METABOLIC DISRUPTORS (SEMIO CHEMICALS) AND THEIR UTILIZATION AS A PEST MANAGEMENT STRATEGY

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Since the time cultivation of crops became a system of organized agriculture, insect species that were pests on these cultivated crops have been controlled by various devious means. This battle against insect pests has been a continuous one, with a few instances of complete success. Most often the winner was the pest insect.

The old traditional methods of control included, biological control which involved the use of certain other species of insects as either parasites or predators on the pest insects. Hence the former came to be categorized with the group of beneficial insects. Such an approach had led to instances where pest insects came to be managed very successfully. The most successful one ever achieved on a plantation crop was the control of our own tea tortrix, with the introduction of the parasitic wasp, *Macrocentrus homonae*, from Indonesia. Besides the harnessing of other beneficial insect species, biological control programmes have, since of late, successfully utilized parasitic nematodes in a big way, as well as various pathogens including fungi, bacteria and viruses that cause disease outbreaks in insects. On account of the crucial role that such disease causing organisms play in the maintenance of an ecological balance amongst insect species, insect pathology has evolved into a specialized branch of study of its own.

The other old traditional form of insect pest management has been the adoption and modification of certain selected cultural practices, that render either the plant itself, or the environment in which it grows, less favourable for the pest insects and consequently reduce the damage they cause. The use of selected resistant varieties of crop species is a well-known old technique that is still employed as one of the most reliable means of pest management.

Since the mid-1940s various synthetic biocidal chemicals have been widely used in insect pest control. The drastic turn of events took place with the advent of DDT, which emerged as the 'miracle insecticide' during World War II. Following the discovery of DDT, several other synthetic insecticides were tested and used very widely and these were even regarded as 'chemical miracles' that ensured bountiful harvests. Such a pesticidal approach (though apparently a very successful one that overshadowed all other ecologically acceptable traditional means of pest management), later led to several instances where the farmers and other cultivators had been forced to depend entirely on the use of such chemicals, so much so that they were on a 'pesticidal tread-mill'.

The above pesticidal approach dominated the agricultural scene for nearly twenty five years from mid-1940s to early 1970s. Besides leading to several instances of pest resurgence, secondary pest outbreaks and the development of resistant strains, various other forms of harmful side-effects were observed on the environment, including those on man himself. Thus, the wide-scale and careless use of this resourceful management too led to an almost total dislocation of the delicate ecological balance. Chemical pesticides still have an important role to play in pest management, provided their use is carefully integrated along with other ecologically acceptable means of management, rather than resorting to their use as a unilateral approach. Such a situation led to the pesticide dilemma that is presently confronting us.

The usefulness of selective pesticides cannot be denied and it must be accepted that we will have to depend on these to meet the growing demands towards increased productivity of the various agricultural commodities. Such selective chemicals should have the least impact on the environment. Yet, these insecticides are biocides that are likely to have some form of harmful effects on the non-target organisms in the long run.

It is as a consequence of such an understanding that scientists are presently turning their attention towards those chemicals that will not have any effect whatsoever on the environment but are highly specific in their activity at the behavioural or at the general growth physiology level of target insect species. These are not biocides but are chemicals that cause certain physiological disorders either leading to physical deformity during development processes, sexual sterility or cause confusions in chemical communication, particularly during the process of locating mates, thereby markedly reducing the offsprings. Such group of chemicals have now come to be referred to as 'semio chemicals'.

The time has arrived for man to venture into outer space on journeys that will take a very long time and as a consequence has to synthesise his own food, using his own waste products harnessing solar energy. We have to think far ahead to cope with the pressures of ever increasing demands and the consequent fight for survival. The entomologists are no exception. Novel approaches to pest management will therefore have to be worked out from now onwards.

The search for Semio Chemicals:

A detailed understanding of the feeding behaviour and the nutrition of the insect is the first step that has to be taken before one ventures into carrying out research for selecting compounds that could block certain essential metabolic pathways. The field of insect nutrition and insect behavioural physiology is one that is receiving the greatest attention today in many an entomological research programme.

Most insects cause damage to plants during their efforts at obtaining nutrients needed for their growth and development. Therefore, an elucidation of a detailed knowledge of critical dietary requirements of an insect is the first step one has to take to evolve a technique to induce disruptive physiological changes.

Such an approach could be undertaken only by initially developing a completely defined artificial diet to rear the insect through successive generations in laboratory cultures. Such a study would provide the essential information about those critical dietary ingredients needed for normal growth and development. The composition of such perfected diets could then be altered both quantitatively and qualitatively in order to create certain nutritional faults in the diet that would lead to imbalances of essential nutrients. Another way is to block the availability and assimilation of the critical dietary ingredients that will lead to sterility and/or physical deformity and consequently lead to the development of a large population of abnormal and deformed insects that will compete with normal ones in the field.

The diet that could be truly classified as a completely defined one (holidic diet) should contain only known ingredients of very high purity, and should enable the insect to develop normally through successive generations. To claim this as a holidic diet, there should be further proof of the complete absence of any microbial symbionts that could possibly contribute certain essential dietary ingredients.

A basic knowledge of the nutrition of insects has been made use of by other investigators in recent times to develop and induce specific nutritional imbalances in the host plant (Pratt *et al,* 1972). For example, some non-genetically linked 'resistance' has been induced by changing the physiology of host plant by the regular application of specific artificial fertilizers and other soil adjuvants for the control of the aphid, *Myzus persicae* (Wooldridge & Harrison, 1968; Harrewijn, 1972), *Brevicoryne brassicae* (Van Embden, 1966) and the spruce budworm, *Choristoneura fumiferana* (Shaw & Little, 1972). Recent studies have demonstrated that a very good potential exists for creating such imbalances especially in respect of amino acids, in the case of our own tea tortrix, *Homona coffearia.*

An exogenous supply of the amino acid, threonine was found to be very critical for the development of the tea tortrix, since in its absence this insect failed to reach maturity. An additional exogenous supply of the amino acids tyrosine and cystine, provided in amounts slightly more than what is really needed, proved to be very detrimental and arrested development.

Tea is a crop that places a very high demand on fertilizers, especially nitrogenous fertilizers which could be supplied in different forms, including sulphate of ammonia and urea. These nitrogenous fertilizers are usually provided along with others including muriate of potash, phosphates and magnesium salts. Thus a good potential exists for manipulative changes, which could influence the synthesis of some of the critical amino acids in the tea plant. There is already some evidence for developing such 'resistance' in young tea plants to parasitic nematodes through alteration of potash levels (Gnanapragasam, 1982).

The fatty acids, caproic, caprylic, capric, myristic, oleic and arachidonic acids, when supplied as additional exogenous ingredients were found to be toxic to the tea tortrix. The possibility of using fatty acids to control insects has been reported by House (1967) and Maw and House (1971).

The polyunsaturated fatty acids, linoleic and linolenic acids were found to be very critical dietary supplements to the tea tortrix. Results of diet-deletion studies in which linoleic and linolenic acids were deleted but supplemented with the saturated fatty acids, stearic and lauric acids showed that the latter could adequately substitute critically needed polyunsaturated fatty acids. In the absence of these fatty acids the final moult of the pupa to adult was affected and moths failed to emerge. When provided in sub-optimal amounts, only partial emergence of adults was observed and the few that did emerge were with malformed crumpled naked wings.

Thus by making the above essential fatty acids unavailable to the insect or by providing small amounts of the toxic acids in the diets, it is possible to suppress the maturation of the tortrix pupa to the adult.

Metalic ions like copper are known to oxidise unsaturated fatty acids (Fruton & Simmonds, 1961). This effect was clearly demonstrated by inducing typical fatty acid deficiency symptom in tortrix moths which emerged from artificial diets treated with as low as 12.5 ppm of copper. The emerging moths were deformed. Thus the use of copper seems to have a potential to control this insect by interfering with the processes of metamorphosis to the adult (Sivapalan & Gnanapragasam, 1980).

Copper fungicides are applied in tea fields to control blister blight leaf disease. When tea fields are sprayed with copper fungicides (treated at the rate of 180 g of cuprous oxide/150 litres of water/ha against blister blight (De Silva, 1966) the copper content in harvested leaves, one week following treatment, has been found to be in the order of 25-40 ppm. A residual amount of copper up to 40 ppm (150 ppm in the dried Black Tea) is the accepted tolerance limit for this metallic ion in tea. However, such treatments are usually given in the wet months which is non-seasonal for tortrix outbreaks. It is worthwhile to try such treatments in the tortrix season as well.

The present investigation has also shown that, as in the case of all other insects (other than some species in which some of the critical dietary ingredients are provided by the associated symbionts), the tea tortrix depends entirely on an exogenous supply of sterols, which is very vital for normal growth and development. They are important components of membrane structures, are precursors of growth and moulting hormones and are also constituents, of the surface wax of insect cuticle.

Since insects cannot synthesize sterols on their own, certain compounds that are likely to have an inhibitory action against the assimilation of sterols will make the latter unavailable to the insect, thereby blocking the physiological process of development. Amongst various tested metabolic disruptors, compounds like the group of azasterols, 25-azacoprastane and the non-steroidal amine-N, N dimethyl-tetradecanamine in very minute amounts were found to very significantly suppress development of this insect. This suppression seems to be due to the possible blockage of the required amount of dietary sterol and consequently interfering in the formation of ecdysteroids, which are the moulting hormones, essential for metamorphosis from larva to pupa and then to adult. Non-steroidal amines, having the structures with chain lengths C12 - C14 are also known to possess structural similarity to juvenile hormones. Therefore the compound N, N dimethyltetradecanamine could have functioned as an antimetabolite of the juvenile hormone consequently disrupting development.

The results of such investigations have thus opened up new avenues for further studies and exploiting the possibility of using such physiological control agents in the field, which has absolutely no harmful effects on the environment, being extremely specific to the target insect only.

Selective metabolic disruptors and antimetabolites, which are now given the specific name of 'Semio Compounds' can now be tested in the field for their potential use in an integrated pest management programme.

Possibilities also exist for the incorporation of selected chemicals in the diet that lead to sterility and thus making possible the mass rearing of sterile males in the laboratories that could be released from time to time to compete with natural field populations and thus achieve some degree of control.

The study of nutritional requirement have also offered several useful clues for the selection of specific feeding attractants that should be further exploited at the practical level by offering such diets in the field. Such diets can be incorporated with selected chemosterilants that are likely to induce sterility in the natural field populations. This programme could be coupled to one of baiting males with the use of female sex pheromones which work is already in progress, and thus evolve a balanced integrated programme of management of pest insects in tea. In a similar manner, detailed studies on the nutrition of other insects, including the shot-hole borer is likely to open up new vistas in pest management.

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