# Integrated pest management

by G.C. LaBrecque*

With the advent of organic pesticides in the early 1940s, pest-control problems virtually disappeared. Protection of man, his animals, and his crops from the ravages of weeds, insects, and related arthropods was now a reality, since economic control could be derived for extended periods with relatively few periodic applications of pesticides. The need for consideration of other control approaches, knowledge of pest population dynamics and biology, and host-pest relationships, was for the most part neglected.

Unfortunately, weaknesses in this control system soon became apparent. By the late 1940s and early 1950s alarming reports of the effects on the environment of the excessive use of pesticides, and the need for ever-increasing dosages and frequency of application, made necessary greater in-depth understanding of the biota's responses to the pressures of pesticides. The result was a change from reliance on a single control system to the development of sound pest-control practices taking into consideration the environment, costs and benefits.

This approach, essentially a pest control system based on ecological principles and integrating a number of disciplinary pest control methodologies, is known as Integrated Pest Management (IPM). IPM appears to have as many definitions as there are advocates of its practice. For optimal use, it involves a thorough knowledge of the pest-biology and its relationship to its environment to determine its most vulnerable points. The principal mission of the Insect and Pest Control Section of the Joint FAO/IAEA Division is to develop and support the use of isotopes and radiation to resolve problems.

For an IPM programme to be effective, a thorough knowledge of the biology of the target species is required. In particular, information on the dispersal, population densities and dynamics, as well as the ecology of the natural enemies of the pest are essential. Studies on these can be accomplished using radiolabelling techniques, as illustrated in the following

*Dispersal* Insects are labelled, then released in the environment and captured in traps located at various distances from the release points. Labelling can be accomplished by inclusion of a beta or gamma emitter in the diet; applying it topically to the integument; dipping the insect in a solution containing the label; or in the case of piercing/sucking insects, by placing the label in the circulatory system of the host. Upon capture the released insects can be separated from the field populations by counter or photographic film In some instances where insect trapping is not a particularly accurate index of labelled insects in the environment, or the insect is secretive in nature and has a tendency to nest in crevices, or has a protective colouration, a gamma emitter would be the material of choice. A properly marked insect can be "spotted" electronically from a distance despite the fact that it is not visible to the unaided eye In the event that conditions preclude the use of radioisotopes, the insects can be labelled with either a rare-earth or stable isotopes. All insects treated with the rare-earths are, once captured, exposed to neutrons which produce radioactivity in the rare-earths. The recaptured, labelled insects are then differentiated from the field insects by their specific radioactivity. In the case of stable isotopes, the labelled insects can be differentiated by chemical analysis.

*Population densities* can be determined in the same manner following the procedures described above, only in this case the field population is determined by formulae involving the product of the total number of insects released and the total caught, divided by the number of labelled insects caught

*Population dynamics* In conducting a sterile-male release programme, a knowledge of the dynamics of the insect population is essential for success. Some of the essential parameters include the quantitative population density, the daily loss rate, the rates of increase and the daily emergence rates. Population densities can be derived following the techniques described above; the daily mortality rate is derived by conducting a release study similar to that defined for population qualification, only in this instance the labelled insects are of a definite age, basically 1 or 2 days. The insects are released and then captured and identified on a periodic basis over a generation span. Given these two parameters along with the increase or decrease of a population from one generation to the next, the daily emergence of adults into the environment can be derived and the number of sterile insects to be released to cope with this emergent population determined.

*Ecology of natural enemies:* Radio-labelling is an effective instrument for determining the predator or parasite of a pest population. In the case of parasites, the rate of parasitization can frequently be determined by simple visual observation. However, in the case of predators, the prey is normally consumed or little trace

* Mr LaBrecque is Head, Insect and Pest Control Section, in the Joint FAO/IAEA Division

can be found. The prey can be labelled either by the release of labelled pest insects or by tagging the host; in this way, the radioactivity will be transmitted to the predator. Sampling of insect populations in the environment will thus identify the various predator species in the environment.

Investigations are in progress in the Agency's Entomology Laboratory, and in other locations through research contracts awarded by the Agency, using the techniques described above, or modification thereof, to study pest ecology, dispersal, population dynamics, densities, host-pest relationships, feeding requirements, behaviour, and pest-parasite-predator relationships, in fruit flies, tsetse flies, and rice insects.

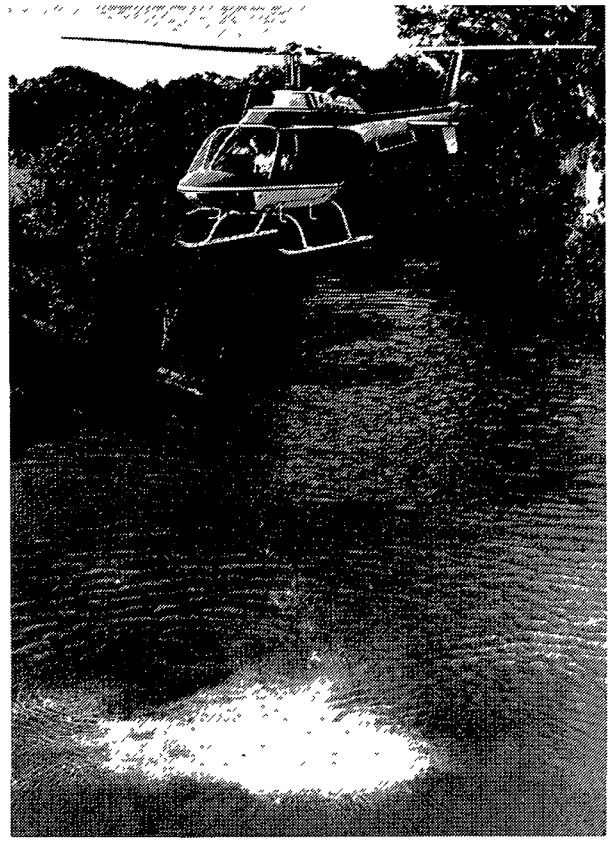
The elements used in these studies range from stable and radio-isotopes to rare-earths. Their selection depends upon the type of emission required, the energy of the radiation, the radio-isotope's half-life, its toxicity to the insect, the form of the radio-element (liquid or solid), and the ease of handling, labelling, and detection of the isotopes.

There are two other approaches in practical application of radiation to the problems of insect control. One is by exposing insects to lethal doses of radiation, as in the case of stored-product insects, and the other is by the release of sterile insects.

The latter procedure involves the mass-rearing, sterilizing and release of insects in sufficient numbers to overcome the fecundity of the natural population. Under appropriate pressure from the sterile males, most of the females will lay sterile eggs. By repeating this process for a few generations the pest population is virtually eliminated.

The Agency's commitment to this control approach for use alone, or inclusion in an IPM programme, has been, and still is, a major area of research. This approach is environmentally acceptable, is species-specific, is readily adaptable to area-wide control schemes against low-density populations; is comparable in cost-efficiency to conventional control measures and can readily be integrated with other control measures. The Insect and Pest Control Section's contribution in all aspects of the sterile insect technique (SIT) has been highly instrumental in the present programme in Mexico against the Mediterranean fruit fly and against fruit flies species in both Japan and Taiwan An extensive project is now in progress in Nigeria to determine the economic feasibility of this approach against the tsetse fly infestations over a 2500 $km^2$ area.

The section is also presently involved in the development of mass-rearing techniques for Mediterranean fruit flies involving the rearing of a male strain only, the development of a release mechanism to ensure proper dispersal of the sterile insect and the development of a completely automated system for the mass-rearing, packaging and sterilizing of $10^9$ medflies/week. Against the tsetse fly research, freeze-drying of blood is in



**Insecticide treatment of a river to control black flies, the vector of river blindness. Nuclear techniques can be used to study the biology of pests. (Photo FAO).**

progress to enable the mass-production of the fly without the need of rearing host animals. The blood can be stored and when reconstituted, be made available to the insects through a membrane-feeding system developed by the Agency's Entomology Laboratory.

Genetic sexing technology is a fairly recent innovation in support of the Sterile Insect Technique. Perhaps the most expensive item in an SIT programme is the mass-production of insects. For the most part, sterile females are theoretically neutral, yet almost 50% of the insect-rearing medium is devoted to rearing them. If females could be eliminated at an early stage in the rearing cycle, the costs, not only of rearing, but also of irradiation and release, would be significantly reduced The principle involves essentially the development of a resistance to a lethal influence and transferring this genetic resistance factor to the male sex-determining chromosome by exposure to a low order of radiation or radiomimetic chemicals. Selection with the lethal influence at an early stage of the insects' development results in the elimination of the females.

In addition to the research described above, the section is involved in the Agency's Co-ordinated Research Programme, which permits scientists from developing countries to meet at periodic intervals to discuss agricultural problems relevant to developing countries and to devise means of solving crop-pest infestation problems by using isotopes and radiation. The

Spraying insecticide to control tsetse flies. With the advent of the sterile insect technique, a thing of the past? (Photo FAO)

objectives of these programmes are initially outlined by a specifically convened panel of experts. Competent and interested research institutes are then contacted and invited to take part in the programme, which normally lasts for a maximum of 5 years. Furthermore, research institutes in the developing countries are given research contracts with nominal financial support. Institutes in the developed countries normally participate on a cost-free basis under research agreements. The participants in such a programme meet periodically to review the results achieved and to discuss and decide on the future direction of the programme.

### Symposium reviews sterile insect technique

The success of using radiation to control insect pests was underscored at a recent international symposium*. As a result of the review, presentations, and discussions at the symposium, it can be considered that:

- Following the many successes of the sterile insect technique as a control or quarantine measure over extensive areas, it can now be considered an economic and environmentally acceptable component of many integrated pest-management programmes.
- The riverine tsetse fly *G. p palpalis* can now be eliminated by the sterile insect technique. Recent advances in *in vitro* and *in vivo* feeding should make the technique economically applicable for control programmes.
- The BICOT** programme in Nigeria is proceeding as scheduled, with no changes in the research and implementation plans recommended.
- The development of a genetic sexing technique for fruit flies can be realized and should be operational in one to two years The technique thus precludes the need to rear females, thereby halving rearing costs.
- Morphological mutants are now available in both tsetse and fruit flies for use in ecological, dispersal and population dynamics studies.
- Some insects, moths in particular, suffer sever somatic damage when irradiated at doses necessary to produce a high degree of sterility in the released insect. When the released insect is irradiated at a lower dose, sterility in the filial generation is high and the sterile release effect is theoretically equal to, or greater than, what could be obtained by sterile adults unaffected by high radiation doses.
- Large sterile release programmes now involve the production of $10^6$ to $10^9$ insects per week. As in all mass-production systems, optimal quality control methods are necessary and are now being incorporated in many phases of mass-rearing, sterility induction and release.

* International symposium on the sterile insect technique and the use of radiation in genetic insect control, jointly organized by the FAO and IAEA, and held, at the invitation of the Federal Republic of Germany, in Munich, 29 June–3 July 1981.

** Co-operative project between the IAEA and the Government of the Federal Republic of Nigeria on the biological control of tsetse flies by the sterile insect technique.