

MAIN TRENDS OF RESEARCH TOWARDS PEST AND WEED BIOCONTROL IN SCIENTIFIC INSTITUTIONS OF THE USSR ACADEMY OF SCIENCES*

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Modern agriculture is now becoming firmly based on industrial technology, its main element being plant protection from noxious organisms.

Intensive technologies so far offer few alternatives to chemical methods of crop protection. Plant protection in these technologies is regarded as a preventive measure, and is based on the use of a standard set of chemical pesticides which are, as a rule, non-specific. An abundance of non-selective compounds in the environment leads to pollution and has a negative impact on entomophagous species. Unfortunately, none of the producers of chemical pesticides throughout the world have offered compounds that are absolutely safe for the environment. Chemicals used in agriculture differ from those used in industrial chemistry in that the latter affect a limited number of humans, i.e., the personnel of a given industry, and it is possible to restrict their release into the environment. Pesticides, however, affect all humans, animals and plants. They are purposefully introduced into the environment, spread widely, become uncontrollable and enter various food chains.

In any agroecosystem, pests (insects, weeds and microorganisms) comprise up to 2% of the total number of species present. In contrast, beneficial species may comprise 60 to 70% of the total species. Therefore, pesticides affect an extremely large number of organisms, many of which help to maintain the stability of the ecosystem.

The following methods have been proposed as alternatives to chemical pest control: 1) agrotechnical methods; 2) biological control using natural enemies of noxious organisms; 3) increased plant resistance; 4) male sterilization; and 5) genetic methods. None of these methods, however, can be considered a panacea, as each of them has its own limitations.

Since the problem of plant protection cannot be solved by a unilateral approach, specialists throughout the world have formulated a concept of integrated pest management on the basis of recent advances in the field of ecology. This approach proposes not an elimination of chemical protection, but rather a thoughtful limitation of pesticide application combined with maximum use of natural enemies and optimal structuring of the agricultural landscape. The concept of integrated pest management is in opposition to the tendency to oversimplify the agroecosystem and regard natural vegetation as weeds.

The development of integrated pest management requires a thorough study of natural enemies of pests and a serious study of the problems of general ecology and ecology of agroecosystems. Integrated pest management and optimal structuring of the agricultural landscape seem at present to be the only acceptable solutions to environmental problems related to pollution by pesticides, herbicides and defoliant.

The recent approach which regards a given crop as an agroecosystem inevitably leads to the replacement of the principle of the *species control strategy* with that of the *species population management strategy*.

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Management of populations of noxious and beneficial species is now implemented through the development of integrated pest management programs oriented towards utilization of the natural activity of entomophagous species and selective plant protection measures such as the use of selective pesticides and limited, local treatment with broad-spectrum materials. Injury thresholds of the noxious species and the level of entomophage efficiency are taken into account in the regulation of these activities.

The major components of an integrated pest management program are biological means of plant protection which act as trigger mechanisms for a reduction in the number of chemical pesticide treatments, thus gradually restoring the activity of natural enemy populations. Biological methods of plant protection are devoid of many of the faults of chemical pesticides; they are ecologically pure, relatively inexpensive and require low energy inputs. They are developed on the basis of renewable resource utilization. Scientific institutions of the All-Union Academy of Agricultural Science and the USSR Academy of Sciences are conducting large-scale research on beneficial organisms and methods of using them in integrated pest management. Our country has achieved good results in this field, but for a number of economic and organizational reasons these achievements are being implemented very slowly.

Biological scientific institutions of the USSR Academy of Sciences and of republic academies are conducting fundamental research on biological methods of plant protection in a number of directions. Work is being conducted, for instance, on the biological basis of employing natural populations of beneficial species in integrated pest management programs, with modelling of the most important processes in the agroecosystem allowing for monitoring and prediction.

A study of fauna, flora, systematics and biogeography is directly related to progress in plant protection. Development of a methodology for integrated pest management would not be possible without taxonomic identification of hundreds of species of noxious and beneficial arthropods. This is based on the fundamental research on the fauna and flora of the USSR, performed by the Zoological Institute of the USSR Academy of Sciences and the Botanical Institute of the USSR Academy of Sciences both in Leningrad, the Institute of Evolutionary Morphology and Ecology of Animals of the USSR Academy of Sciences in Moscow, republic zoological and botanical institutes, and the network of botanical gardens. This is a vast long-term project for preparing unique reviews and identification keys for the fauna and flora of the USSR and neighbouring countries. Without this work, development of modern plant protection based on achievements in the field of ecology would not be possible.

Another recent trend in basic research which is directly related to plant protection is the creation of data banks on some groups of insects, including pests and entomophagous species. This work is performed by the Zoological Institute of the USSR Academy of Sciences in Leningrad.

Research on the species composition of local populations of natural enemies of vegetable, orchard, melon and grain pests is conducted in the Institutes of Zoology of the Ukraine, Moldavia, the Transcaucasian Republics, Kazakhstan, Turkmenia and Tadjikistan, and at the Biological Soil Institute of the Far East.

As a result of bioecological research conducted by the Zoological Institute of the USSR Academy of Sciences in Leningrad, the Institute of Zoology and Parasitology of the Tadjik SSR Academy of Sciences in Dushanbe and the Institute of Zoology of the Turkmenian SSR Academy of Sciences in Ashkhabad, integrated plant protection methods have been developed for cotton in the Central Asian republics. This integrated pest management program allows for an 80–100% reduction in pesticide use in cotton while adequately protecting the crop by other means. Researchers at the Institute of Zoology and Parasitology of Uzbekistan in Tashkent are also working on the development of integrated pest management programs for cotton. They are observing the influence of some techniques used in the sowing of cotton on quantitative relations between winter noctuids, aphids and their natural enemies. The toxicity of a new fungal extract, mycoaphedin-1, to plant-sucking cotton pests is also being investigated.

The Institute of Zoology of the Academy of Sciences of the Ukraine in Kiev is conducting research on integrated pest management in orchards.

An important requisite for successful application of integrated pest management programs is the knowledge of host-parasite relations. These investigations are conducted in the Zoological Institute on two topics. First, a study is being performed on the bioecological, seasonal, geographical and historic aspects of host-parasite relations of scale insects (Coccoidea). Some results of this study have provided the basis of methods for using parasite populations to suppress fruit pests and for the search for and introduction of parasitic Hymenoptera. Secondly, physiological and ethological aspects of host-parasite relations and determination of parasite specificity are being studied experimentally.

The second major trend of research in the USSR involves establishing a scientific basis for the introduction of natural enemies of noxious species. Certain achievements in this field in the USSR have had a great economic impact. Acclimatization of the introduced parasite *Pseudaphycus* in the Central Asian republics and in Transcaucasia has actually saved sericulture in that region from serious damage by the Comstock mealybug. The ladybird *Serangium*, introduced ten years ago from India, has become acclimatized and reduces the population density of the citrus whitefly so efficiently that chemical treatments against this pest have been abandoned.

The use of pesticides has also been abandoned following the introduction of entomophages against such previously serious pests as the wooly apple aphid, citrus mealybug and cottony cushion scale. The introduction of *Phytoseiulus* and *Encarsia* has enabled growers to reduce and in some cases eliminate chemical treatments in greenhouse vegetable crops against spider mites and the greenhouse whitefly. In recent years, the introduced *Ambrosia* leaf beetle has also successfully adapted to the local climate.

On the whole, however, in spite of considerable and sometimes catastrophic damage caused by exotic pests such as the Colorado potato beetle, Japanese beetle, Japanese wax scale, oriental fruit moth and weeds of the genus *Ambrosia*, the rate of introduction of beneficial species from abroad to the USSR is still low.

At present, institutes of the Academy of Sciences and All-Union Academy of Agricultural Sciences in Moscow are carrying out a limited number of introduction programs. The Zoological Institute of the Academy of Sciences in Leningrad has recently participated in the introduction of *Microterys*, a parasite of the Japanese wax scale, from Japan to the USSR and in the establishment of a primary colony on the Black Sea Caucasian coast. The Institute is also conducting studies on the use of predaceous coccinellids imported from Vietnam for the control of aphids under greenhouse conditions. Scientists of the Biological Soil Institute of the Far East Scientific Center of the Academy of Sciences in Vladivostok are using Far Eastern coccinellids in the integrated management of fruit and citrus pests in Transcaucasia.

The third research trend deals with biotechnological and genetic aspects of the mass rearing of entomophagous insects and insect pathogens, on artificial as well as natural media. Academic institutions are conducting studies on the rearing of *Habrobracon* (Institutes of Zoology of the Academies of Science of Azerbaijan and Uzbekistan), predaceous coccinellids and *Trichogramma*.

Species of the genus *Trichogramma* are of particular importance as agents for biological suppression of noxious species. They are currently in use over an area of 16 million hectares each year, and 1500 factories and laboratories with 700 mechanized lines have been established for mass rearing of *Trichogramma*. A broad base has been created for further integration of plant protection methods on grains, vegetables, grapes and cotton. Its implementation, however, is on the whole unsatisfactory due to the extensive nature of *Trichogramma* application.

Knowledge of the physiology of all developmental stages of entomophagous insects is of particular importance for the development of rearing technologies. Therefore, research on photoperiodic and temperature control of development and diapause in insects conducted at the

Zoological Institute of the USSR Academy of Sciences in Leningrad is quite crucial. It provides the basis for developing methods of analysis and prediction of phenology for managing the development of entomophagous organisms in mass rearing facilities. This research has led to attempts at developing methods for using coccinellids and other natural enemies for biological protection of greenhouse crops.

Another major research field concerns the scientific basis of using phytophagous species for biological control of weeds. Worldwide experience during the last decade has brought us to a new phase in the development of biological control of weeds by extensive use not only of insects, but also of phytophagous groups such as fungi, nematodes and mites. The main results of this research have been obtained from work using introduced phytophagous species for suppression of the most harmful invading weeds. This is usually the only radical way to suppress mass propagation of exotic weeds.

In the USSR, the development of weed biocontrol was initiated by the Zoological Institute of the USSR Academy of Sciences in Leningrad, which developed a method of controlling the noxious weed *Ambrosia* using the *Ambrosia* leaf beetle introduced from the United States. The *Ambrosia* leaf beetle has now successfully adapted to a number of regions in our country, including the Ukraine, North Caucasus, Transcaucasia, Kazakhstan and the Far East. This same institute, in cooperation with the Uzbek Biological Institute, has developed a mechanized method for applying a water suspension of larvae of the nematode *Paranguina picridis* to suppress Russian knapweed.

On the whole, it must be admitted that such an important problem as the biological suppression of weeds is still given little attention in our country.

The use of microorganisms for biological control of noxious species is another major topic of research. Work on this problem is conducted at the Institute of Zoology and Parasitology of the Lithuanian Academy of Sciences (Vilnius), the Institute of Microbiology of the Armenian Academy of Sciences in Erevan, the Institute of Forest and Wood of the Siberian Department of the USSR Academy of Sciences and the Institute of Zoology of the Kazakhstan Academy of Sciences in Alma-Ata. Original data has been obtained in Vilnius on the ecology of entomopathogenic representatives of the *Bacillus thuringiensis* group. In addition, the Biological Institute of the Siberian Department of the USSR Academy of Sciences in Novosibirsk and the Institute of Forest and Wood of the Siberian Department of the USSR Academy of Sciences in Krasnoyarsk are studying the influence of the entire complex of bacterial preparations and of mixtures of viral and bacterial preparations on pests.

Twelve institutes of the Academy of Sciences and a number of higher schools are working on the topic of the ecological role of biologically active compounds in regulating relations in the agroecosystem. The Institute of Evolutionary Morphology and Ecology of Animals of the USSR Academy of Sciences in Moscow studies the theoretical basis of chemical communication among animals for the purpose of managing the behavior and physiology of economically important species. It develops techniques for identifying components of sex pheromones of lepidopteran pests which govern their intraspecific relations. Methods for application of sex pheromones of the turnip moth, *Agrotis esclamationis* L., and of orchard leaf rollers are being developed.

The Institute of Organic Chemistry of the USSR Academy of Sciences in Moscow, the Institute of Chemistry of the Bashkirian Branch of the USSR Academy of Sciences in Ufa, the Institute of Chemistry of the Moldavian Academy of Sciences in Kishinev and a number of scientific research institutes of the All-Union Academy of Agricultural Sciences in Moscow are synthesizing juvenile hormones and pheromones for pest control. The Institute of Zoology and Parasitology of the Lithuanian Academy of Sciences in Vilnius is developing models of the structural organization of pheromone cues and studying the role of its components in insect behavior. The Institute of Bioorganic Chemistry of the USSR Academy of Sciences in Moscow is working jointly with the Central Asian Institute for Plant Protection in Tashkent and the

Azerbaijan Institutes for Plant Protection in Baku on the isolation and synthesis of cabbage moth and *Heliothis armigera* pheromones for use in integrated pest management. Institutes of the USSR Academy of Sciences also deal with the use of pheromones in pest control in greenhouses.

This is a general outline of the research trends on biocontrol of noxious organisms conducted by scientific institutions of the USSR Academy of Sciences. Our immediate task is to implement integrated pest management on the main agricultural crops in different regions of the country. This is expected to reduce the levels of pesticide pollution in agroecosystems, which will in turn enable us to focus on biological control of pests and eventually create a real opportunity for agroecosystem management.