the measures of

locust control and during locust invasions enormous quantities of egg masses have been dug out of the soil and destroyed.

Among aids to hand destruction of pests mention may be made of such simple contrivances as the fly-flappers, insect hand-nets, sticky rackets, etc. In the Punjab, hand-nets have been very successfully used against Sugar-cane *Pyrilla*. In the hands of an army of boy scouts this simple implement may work wonders. An elaboration of the hand-net is the "field-bag", which is effective against grass-hoppers. To the same category belong the hopper-doers.

One method of dealing with insects boring into stems of fruit trees is to hook them out by means of metal wires with hooked or barbed ends.

Trapping has been used effectively against insects. The simplest form of trap is a pit, trench, or ditch. Insects moving in large swarms readily fall into ditches dug in their path. When in these ditches they can be earthed over. This method has been extensively employed in locust control, and, in conjunction with barriers has proved most effective. Locust hoppers may even be driven to a trench made for their reception.

Lures are often used to entice insects to their doom. Entomologists have taken advantage of the fascination which light exercises over certain insects, and have evolved light-traps varying from a lamp placed over a vat containing kerosenized water to elaborate automatic electric appliances for attracting and capturing insects. The most recent of these is the violet ray apparatus. Lighttraps have given excellent results against *Amsacta* moths, *Ber* beetles (*Adoretus nitidus*) and *Nephotettix*.

It is presumed that insects are guided towards their food, most probably by some sense akin to our smell, and this is the sense which most often brings the sexes together. If agents of these attractions can be discovered, it should be possible to devise effective traps for capturing most insect pests. Insects' response to certain chemicals is well-known. Sweetened baits are used to capture flies, ants, cockroaches, etc., and sweetened beer is used for house crickets and moths, and other chemical traps have also been tried. The males of the Mediterranean Fruit Flies are attracted strongly towards kerosene oil, and those of our Peach Fly towards euginol. Unfortunately, the females are not influenced in the least by these chemicals.

Heat is an effective insecticidal agency. No insect can long survive an exposure to a temperature of 150° F., and most of them succumb to 130° F. if exposed to it for a few hours. In India, where bountiful nature has bestowed us with a free source of strong radiant energy, sun-heating is an economical and effective measure against insect pests. Such material as weevilled grain, cotton seed harbouring hibernating Pink bollworms, insect-infested seeds, drugs, spices, woollen material, books, furniture, etc., can be sun-heated. It is also possible to raise the temperature of a room sufficiently high to destroy insect life. Modern flour mills, grain elevators, ships, glass-houses, etc., are provided with permanent installation for heating them to the required temperature. There are machines available which heat to a temperature lethal for insects, infested grain, or seed, which is run through. In Egypt such

heaters are used extensively in campaigns against the Pink bollworm of cotton, the hibernating caterpillars, which are responsible for the carry over of the pest, are thus destroyed. The same measure has been proposed for the United Provinces. Whether heated in a machine or by exposure to sun, this pest can be checked by systematic and organized campaign of heat treatment of all seed, prior to the emergence of moths.

Heat cannot be employed in all cases. Rice exposed to a temperature of 130° F. is spoiled because the enamel of the grain cracks, similarly tobacco deteriorates on exposure to high temperature. Therefore, low temperature is employed in these cases. Cold reduces insect activity and there is practically no insect damage if the temperature is below 40°F.

Fire is employed to destroy insects. Locust hoopers congregating in thick swarms over dry bushes may be burnt to death. Flame throwers although expensive to work, have been used extensively in locust campaigns. If a material is badly infested and its destruction will save a much greater damage, then fire is a valuable "purifier", hence the recommendation "cut and burn". All refuse collected from stores, mills and factories suspected of harbouring insect pests, should be consigned to fire. Such crop remnants as contain hibernating stages of insect pests should be pulled out and used as fuel. Borers of sugarcane, rice, maize and *jowar* will be greatly reduced, if stubbles of these crops are collected and burnt before the emergence of moths after winter. Burning cotton sticks before the new crop is sown will eliminate many of the cotton pests.

Poisons—man's favoured weapon against his enemies—came into use quite early in fighting insects. Some poisons act when taken internally (stomach-poisons), and the commonest and most efficacious of these are the arsenicals. These are poisonous to man and domesticated animals and for this reason there is considerable, although unjustifiable, prejudice against them. In 1923 the U. S. A. used 45 million pounds of arsenicals without any serious mishap. Recently, however, some flourine compounds of sodium and calcium, and other chemicals, have been discovered which are distasteful to poultry and not so poisonous to cattle and man.

The stomach-poisons are applied to the food of the pest. Either a thin film of poison is spread over the surface of the plant, which the pest devours, or it is mixed with a material which the pest would eat readily (poison-baits). The poison-bait of bran, or other similar material, is the most efficacious method of dealing with locusts and grasshoppers, cutworms and house crickets, and insects with similar habits.

A large number of serious plant pests puncture the tissues and suck the plant juices. Such insects cannot be killed by stomach-poisons, and insecticides have to be used which cause their death when coming in contact with their bodies (contact-poisons). Soaps, emulsions of mineral oils, sulphur compounds, naphthalene compounds, rosin compounds, etc., have such action.

A number of plant products of excellent insecticidal value are available ; of these some act as stomach-poisons, *e.g.*, hellebore, while others as contact poisons, such as nicotine and pyrethrum, and still others act as both, *e.g.* derris.

Insecticides whether in the form of dust, suspension, emulsion, or solution must be applied evenly, quickly and economically.

Very rapid advances have been made to evolve suitable spraying and dusting machinery. From simple hand syringes and dust shakers we have advanced to elaborate power sprayers and dusters. Certain orchardists have stationary power pumps with permanent pipes laid among rows of trees, and on the other extreme we have aeroplane dusting and spraying of crops and forests. How efficacious aeroplanes are may be judged from the fact that an acre can be sprayed in seven seconds. Locust hoppers are poisoned by dusting their food plants by means of aeroplanes and attempts are also being made to deal with the flying swarms from the air. In India no aeroplane dusting or spraying has been tried so far.

Most of the insecticides, and spraying and dusting appliances are imported into India, and very often the prices make their use prohibitive. The future development of the insecticidal method of insect control depends directly on the availability of cheap and suitable insecticides and dusting and spraying appliances.

Poison gases have been employed very commonly against insects attacking stored grains and stored products, and against other household pests. The fumigants most commonly used are hydrocyanic acid gas and carbon bisulphide, but sulphur dioxide, carbon monoxide and dioxide, carbon tetrachloride, para-dichloro-benzene, and even pyrethrum powder and tobacco extracts are also employed. The latest development of this method is fumigation under vacuum, where the material to be fumigated is placed in a special container the air of which is withdrawn, and the fumigant introduced. This facilitates penetration and reduces the time of exposure. Fumigation, with hydrocyanic acid gas, of living plants in green houses or in special boxes and even under "tents" is an effective method of pest control. The Indian Central Cotton Committee fumigate all consignments of American cotton to safeguard against the entry of the notorious Boll Weevil of cotton, and all living plants imported into India have to be similarly treated at the port of entry to safeguard against foreign pests.

The ancient practice of storing grain with a small quantity of an amalgum of mercury with oil or ashes has a scientific basis. It has been found that in the presence of mercury vapour insect eggs do not hatch.

To fight soil-insects; insecticides in the form of dust, liquid and gases are employed. Dusts may be sprinkled over or dug in, and liquids and vapours are forced in. Soil injectors of different types have been evolved leading from hand injectors to traction injectors.

The most interesting development of chemical warfare against insects is through injections of chemicals into the tissues of plants. Barium chloride, aluminium sulphate, pyridine in very weak solutions have given good results against Woolly Aphis of apples. Small pieces of potassium cyanide introduced into the trunk of trees destroy scale insects and other sucking insects, but the process is not without risk. Trunk borers of trees may be treated by plugging the burrow with cotton wool soaked in chloroform-benzene mixture or similar other material.

Even more ingenious than the above is the development of immunity or resistance among plants through soil treatment. Mosquito Blight of tea has been effectively checked by applying phosphatic manures. This field of attack presents immense possibilities. It is reasonable to suppose that soil conditions may so influence a plant as to develop immunity or resistance against certain pests.

Insects have also been destroyed through ethereal vibrations. The Cigar beetles have been destroyed by exposing boxes of cigars to Roentgen rays, and radio waves have been used for the control of plant pests. It is expected that ultrasonic waves will prove of great value in insect control.

Valuable crops may be protected by enclosing them within trenches or metal sheet barriers. Invading bands of locust hoppers and similar other swarming insects are thus kept away. Valuable seed beds may be protected by wire-netting and valuable fruits may be enclosed in paper bags, or bags of netting. Wire gauze of suitable meshes wrapped round the stem of a fruit tree is a good protection against attacks of borers, such as the fig-tree borer.

A number of insects lay their eggs in the soil and their young ones on hatching out crawl up the trunks of trees to reach the soft shoots or flower heads. These insects may be stopped in their ascent by the use of barriers applied to the trunks of trees. Bands of smooth-glazed paper, smooth oil cloth, tin sheets, coal tar and other sticky materials form effective barriers. Bands of fluffy cottons are particularly efficacious against *Monophlebus* nymphs that crawl up the trees from the soil. A ring of sticky substance, heavy oil or coal tar painted on the soil does not permit insects to reach valuable plants. Coal tar and gas refuse are good repellents to safeguard against white-ant attacks. Tapes soaked in corrosive sublimate are not crossed over by ants.

Insects, although the favoured of nature, are an important source of food supply for some animals and are subject to attacks of organisms causing disease and death. And just as is the case with human beings overcrowding in a locality encourage epidemics. Whenever an insect appears in enormous numbers its enemies also increase. Bacteria, fungi, protozoa and parasitic-worms the chief casual agents in human diseases—also parasitize insects. Quite often severe onslaughts of insect pests are wiped out by these organisms. Of the animals with back-bone, some fish, all frogs and toads, many lizards and snakes, numerous birds, hedgehogs, shrews, bats, lemurs, monkeys and many other mammals mainly subsist on insects. Larvicidal fish, whose favourite food are mosquito larvae, have secured a place of honour among measures of malarial control. Birds, because insects form the staple diet of a large number of them, are farmers' best allies. It has been truly said that without his beautiful feathered friends, man will find it difficult to hold his own against insects. Unfortunately it is this group of beneficial animals which man has reduced in numbers to his great misfortune. For their useful work in dealing with the locusts the starlings have received government protection. Bird protection and encouragement is of great value to the farmer. It must, however, be remembered that in absence of insects even the insectivorous birds feed on grain and fruit, and it is, therefore, necessary to watch bird increase and activity with great care. The value of the study of birds and their food

to an agricultural country cannot be over-emphasised. Combining fruit-growing with poultry-farming has evident advantages. In a limited area a pen of poultry would clear off grass hoppers within a short time, and will make a short work of other insects found on the surface of the soil or just below it. Even insect-eating bats have their value.

The chief enemies of insects are, however, those of their own kith and kin. It has been estimated that in a given area 25 to 30 per cent. of the insects present feed on other insects. Were it not for this army of beneficial insects, the harmful insects would have obtained a sure victory over mankind. The commonest examples are the Lady-bird beetles, Lace-wing flies, Hover flies, Dragon flies, predacious beetles, preying mantids, flies and wasps and members of other groups. These tigers among insects devour Green-flies, White-flies, Scale-insects and other insects. There is yet another section of this useful army which consists of parasites—small wasps, flies and members of certain other groups. They lay their eggs on or in the bodies of insects and their young ones live on the tissues of the victim and kill it. All the stages from egg to adult may be parasitised.

Entomologists have attempted to array this army of beneficial insects on the side of man. In some cases wonderful success has been achieved. One single instance will be given. The Cottony cushion scale of citrus was introduced from Australia into California in 1868. By 1890 it had killed thousands of trees, and the citrus industry was in danger of being completely wiped off. From Australia 500 of the Lady-bird beetle predators of the scale were introduced and distributed among the fruit-growers. Within a year and a half the beetles had multiplied in sufficient numbers to check the scale.

Biological control of insect pests has given best results against introduced pests. In India, where most of the pests are indigenous, an equilibrium has been set up between the pest and its enemies, therefore without special efforts it is not possible to give a predator or a parasite a chance of winning the battle. There is, however, a great need for large-scale, intensive investigations to determine the possibility of biological control of insect pests.

For India with her low yield of crops, and poverty-stricken illiterate peasantry, the cheapest and simplest methods of insect control are the best, and prevention very often is better than cure. Most effective results can be obtained by carrying out farm operations intelligently. It is estimated that 95 per cent. of the insects pass some portion of their life-cycle in the soil. Tillage operations expose insects in the soil to the severity of climatic conditions—blazing heat, heavy frost or desiccation and to their enemies—predators and parasites. Very few insects can survive in a field which has been ploughed up often enough. Soil preparation is thus of great importance in insect control. Irrigation is also an effective method in pest control. White-ant attack on wheat or sugarcane can be checked by watering, and flooding destroys many other pests. Manuring to produce vigorous and quick growth, and early maturity also help in decreasing losses caused by insects. Soil conditions very often determine the degree of resistance that a plant develops against a pest, and soil conditions depend on tillage, irrigation, drainage, manuring, etc. Altering time of sowing to escape insect attack also has great possibilities. In places where mole crickets injure wheat, delayed sowing is an effective remedy.

A proper crop rotation is useful in combating insect pests. It has been seen that cotton sown after gram is likely to be damaged by *Laphygma*, which feeds on gram and can also feed on cotton.

Cleanliness on the farm or in an orchard is of utmost value in insect control. Accumulation of rubbish, fallen leaves, old vines, dry twigs, stones, etc., provide shelter to some insects during the intense heat of summer and the severe cold of winter. It is in such situation that insects which are active at dusk and at night, lie concealed during the day, and the day-insects spend their night. Remnants of crops which are left in the field after a crop has been harvested provide food to some and shelter to many. Borers of rice, maize, *jowar* and sugarcane overwinter in the stubbles that are left in the fields. Weeds that grow among crops and fruit trees often provide food and shelter to insect pests. Sprouting crop remnants or volunteer plants supply food to insects at a critical stage of their annual cycle when their main food-supply is not available. To control your insect foes destroy their shelter and cut off their food supply, particularly at the most critical time of their seasonal cycle. Very often the most serious pests of crops are very specific in their choice. Spotted bollworm of cotton would confine itself to the Malvaceous plants—the family to which cotton, common vegetable *bhindi* (ladies finger) and common garden plant *Althea rosea* belong. Top borer of sugarcane has only *sarkanda* as its chief alternative food plant. Red pumpkin beetles do not feed on any plant outside the Cucurbits.

In some cases the alternative food plant is used as a “trap crop”, a crop which attracts the pest. This crop is grown to attract the pest to itself and when the pest has concentrated on it, the crop with the pest is destroyed, *i.e.* cut and fed to cattle or ploughed in or burnt.

Domestication leads to decrease in the natural resistance of plants and animals. The more highly domesticated or “improved” a variety, the more severely it is likely to be attacked. There are, however, some varieties which, to a certain degree, combine resistance to pest attack with other useful qualities. The possibility of evolving such varieties has been demonstrated. A cotton which is Jassid-resistant has been produced, and there are varieties of Coimbatore sugarcanes which are partially resistant to *Pyrilla* and Top borers. It is known that apples grafted on the root-stock of Northern Spy and Winter Majetin develop resistance against Woolly Aphis. It is very essential that when new varieties have been evolved their behaviour towards the commoner pests is carefully studied under varying conditions. Moreover, it is very important that the real basis of such immunity is scientifically investigated, so that we are able to build up a science of plant resistance. Very often a very small factor, which may be considered of no consequence otherwise, such as slightly increased hairiness, a little toughness of the cuticle, a slight change in the acidity of the cell-sap, a more vigorous growth at a particular stage, a particular habitat bringing about alteration in the micro-climate for the insects may have far-reaching benefits.

It must, however, be remembered that there does not exist any plant that completely defies insect attack, and it is not likely that man will ever be able to produce a variety of any of his domesticated plants which will possess

complete immunity, from all insects, for all times. There will be a continual race between our defensive efforts and insect attacks. Whoever can make more rapid progress is sure to win.

This very brief and cursory review of the measures, which man has evolved to combat insect pests, shows that all the elements of human warfare are reflected in our attempts to fight insects. From hand-to-hand fight we have advanced to poisonous gases and attacks from the air. We are using electricity and are looking forward to death waves. There are, however, a few aspects in which there are tremendous differences. Our internecine wars we fight by means of a thoroughly trained and organized force. Most nations have enormous standing armies, kept at high efficiency and at all times fully prepared for action. In some countries there is conscription and every able-bodied man is trained to fight. To combat insects we have no trained army and every cultivator without knowledge and training is expected to fight his battles by himself. Further, human wars are carried out with utmost abandon and the question of expense, although fundamental, is often relegated to the distant background. Nations may indulge in the luxury of wars on borrowed money. On the other hand when dealing with pests of crops, the question of first importance is that of expenditure, which is to be carefully considered in relation to the advantages gained and the measures to be adopted must necessarily be most economical. If it does not pay to kill an insect pest, it is not killed. No army can fight its battle to a successful issue, unless scientific research has provided it with weapons superior to that of its foes and through regular practice of war-craft it has not reached a high standard of efficiency, and unless it knows, through its spies and through field reconnaissance, all about its enemies. Even then, the success is doubtful unless the entire resources of a nation—human, animal and material—are placed at the disposal of the army. Surely when fighting insects our most terrible foes—we must be armed with a full and detailed knowledge of their habits, behaviour, weaknesses, and disseminate this knowledge among the entire community to create a communal feeling against insects and prepare every man and woman, boy and girl, for this most noble of wars. In European countries training for defence against poisonous gas attack is being taught to the civil population; then has not the time arrived when the entire population should be acquainted with the methods of defence against our bitterest foes—the insects—constantly present and always at war with us inflicting us with foul diseases, causing us terrible loss in life, food and property? Thus there is a growing need for more and more research in methods of combating insects, and public instructions in warfare against insects.

Without organization insect control is impossible. A solitary individual, who spends money and energy on insect control, wastes his resources, if his neighbours do not undertake such measures. Therefore, co-operation amongst the farmers is absolutely essential for insect control. To obtain the necessary co-operation and concerted action pest control organizations are essential. Legislation is the basis of organization. We must have laws to enforce co-operative action against pests. We must also have laws to safeguard the carriage of pests from one locality to another. Some years ago in Madras a

Pest Act was introduced and recently the Kashmir Durbar has legislated against San José Scale. It is true that all plant material imported into India is fumigated at the port of entry, but there is no check to the introduction of pest over the land routes and the pest laws are absent in most parts of the country.

Our country is far behind other countries in the development of pest control measures, and yet we have to compete with those countries in the world market. Our crop yields are low and in most cases the lowest in the world ; we can no longer ignore the waste that is going on perpetually. Even 10 per cent. of the Rs. 1,95,00,00,000, that we allow insects to take from us, if saved and spent on rural reconstruction, will make India the land of peace and plenty.