Tea Q. 42, (4) 175-181. 1971. Printed in Ceylon.

The Environment and Agriculture

AN ECOLOGICAL APPROACH TO PEST MANAGEMENT IN TEA

*D. Calnaido

The primary aim of Agriculture is production. The goal of all disciplines of the science of Agriculture is to increase production. Similarly, the main consideration of all pest control strategies on agricultural crops must necessarily be oriented towards the economics of production. Agricultural entomologists should not lose sight of these important concepts and concentrate merely on the control of pests. Crop protection, to increase crop production should be the aim. This is also true of pest control in tea in Ceylon. It is, therefore, important to reconsider our strategy in relation to the present economics of the crop and to reorient our approach to pest control methods in the future.

The crop and its associated environment

An important consideration of tea culture is that tea is a perennial crop, grown mainly in the tropics in extensive areas of monoculture, for harvest of its vegetative component. This fact has particular significance in pest control because, (1) the adverse effect of insecticidal sprays are more severe in perennial crops than in annual crops, (2) in the tropics there is the abundant insect fauna accompanied by a delicate balance of pest-parasite populations and this balance could be easily upset by use of insecticides ; this is clearly evident in tea ; (3) the vegetative harvest has special significance in pest control, as opposed to the harvest of fruits or flowers or any other component of the plant. In a fruit harvest, any destruction of a unit of a plant, bud or shoot, results in a direct reduction of the harvest for that particular season; whereas in a vegetative such as we have for tea, (where the shoots are plucked regularly, resulting in further growth of shoots), a temporary insect damage to its shoots may not affect its yield in the long run, although heavy loss of one or two plucking rounds may be experienced in the short period of the pest attack. There are many instances of crops, in which pest attack of its vegetative parts have encouraged further vegetative growth. As evidence of yield increases in tea resulting from pest control are meagre, despite extensive experimentation, could it be that the above is true also of tea ? One other important consideration is that by the extensive monoculture of the crop, the ecosystem is naturally more suitable to the pest and less suitable to their parasites, and that this is aggravated by the use of insecticides.

There is also the important consideration of the economic viability of the crop. In the late fifties and early sixties, when tea estates were economically stronger, the attitude was to immediately spray tea fields showing any signs of a pest attack, often with strong, persistent insecticides such as those of the organo-chlorine group, without sufficient knowledge of the benefits achieved or the adverse effects of these spray operations. The destruction of the pest appeared to be the main consideration. No attempts were made at an ecological approach to pest control by the regulation of insect numbers, with due regard to the various ecological factors, operating in the ecosystem. This untenable technique in pest control can no longer be continued, particularly in the present context of tea production, where it is absolutely necessary to carefully control the cost/profit ratio of production. We have, therefore, not only to control pests, but also limit the rising cost of pest control operations, as this is of paramount importance not only in terms of the revenue expenditure of estates, but also the costs in terms of foreign exchange, for the import of insecticides and equipment for their application.

* Tea Research Institute of Ceylon, Kandy, Ceylon.

The scientific principles governing pest control

In any planned pest control program it is important to bear in mind the scientific principles governing the subject.

Ecological approach

Our approach to pest control must necessarily be based on a knowledge of pest ecology. The most important and basic aim of studies in pest ecology is to obtain sufficient information so that we could manipulate pest populations to our advantage. This involves studies on the various factors that regulate insect populations which will enable us to detect the most important conditions for increase in their numbers, so that we could, as far as possible, alter those conditions to bring about a reduction of pest populations (Chant 1964). Any serious studies on pest control should, therefore, lead us to studies on pest ecology and we have to begin by elucidating the population dynamics of pests and their parasites and predators in a given locality. Another important point to be borne in mind is that we have to study the ecology of the pest in relation to the ecology of the crop. Various cultural practices in the crop will influence the pest and we need to have a knowledge of these, so that we could alter or time some of the cultural operations to our benefit.

Strategy and tactics in pest control

'Strategy' in pest control is our general approach to control and also the choice of the methods of control. This will necessarily be based on our knowledge of the population dynamics of the pest in relation to its host crop. 'Tactics' refers to the details of how a chosen method should be applied to solve the problems posed by the specific pest (Chant 1964). An economic entomologist has, therefore, to decide which factor or group of factors can be manipulated to cause the desirable change in the insect populations, by the increase of populations of desirable insects and the decrease of populations of the pests. A pest should be viewed not in isolation, but as a product of its environment, including all major elements both biotic and abiotic. The whole ecosystem must be kept in mind when we attempt to destroy a pest. In the past too much reliance on chemical methods of control has hampered research into pest problems. This does not mean that chemical control should not be used. We should appreciate the fact that pesticides are one of the most useful and effective weapons we possess, but we must use them carefully and sparingly. Insecticides can be particularly useful to take care of pest outbreaks.

Our attitude to a pest problem should, therefore, follow a scientific approach (Chant 1964). Firstly, we should aim at assessing the importance of the problem. This would involve identification, population surveys, measuring crop losses, *etc.* Secondly, we should develop a quick and effective palliative to prevent damage. This is where insecticides would help most. And thirdly, we should attempt to solve the problem by long-term ecological research. Although for convenience we have drawn out the above procedure, in fact, pest control is basically a matter of understanding and knowingly manipulating the multitude of factors, both natural and imposed, that govern the abundance of pest populations. The knowledge of the population dynamics of the pest will provide a useful guide in choosing the appropriate method or methods of control and will help us determine our overall strategy in pest control (Smallman 1964).

Methods of pest control

Today the economic entomologists have many methods of insect control at their disposal and the choice of a combination of methods—integrated control—has become more popular, than the reliance on any one particular method. We have become more cautious of the most powerful, easy, quick and effective means of pest control by the use of insecticides and we have revived old methods and are discovering new ones. It is important to note that all these methods will affect the ecology of the pest and the environment and therefore they are fundamentally ecological. As such, an ecological approach will not only enhance the effectiveness of the methods of control used, but will also safeguard us from their ill effects.

Much research is being done on the ecology of pesticide performance and behaviour, and improved used of pesticides are being developed. In the choice of the types of insecticides, those having selective action on pests and predators are preferred. The timing and regulation of the dosages of pesticides, and caution and variation in their methods of application are being profitably employed. We should consider insecticides as short-term palliatives of special importance to take care of outbreaks and not as long-term solutions to pest problems. Above all, we should use insecticides only with a knowledge of their effects on the ecosystem, and not consider only the immediate action on the pest alone.

Biological control which includes the use of predators, parasites and pathogens such as bacteria, viruses, fungi and protozoa, are being utilized more and more successfully. A long term method, but one that is most effective and economical, is to develop resistant varieties of plants. The timing and variation of the cultural operations in the crop have also been used to our advantage. There are then the newer methods which are based on the knowledge of the biology of the pests. One of the most successful of these is the sterilization and release of large populations of males which have been subjected to a radio-active cobalt source ; this method is used in the United States to control the Screw Worm—a serious pest of livestock and wild life. Chemosterilants are being used to control the Mexican Fruit Fly in California and they have also been tried on mosquitoes, weevils and houseflies. Attempts are being made to alter the genetic characters of pests or to take advantage of their physiology and behaviour to control them. Novel methods, such as ultraviolet light, radio waves and electronics are being experimented with in the United States. Finally, some of the most persistant and common pests are being controlled by the creation of unfavourable ecological conditions. Good examples are the attempts at the eradication of the Testse Fly and mosquitoes. In both these cases, as in the control of the Moroccan Locust, the destruction of breeding grounds have been found to be the most effective means of preventing pest outbreaks.

Some of the above methods will not be suitable on tea because of the costs of such methods, the ecology of the crop and the nature of the pest problems. Techniques have, therefore, to be worked out that will suit the crop, with due regard to its economic and cultural backgrounds. I foresee the future of the Entomology of tea to be more oriented towards biological control, in its widest sense. This will include the planning of pest control in such a way as to obtain maximum benefits of the existing natural parasite populations in tea and the introduction of new ones, the search for resistant varieties of plants, and cultural methods of control, which I believe have not been sufficiently investigated. For instance, hard plucking can be used as a method of regulating populations of thrips, yellow mites or lygus bugs ; a 'light skiff' prune may be tried out in some instances of pest occurrences ; while 'selective pruning' could alleviate the long-term effects of shot-hole borer damage (wood-rot *etc.*). Whatever methods, a combination of methods we use, they must also be integrated with the multitude of economic and biological factors of tea

culture, so that we will be using the best possible methods to bring about increased production. The above approach will be in keeping with the aims of 'integrated control' as defined by the FAO Committee on the subject, as *'a pest management system, that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods, in as compatible a manner as possible, to maintain the pest populations at levels below those causing economic injury'.*

One more simple but important method is to alter the conditions of the crop environment, which, in tea, is extensive monoculture to make it more favourable for the insect-parasite populations. This can be achieved by the planting of trees, on boundaries or as wind belts, providing reasonable cover of shade trees,where necessary the reservation of forest belts and grasslands, and also by the planting of suitable ground covers. A comprehensive scheme of re-forestation (Forest Department 1970) could in the long run be both effective and economical, and will be the best method of environmental manipulation, so as to exploit the predator/parasite/pest complex, to our economic advantage.

Ecological consideration in tea entomology

The closely planted perennial culture of tea on Ceylon estates, somewhat simulate forests ecologically and one can, therefore, notice similarities in tea and forest entomology. Some of the cultural practices in tea, such as pruning, plucking, fertilizing and weeding, influence the microclimate of the crop and, therefore, the pests of tea. When we consider the fact that tea cultivation covers such large extents and notice the relatively rare occasions and the limited areas in which the many harmful caterpillars achieve pest status, we are reminded of the natural biological control that exists. Let us appreciate this, make a serious study of the pest-predator-parasite complex of tea and attempt to encourage this prevalent insect population balance, rather than destroy it with the unplanned application of insecticides. This approach calls for the use of only the right type of insecticides, and that too sparingly, as an immediate and palliative measure, till such time as we get down to the study of each pest problem from an ecological angel, bearing in mind the idea of the ecosystem as a whole, and modifying our methods as new information accumulates. The problems of mites too call for a similar approach and I believe that the practice or prophylactic insecticidal sprays against mites, that some estates resort to, is far too short sighted a policy.

The importance of ecological research on a pest is clearly demonstrated by recent research on the Shot-hole borer, a beetle borer of tea which is recognized as a serious pest of tea. Perhaps it is also the most studied pest in Ceylon and much is known about its ecology, although much more needs to be known. The most important findings of ecological research pursued at the Mid-Country Station, of the Tea Research Institute of Ceylon at Kandy, is the information gained on the population dynamics of the pest in relation to the host plant (Calnaido & Thirugnanasuntharan 1966). We have found that in the crucial area of distribution of the pest in Ceylon—roughly from 300 to 1000 m amsl—the one factor that is most responsible for the regulation of the pest is the quantity of suitable wood formed after pruning. This information and the knowledge of the mode and times of dispersal of the pest (Calnaido 1965), has helped us to time our insecticidal sprays, so as to achieve the maximum benefit. Further, the knowledge of the population dynamics of the borer now explains why some of our earlier methods failed and affords us a new basis for its successful control in the future. For instance, we now know that the practice of burying pruned branches or pruning at the 18th month, will not help to control the pest. The knowledge of the aerial migration of the pest has cautioned us that spraying larger areas will not bring about better control, but will only be harmful

to parasites of pests, thereby producing an imbalance of other pest populations. We have experience the dangers of spraying a persistant insecticide such as dieldrin at pruning time, and now we realize the futility of this method of control, as compared with the proper timing of the application of a less persistant and safe insecticide at about the end of the first year from prune. We now see in the problem of shot-hole borer control in mature tea, a necessity to protect the new wood, resulting from the prune, mainly in the second year of the pruning cycle ; and we are also aware of the importance of carefully protecting the stems of young tea plants from the time of planting. We have also found tea clones that are relatively tolerant to the borer and have encouraged their propagation (Calnaido 1971). Research on population dynamics, the distribution of the pest and on host selection are being actively pursued.

Tea pests and their control

Any carefully planned strategy on pest control must not only take into consideration the crop and its back ground, but also include an appraisal of the importance, intensity and frequency of occurrence of the pests that need control. For convenience, we may arbitravily group tea pests as follows :

Group 1—*Non-pest insects, that achieve pest status*

Insects that are found in tea, but are kept under control by natural agents, so that they do not achieve pest status, unless the environment is disturbed by the use of insecticides. It is interesting that we have had many examples to this type of pests in tea. We have had a whole range of caterpillar pests ; which although recorded in tea did not bother us until the use of dieldrin, *eg* looper, twig and lobster caterpillars and many other insects. This group of insects can be easily controlled by carefully regulating the insecticidal sprays.

Group 2—*Minor pests*

These are insects that occasionally infest fields and cause damage, often not very serious, but could sometimes become troublesome. They could be easily controlled with appropriate insecticidal sprays. Examples are lygus bugs, *Helopeltis*, army worms, stem boring caterpillars, scale insects and thrips.

Group 3—*Fairly serious pests*

These are moderately serious pests with high frequencies of infestation. Examples are the Tea Tortrix and nettle grubs. These insects are very effectively kept under control by a host of parasites, but frequently this balance is upset, on account of spraying or simply due to a change in natural conditions, which is not clearly understood, when they frequently become troublesome pests. The use of insecticidal sprays on this groups of insects, however tempting, appear for several reasons to be an unwise step. (1) If the infestation is allowed to take its course, sooner or later, the parasite will-re-establish itself and it will take control of the pest ; in this case the insecticidal spray will only hinder the delayed natural control. (2) Once the use of insecticides is begun, we may be compelled to use more of it to arrest further infestations that may recur on account of the failure of the earlier sprays of insecticides due to one reason or another ; or because a second spray may be necessary to take care of the earlier developmental stages such as eggs ; or because the destruction of natural enemies by the insecticidal sprays, will result in greater dependance on chemical control. This means that we will be compelled to be more and more efficient with our spray programmes, causing greater imbalance

of pest populations. (3) The costs of spray operations will, therefore, become prohibitive. (4) The most important question is that, although we may obtain a yield increase in the short period of infestation, would we get a yield increase, commensurate with the cost of control operation, in the long run, when the yeild through the whole pruning cycle is considered ? It is, therefore, suggested that this group of insect pests be carefully watched and control measures taken *only in cases of outbreaks of large populations.* A more realistic and effective approach would be to devise means of breeding a constant source of the *Macrocentrus* parasite in the laboratory, and releasing the parasite when necessary.

Group 4—Sporadic soil pests

These are a group of soil insects, such as the cut worms, white grubs *etc,* which appear sporadic and of localized distribution, which rarely pose serious problems of control. Usually their numbers could be regulated with effective soil insecticides and cultural practices of better crop sanitation.

Group 5—Serious perennial pests—Mites

Mites are not insects, although they are serious pests that may need control. It is, therefore, preferable to group them separately. This is a group that may need judicious insecticidal control. Meanwhile, research on resistant clones and cultural methods of control must be undertaken . For instance hard-plucking can be used to regulate yellow mite infestations.

Group 6—Serious and chronic pests—Termites and Shot-hole Borer

These two are serious pests that have todate eluded satisfactory control and will remain a serious challenge to entomological research even in the future. Both these pests with their hidden habitats within the plant not only elude control but also pose problems of proper assessment of the damage they cause and the estimation of the benefits obtained from their control.

Conclusions

As pest control involves the reduction of pest populations in a given locality, for its safe and effective execution one must necessarily have at least some knowledge of the various ecological factors, both biotic and abiotic, governing these populations. This knowledge could only come from the study of the ecology of the pests. Ullyett (1951) in evaluating the relationships of 'Insects, Man and the Environment' concludes that 'insect ecology must become the foundation of Economic Entomology'. The more one delves into the history of pest control, particularly that in recent times, one will be convinced that when determining the methods of pest control it is important that one is guided by a knowledge and understanding of the population dynamics of the pest. In our efforts to control the pest we must not concentrate on the pest alone and seek 100% mortality, but we should also be mindful of what we are doing to the environment in the process of eliminating the pest. We should learn to live with our pests and endeavour to only manipulate their populations to our advantage.

Pest control in tea, which in the past has been dependent on the use of insecticides must in the future become a subject of intensive ecological research, so that we are able to apply the scientific principles of pest control bearing in mind the economics of the crop, the pests and the interactions of the other insect populations of the enviornment, and above all with production as our goal.

REFERENCES

CALNAIDO, D. (1965). The flight and dispersal of Shot-hole Borer of Tea (*Xyleborus fornicatus* Eichh., Coleoptera : Scolytidae). *Ent. Exp. Appl.* **8,** 249-262.

CALNAIDO, D. (1971). Differences in susceptibility of Tea clones in Ceylon to the Shot-hole Borer Beetle, *Xyleborus fornicatus* Eichh. (Coleoptera : Scolytidae. *Entomologie* (In the press).

CALNAIDO, D. & THIRUGNANASUNTHARAN, K. (1966). Preliminary ecological studies on Shot-hole Borer and their relation to the control of the pest. *Tea Q.* **37,** 28-45.

CHANT, D. A. (1964). Strategy and Tactics of Insect Control. *Canad. Ent.* **96,** 182-201.

FOREST DEPARTMENT, CEYLON, (1970). Notes on the planting of forest species. Mimeographed 26 pp.

SMALLMAN, B. N. (1964). Perspectives of Insect Control. *Canad. Ent.* **96,** 167-171.

ULLYETT, B. C., (1951). Insects, Man and the Environment. *J. Econ. Ent.* **44,** 459-464.