

# THE CONCEPT, PHILOSOPHY AND FEASIBILITY OF INTEGRATED PEST CONTROL WITH PARTICULAR REFERENCE TO COCONUT

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## I. Introduction

Although the insects are minute the problems created by them are of such huge magnitude that their solution often requires concerted action on a very large scale. Even the very minuteness of insects constitutes a very important and effective evolutionary strategy; their minute size has been obviously dodging their enemies including man by keeping them in a state of complacency. It is fairly clear that insects originated with the origin of land plants. The intensification of agriculture has been accentuating the pest problems. Adequate steps are to be taken to stop this accentuation. The strengthening of the pest control research has to commensurate with the magnitude in agricultural revolution, if pest problems are not to be allowed to become the limiting factor in our production drive.

With the advent of green revolution the great debate on production technology has yielded place to protection technology. Pradhan, the pioneer agricultural entomologist of India had pointed out the worsening pest situation and has also exploded the time honoured statistics of 10-20 per cent loss due to crop pests. He laid bare the fact that under high yielding conditions of crop husbandry, the losses shoot upto 70-80 per cent. The term pest broadly includes all living organisms inimical to the the interests of man such as plant pathogens, weeds, harmful insects, mites, nematodes and mammals like rodents, bats, jackals, monkeys, elephants and stray cattle. The ingenuity of man's nature has developed a plethora of methodology and weaponry to fight these battles. The power of adaptability of his foes is however boundless. It is not pos-

sible to annihilate an insect pest or disease completely. Effect should therefore be directed towards suppressing the pests and diseases.

The indiscriminate use of pesticides in the control of crop pests has resulted in pollution of environment. It has become imperative that alternate, less hazardous and long lasting methods of pest management must be developed. Several methods of pest control like biological control, cultural control, mechanical control and use of genetic resistance, apart from chemical control have been tried on crops with varying degree of success. It is being increasingly realised that no single method of pest control is adequate to keep all the crop pests in check. An integrated pest management making use of all available measures of pest control and exploitation of all natural factors which operate against the pest

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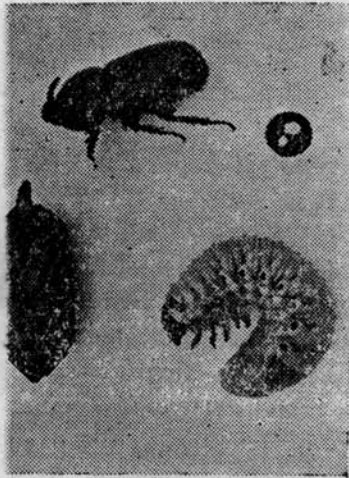
Central Plantation Crops Research Institute, Regional Station, Kayangulam.

efore appears to be the most and promising way of dealing with pest problems in crops.

### General discussion on the different constituents of intergrated control-philosophy behind the same.

#### Chemical Control

ant breeding and fertilizers are lutely essential pre-requisites he prevention of famine, but lead us farther and farther from the biological balance



Life cycle of rhinoceros beetle.

ture. Inevitably crops became asingly susceptible to insect population. Until a few years only the chemical method had ved real success in pest control. since the second world war and potent insecticides have discovered. DDT was the first effective synthetic insecticide rapidly gained very great imnce in the control of a number sts. This was followed by contact insecticides like BHC, 1, Dieldrin, Endrin etc. The stic organophosphates origin- 1 Germany during the second war as substitutes of nicotine

and were quite useful in agricultural pest control. But because of their extreme toxicity to warm blooded animals, these potent insecticides could not be used widely to control insects affecting man and animals. Now emanating from U. S. A. is an attitude of alarmingly exaggerated and mounting antipathy towards the use of chemical pesticides particularly DDT. If the environmentalists succeed, "then the world will be doomed not by chemical poisoning but from starvation".

The excessive and indiscriminate use of insecticides and other toxic substances for agriculture, forestry and health purposes definitely poses a threat. After repeated uses resistance develops and then increasingly stronger doses will have to be used. The greater susceptibility of numerous beneficial pollinators, parasites and predators to modern insecticides than the pests themselves and the rapid resurgence of the pests in the vital absence of its natural enemies is a serious problem that confronts the agricultural entomologists. In such a circumstance, selective insecticides with less retentive toxicity can be used. Selective insecticides are those which owing to ecological and physiological difference between the pest, predators and parasites would kill the pests at a concentration which does not affect the beneficial insects.

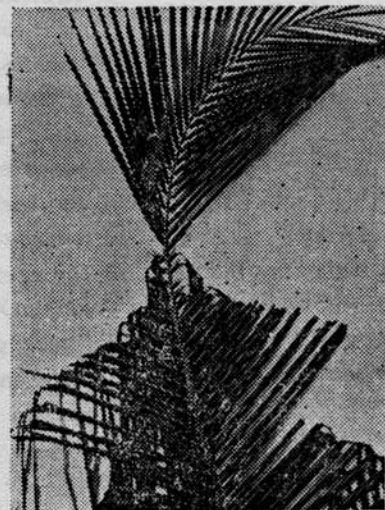
#### 2. Biological Control

Since the plant protection problem is becoming more and more complicated due to the side effect of pesticides the biological method of control is becoming popular and is considered to be comparatively more economical, besides being harmless and effective.

By biological control we mean the control of a harmful animal or plant species by the action of its natural enemies viz. parasites, predators and pathogens. In other words it is the encouragement of the natural control of a pest. This may be accomplished either by utilising the indigenous parasites, predators and pathogens or by introducing the exotic ones.

#### Parasites

Usually the adults of parasites are free living. In their, larval stages, they develop as endo or ectoparasites upon a single host individual, the latter eventually dying as a result of attack. In U. S. A., Australia, New Zealand, Fiji and Canada in all about some 30 major pests have been fully controlled through the use of parasites and predators. In Fiji the coconut moth *Levuana Iridescons*, which was a great threat to copra export was controlled by the introduction of a tachinid fly, *ptychomyia remota* from Malaya. The expenditure involved was only about £ 22000 and yet it saved a potential loss of annual income of

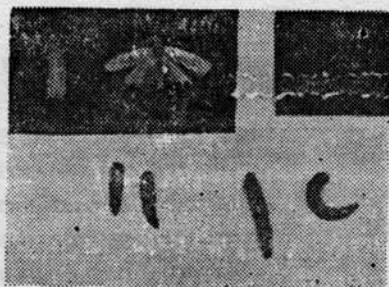


Coconut leaf damaged by rhinoceros beetle

some £300,000 from this pest. There are a number of parasites which attack the leaf eating caterpillar *Nephantis serinopa* in its various stages. Bethylids, braconids and elasmids are the important larval parasites and eulophids are the pupal parasites of *Nephantis* in India. There are a number of parasite breeding stations in the coconut growing states of India. In addition to the indigenous parasites, experiments are in progress at Kayangulam using the exotic parasite of *Nephantis*, *Spoggosia bezziana* introduced from Sri Lanka. A Nematode bacterium complex DD-136 is found to parasitise a number of insect pests.

#### Predators

A predator is to a large extent free living in the larval stages also and it kills the host immediately by direct attack. A number of predators of *Oryctes* have been reported from India which attack them in the immature stages. Both the adult and larval stages of *Santalus* (Histerid) and *Scaritis*



Life cycle of leaf-eating caterpillar

(Carbid) are predatory on the eggs and grubs of *Oryctes*. An exotic predatory reduviid bug, *Platymeris laevicollis* is found to feed on *Oryctes* adults. In Central Plantation Crops Research Institute, Regional Station, Kayangulam experiments are being conducted with this bug to examine whether we

can get them established here for the control of *Oryctes*. In the experimental centres where *Platymeris* have been liberated the attack of rhinoceros beetle is found to have decreased considerably.

An important finding during studies on integrated control of giant African snail *Achatina fullica* was the principle of using distantly related enemies like the predatory millipedes instead of closely related ones. The useful principles involved seems to be that taxonomically the farther the groups are to which the pest and biological control agent belong, the more there is safety margin between the two in the use of chemical pesticides.

There is no doubt that vertebrate predators, of which the most important are birds and rodents, destroy large number of noxious insects, but opinion is divided on the efficacy of this method of natural control.

#### Pathogens

Certain bacteria, fungi, protozoans and viruses are capable of producing deadly diseases in insects. But even though they are common in the field and occur sporadically and cause devastating control, have so far proved somewhat unreliable when artificially introduced. In a few cases the disease causing organisms that attack certain species of insects have been utilised to create epidemics among them. In Central Plantation Crops Research Institute, Regional Station, Kayangulam experiments are being conducted using certain pathogens like *Metarrhizium anisopliae* and *Rhabdionvirus oryctes* against the grubs of *Oryctes*.

The quest for a better substituet

for DDT in U. S. A., to save crops, has yielded bacteria and viruses which destroy insect pests without ill effects for human beings and animals and of course for plants. The environmental protection agency of the United states has



Life cycle of Red Palm Weevil

approved for commercial use a virus developed by Carlo Ignorffo, Head of one of America's agricultural research services Laboratories. A. M. Heimbil, who leads another laboratory says, "without counting bacteria, there are over 100 pesticide viruses coming also for different uses—most of them for very important uses". Some are absolutely specific. But there are others that can be used against several different pests now attacking feed and fibre crops. Heimbil has developed bacterial insect killer which destroys lepidopteran noxious insects at the larval stage. The British delegation to the United Nations Conference on human environment at Stockholm has given details of a new centre on virus insect killer to be set up at Oxford. Now another FAO specialists conference has followed this up by calling for measures to encourage the indus-

duction of viruses "target-destroy individual pest. Completion of tests to that these viruses are harmless, animals and environmental.

Success of biological control on the ability of the insect parasite, predator or to survive in the new environment



Life cycle of cockchafer beetle

environment and also the ability to adapt itself advantageously at the various stages in the life history.

Diversified pest control as opposed to single approach pest control

Now that no species of insect has appeared from the earth because of man's activities. It is possible to suppress destructive insects when such insects migrate to a new locality they should be controlled, while their numbers are low, even at great expense. If they multiply, continue to multiply, and cause serious losses. The origin of agriculture is associated with the practice of monoculture, in place of mixed cropping, leading to origin of insects.

Now these monocultures with a narrow germ plasm are being replaced by those of narrower and narrower germ plasm in the form of varieties. These are further

leading to adverse effects so far as pest control is concerned. These adverse side effects of modern agriculture can be to a large extent minimized by replacing single approach pest control with diversified pest control which should be properly integrated and scheduled. Our efforts should be for the proper balance between various control methods conventional and sophisticated or an integration of different methods so that plant protection may be effectively implemented at the least cost to both grower and consumer.

#### 4. Sterilization

As in other fields of biology there are many pest control problems in which the application of nuclear radiation and radioisotopes can be usefully recommended. The use of sterilized insects is a form of biological control that may not be offered as a panacea or as a replacement for conventional control procedures. However the gratifying success with sterilized screw-worm flies should encourage entomologists to think about the possibility of applying sterilization technique to some other species. Dr. Knipling's work on control of screw worms (*Callitroga hominivorax*) is the most outstanding one. The phenomenal success of eradication programme of screw worm, pest of sheep and cattle in the U. S. A., by the release of males sterilized by irradiation, has already become an entomological classic in its own right. The laboratory bred, sterilized insects are capable of competing for mates with the normal insects in the population. By overwhelming the natural population with sterile insects and by continuing their release for several generations, the declining

number of fertile individuals in the natural population experience progressively greater difficulty in encountering fertile mates until the chances for successful matings reach zero. For the sterile male technique to be effective in the control of an insect, Knipling listed five conditions which should prevail. (1) A method of mass rearing of the insect must be available. (2) Adequate dispersal of the released sterile males must be obtained. (3) The sterilization procedure must not adversely affect the mating behaviour of males. (4) The female of the insect to be controlled must normally mate only once, or if more frequent mating occurs the sperms from gamma irradiated males must compete with those from fertile males. (5) The population density of the insect must be inherently lower or the population must be reduced by other means to a level which will make it economically feasible to release a dominant population of sterile males over an extended period of time. It does not seem feasible for application to



Spraying the breeding material of rhinoceros beetle

the huge population of many of our economic pests that exist over widespread areas. It also is not applicable where the released males would themselves constitute a pest (as in the case of adults of *Oryctes*

*rhinoceros*). It seems best adapted to those species that are reduced rapidly, but that fact should not eliminate consideration of insects with an annual life-cycle. It would only take more time to do the basic research and years instead of months to evaluate results in the field. For those species that produce but one or a few generations per year in nature but which develop more rapidly in the artificial climate of the laboratory, control must be easier because, although insect breeding is retarded out of doors, unlimited population of sterile males might be reared in the insectory for release at the beginning of a season. The area from which the pest is to be eradicated should be so situated that reinfestation can be kept to a negligible level or completely excluded. The number of sterile males released per unit area has to be several times higher than the population of normal ones. When male sterilization technique is employed as a part of integrated control, it is more efficient at low population levels. Population is first brought down by chemical and biological means and then sterile male technique should be applied. This method can be very effective if applied against univoltine grasshoppers and internal feeders (tissue borers) with definite broods. This system of insect control will be of great value in the elimination of new incipient infestations, in preventing the spread of insects and for use in conjunction with other methods to eliminate population of well established pest species.

Other sterility method of insect control which is still largely under development, involves the sterilization of the required proportion

of individuals of the natural population by exposing them to chemosterilants in essentially the same manner that insects are exposed to insecticides for destruction. When sterilization is accomplished reproduction is reduced in two ways. The individuals sterilized, without adverse effects on mating behaviour and competitiveness, can not reproduce. This effect alone is comparable to destruction by conventional means. However, the sterile organisms then become biological agents capable of competing for



Spraying the *Nephantis* infested palm

mates with the unexposed normal populations. Therefore, the total immediate control effect on reproduction of the entire population is potentially doubled. If they are long-lived species, and if the sterilization procedure is irreversible, they will continue to reduce the reproductive rate of the normal population in subsequent generations. Thus chemosterilants may be defined as chemical compounds which reduce or entirely eliminate the reproductive capacity of an animal to which they are adminis-

tered. Chemosterilants may affect only one sex of a sexually reproducing animal (male sterilant, female sterilant) or both sexes (male-female sterilants).

The damage done by rats to crops including coconut is enormous. They cause shedding of tender nuts. Preliminary trials under laboratory conditions have given indications that certain chemosterilants like colchicine and furadantin are capable of inducing sterility in rats.

##### 5. Use of attractants and repellents in pest control

Attractants are materials that are utilized to attract insects into traps and to induce them to eat poisoned baits i. e. stimulants that elicit a positive directive response. Repellents or deterrents are those chemicals which generally secure protection for plants, man and livestock against insect attack by repelling them. The use of repellents has gained importance, particularly during the second world war and much work has been done during the last few years.

*Oryctes* is attracted to decaying coconut stem for oviposition. In Central Plantation Crops Research Institute, Regional Station, Kayangulam several attractants were tested for attracting Red Palm weevil and *Oryctes* and it was found that tender coconut stem split longitudinally and treated with fresh toddy are suitable for this purpose.

Several repellents like coaltar, "Mason mixture" etc., were tried at Central Plantation Crops Research Institute, Regional Station, Kayangulam to ward off *oryctes*

attack on palms, but with very little success. There are instances where repellents have been very successfully used against noxious insects. During the second World War many thousands of possible repellent compounds were tested against mosquitoes and these investigations resulted in the development of several compounds of outstanding importance as repellents for use against mosquitoes and certain biting flies. At the Indian Agricultural Research Institute, New Delhi, neem seed extract has been tested and its efficacy as repellent proved against many crop pests particularly locusts.

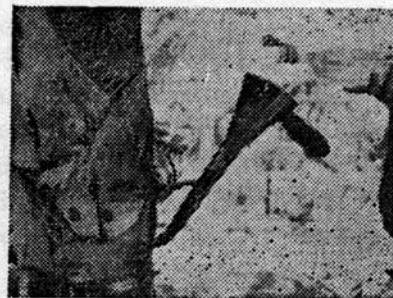
The attractiveness of nectar to bees and of light to myriads of other insects is proverbial. Among phytophagous insects especially the physical nature of the surface may determine the acceptability or non-acceptability of a plant as food. Hairs, spines and pubescence commonly confer immunity upon plants which are successful resistant varieties. Plant species with shiny wax

cuticles may be as effectively repellent to many insects. The specific attraction of ovipositing insects to the food plants in their younger stages is well known. Neem leaves are seen to attract large number of cockchafers particularly in May and June. These adults which congregate on the branches for copulation and feeding can easily be captured and destroyed. Among chemical attractants odours particularly sex scents and food odours may be considered to be the most important. Sex pheromones may be useful in insect control programmes in either of two ways. They can be used as a survey tool, to monitor insect infestation or they can be used as a direct agent of control i. e. attracting them to the spot and killing them. The presence of a potent sex attractant in females of the almond moth has recently been demonstrated. Extract of this from virgin females was found to attract large number of males in godowns infested with the pest.

### 6. Breeding Resistant Varieties

Differences in the responses of plant varieties to insect attack and the interrelation of plants and insects have been on record for more than a hundred years. A good resistant variety is able to avoid, tolerate or recover from insect attack better than a susceptible variety, whereas an immune plant variety is left alone by the insect species under all conditions. Such insects as the hessian fly on wheat, the grape *Phylloxera* and the woolly aphid may be satisfactorily controlled by host plant resistance, but not so far by insecticides. About the middle of the 19th Century it was found that the Ameri-

can species of grapes were highly resistant to grape phylloxera, *Phylloxera vitifoliae* (Fitch), while the European species were very susceptible. By grafting European grapes on American root stocks, damage from the pest is avoided and



Curative insecticidal treatment to weevil infested palm.

European grapes can be grown. Virus diseases of plants also have been overcome so far, mainly through breeding resistant varieties of crops.

The development of resistant varieties usually requires a long period of controlled experiments and plant breeding. There should be the combined efforts of the entomologist and the plant breeder for selecting and breeding strains of plants that are resistant to a particular insect.

### 7. Plant Quarantine

Plant quarantine means legal action intended to prevent or delay the establishment of a pest or disease of plant crops in an area where it does not already occur or to prevent or delay further distribution of a pest or disease in an area where it is not already of general occurrence.

Quarantine measures involve the following steps. (1) Embarkation against importation of likely carriers. (2) Certification at origin as



Young palm killed by the deadly tissue borer.

evidence of (a) effective treatment of the shipment (b) origin in area free of the pest and a degree of pest freedom greater than that can be attained by inspection or treatment at destination. (3) Effective treatment at destination. (4) Inspection at destination and restriction on or treatment of infested carriers. (5) Operation of organised pest detection programme within the protected area. (6) Eradication or containment of incipient infestation found in the protected area.

Eradiation of pests employing sophisticated techniques evolved by recent advances in entomological research together with an ever increasing vigilance at our ports of entry, have brought about a gradual change in the thinking of many entomologists and more confidence as to the possibilities that exist for protecting agriculture from foreign pests.

### 8. Philosophy behind the concept and implementation in India.

Integrated pest control is certainly a new concept, but the concept is so simple in theory that many people remark that it is such a commonsense approach as we should have been following it all the time. Thus its theoretical simplicity masks its novelty. But it is to be stressed that it has been very little practised in the past. Even during very recent years although there has been a good deal of talking and writing and the idea has been fast catching up, comparatively few concrete suggestions have been made implemented. The immense potentialities of this concept all the world over, the practical feasibility of evolving integrated pest control schedules

for protecting a number of crops and the inevitability of such an approach under Indian conditions have created the urgent scientific necessity for organising integrated control projects for five major crops in India viz., paddy, coconut, sugar-cane, groundnut and cotton. This integrated control projects are found to be feasible not only for effecting a compromise between chemical and biological control but also for effecting quite a workable integration of all the different methods of control, conventional and non-conventional including



Roots damaged by the cockchafer grubs

the modern sophisticated methods for the control of an important pest or different pests affecting the same crop or commodity and also of various pests affecting different crops in a particular area. Thus the concept of integrated control is rapidly bringing us to the threshold of reliable unified approach to our pest problems as a whole.

There are some very definite advantages in evolving and practising integrated control schedule. They are (1) These fit better in

our national economy. For developed countries these are desirable, but for developing countries like India these are inevitable. (2) More efficient and cheaper control. (3) They avoid upsetting of balance in nature (4) These will avoid or at least considerably delay the development of insecticide resistant races of pests. (5) will considerably reduce residue hazards of pesticides. [6] once microbial insecticides are established in the field they will self-propagate and little effort is needed from our side in manoeuvring their spread.

### III. Feasibility of evolving integrated control schedules for coconut pests.

Coconut being a perennial crop afford abundant supply of food to a wide variety of pests affecting all portions of palm from root to crown and all ages of its growth from nursery to adult palm. The important major pests are the rhinoceros beetle [Fig. 1] tunnelling tender unopened leaves [Fig. 2], leaf-eating caterpillar [Fig. 3], the tissue boring red weevil [Fig. 4] and root damaging cockchafer [Fig. 5]. Rats are also a serious menace to the crop. Conventional pesticides were tested at Central Plantation Crops Research Institute Regional Station, Kayangulam with some what good results in combating these pests and getting corresponding increase in yield. But it is seen that an integrated control schedule embracing mechanical; cultural including sanita-tional; chemical prophylactic as well as curative; biological using indigenous and exotic parasites and predators and some modern sophisticated methods including microbial pesticides, chemosterilants

the autocidal method employing the sterile male technique would better results.

will be useful to highlight the possibilities in an integrated control programme on major pests of coco-

#### Beetles Rhinoceros L.

To assess the combined/individual efficacy the following conventional methods have been tested in the field. Extraction of the beetle from the crowns of palms can be done by means of a hooked pointed metal rod about  $\frac{1}{2}$  meter long with a hook at one end and a ring or handle at the base. Treatment of breeding places of the beetle [Fig. 6] where the immature stages of the rhinoceros beetle are present, is quite essential for the control of this pest. 0.01 per cent BHC/Carbaryl is effective for treating the breeding places. The prophylactic method of filling the innermost 2-3 axils with 5 percent BHC-sand twice a year during pre and post-monsoon periods gives adequate protection to palms against the pest. Maintenance of plant and field sanitation is also essential for checkmating the pest. The exploitation of natural predators / pathogens including *Arrhizium anisopliae* and introduction of exotic biological control agents including *Platymis laevis* more lasting results can be achieved. The following non-conventional / sophisticated methods should be tested for their efficacy and incorporated into the integrated control project. Nematode DD-136 (*Daplelectana Carpocapsae*) and the associated bacterium *Achromobacter natophilus* and the virus pathogen, *Rhabdionvirus Oryctes* and the

associated bacterium is found to attack all the instars of the grubs. By using attractant the beetles can be attracted to traps and can be killed. Ecological manoeuvring will also be useful in controlling the pest. By creating sub-optimal or unfavourable conditions at the breeding sites the pest can be denied facility for multiplication.

#### Nephantis Serinopa M.

The following different methods are to be incorporated in an integrated control project for the leaf eating caterpillar. The badly infested leaves/portions of leaves must be cut and burned. Malathion 0.05 per cent or any other chemical [proved effective against the pest and less harmful to parasites viz. trichlorophon/dichlorvos] must be sprayed on the under-surface of the leaflets [Fig. 7]. Depending on the various stages of the pest laboratory bred indigenous parasites must be released. Along with these the exotic parasites like *Spoggosia bezziana* can be employed. The nematode DD-136 and the bacteria *Serratia marcescens* and *Bacillus thuringiensis* can be used against the larval stages of the pest.

#### Rhynchophorus Ferrugineus F.

An integrated control schedule formulated against this deadly tissue borer [Fig. 8] include the following conventional/sophisticated method. Mechanical-cum-sanitization control methods are essential prerequisites for effective pest management. By using attractants adults can be attracted into traps and can be killed. The adult females lay eggs on the wounds in the palm and through the wounds young ones bore into the interior. So prevention of injury on the palm is

also an essential pre-requisite for checkmating the pest. As a prophylactic measure the damage caused by rhinoceros beetle, leaf and bud rot disease has to be treated with appropriate pesticides. Leaf axil filling of young palms also give some measure of protection against this dreaded pest. The infested palms can be cured by injecting Pyrocon E/ Carbaryl [Fig. 9]. We can also exploit the natural predators / pathogens and introduce exotic-bioagents for the control of the pest. If the trials already in progress [in collaboration with BARC, Trombay] prove successful the sophisticated sterile male technique can also be integrated into the envisaged programme of work.

#### Leucopholis Coneophora B.

The following will essentially be the different constituents to be integrated for control of this subterranean pest [Fig. 10]. Mechanical-cum-cultural methods like deep ploughing or digging of the soil to expose the immature stages to desiccation in the sun or predation by natural enemies like birds and mammals are quite useful in controlling the pest. Treatment of the soil with 5 per cent BHC/Aldrin/Chlordane at 120 kg./hectare twice a year in April and August is effective in combating the pest. The adults can be attracted to light and killed. Exploitation of the biological control agents like *Campsomeiriella collaris* (scoliidae), DD-136 (nematode) and pathogens (indigenous/exotic) will also be done, which will definitely enhance the scope of integrated control schedule.

#### IV. Conclusion

Taking all these problems, possibilities and programmes in view,

it is found necessary that in order to ensure that our agricultural production drive does not fail due to failure at the protection front, the strategy for pest control research should be as bold as the new strategy for agricultural production. The integrated control has quite wide applicability in various other fields like Public Health, Veterinary, Defence, Science, Forestry, etc.

It may also be seen that the integrated control programmes in general have to be based upon a high level of scientific ground work. Their successful development requires more than the acquisition of

just basic knowledge. The personnel needed for this work would have to be sensitive to the integrated control approach and capable of conducting research on the population dynamics of pests and inter-relationships with the different organisms in the environment. Besides, the plant protection worker should be vigilant with regard to the changes that are constantly being introduced by the cultivator in the agroecosystem purposefully as well as inadvertently and watch for any eruption in the pest and disease complex. This would also require educating the growers. To quote the Director-General of Indian Council of Agricultural Re-

search, Dr. M. S. Swaminathan, "we should contribute to the best of our ability and without detriment to our other responsibilities, towards bridging the gulf between research and field accomplishments".

Not only are we trying courageously and confidently to solve our stupendous food problems but also the eyes of the world are eagerly looking at our capacity to rise to the occasion. In the words of the Prime Minister of India, "our hopes of larger harvest will be realised only when we give adequate attention to pest control programmes".

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