Entomology — The Decade Ahead

J.T. Schulz
Department of Entomology

Low input-sustainable agriculture, adaptive agriculture, regenerative agriculture, biotechnology (including genetic manipulation) and expert systems — these are a few of the focal points of current discussion and research in the agricultural, biological, physical and mathematical sciences. These broad concepts encompass research areas toward which we as entomologists are directing some of our current efforts and will be increasing our activity in the years ahead.

While the concepts and objectives inherent in the use of integrated pest management (IPM) are not new, these concepts, if appropriately implemented, are as valid today as they were 10-15 years ago when IPM programs were first thrust into the forefront of agricultural research. And, in fact, IPM programs dovetail nicely with current definitions of both sustainable and adaptive agriculture. Embracing the use of multiple tactics derived from multidisciplinary research for the management of noxious pests, IPM predictive models document action thresholds (economic thresholds) and permit a judicious and more precise use of control methods (economic inputs), especially the use of pesticides.

The Department of Entomology, has focused past IPM research activities largely on sunflower and sugarbeet, principally because of the pest complexes involved and the dependency on a single tactic for control and management of these complexes, the insecticide. Models are continually being refined to reflect current economic considerations, changes in agronomic practices, changes in cultivars and increased knowledge about the pests derived from results of ongoing research. Recently, increased emphasis has been directed to the acquisition of similar information that will permit us to better manage the insect complex of corn and predict changes in insect activity that may occur as a result of changes in tillage practices, crop rotations and other refinements in agronomic production practices. Results of these types of research activities require the test of time in order to achieve the validity and consistency needed for accurate predictions.

With the addition of new staff three years ago, the department has been able to sharply increase its research efforts in host plant resistance (HPR) on sunflower and sugar beets. The new technologies of the molecular biologist, in concert with older, time-tested methods of developing and evaluating cultivars are being utilized. With increasing recognition that susceptible cultivars are defective, the blend of new and old techniques will be directed to the development of multiple and durable pest resistance in these two hosts.

A goal for biotechnologists which shows promise of achievement is incorporation of genes for the production of *Bacillus thuringiensis* endotoxin in crop cultivars to convey insect resistance. With some crops, good results have already been obtained on an experimental basis. However, the mode of action of the endotoxin in controlling lepidopteran (moths/butterflies) pests may result in development of insect biotypes resistant to the toxins, thus limiting effectiveness of the incorporated gene as a resistance factor in plants.

The efficiency of endotoxin may be increased through combination with other resistance factors, providing additive or synergistic control. However, some resistance factors may be competitors or inhibitors, and in combination increase crop susceptibility.

Plant-produced phenolics have potential as weed, pathogen, and insect control compounds. Their role in insect resistance is being studied in this department. Certain phenols are toxic, for example, to sunflower moth larvae at low dosages; others induce chronic effects on insect development which also are of interest. Initial results indicate that nonlethal doses of toxic phenols may inhibit the action of **B. thuringiensis** (B.t.). With many private biotechnological firms engaged in the incorporation of *B.t.* genes in various host plants, the possible inhibitory effects of certain plant chemicals on this bacterium is of significant interest. Research is underway to clarify the interactions of *B. thuringiensis* and plant phenols.

The department's expertise in IPM, HPR and ecology may be sorely tested in the next few years. As we prepare for what appears to be an imminent arrival of the Russian wheat aphid, information and experience from states to the south and west of North Dakota suggests that there are no cultivars of wheat that exhibit resistance to attack by this species. Application of insecticides has been the only means available for reducing losses in areas experiencing infestations by this species. While North Dakota producers will also have to rely on this single tactic initially, research in all facets of insect biology, ecology, behavior management and control will be initiated so that, hopefully, reliance on a single control tactic will not be necessary.

The department must strive to expand its research in biological control. A major multidisciplinary effort directed to the biological control of leafy spurge will continue. Controlled releases of several exotic insect species continue to suggest that some of these species can adapt to the environment of this region and successfully feed and reproduce on the leafy spurge host. Confined releases have recently been expanded from research sites in east-central North Dakota to western North Dakota. Continued success with the insect complex under these varied conditions will hopefully permit larger releases of some of these species. As pathogens are identified that are also deleterious to leafy spurge, the role of the insect in transmission of some of them will be undertaken.

Environmental and economic considerations associated with pesticide use and the potential development of resistance by insects to currently used insecticides are critical concerns. A research effort to achieve methods of biological suppression of grasshoppers has been and will continue to be a major thrust in the department. Our current work is focused on a fungal pathogen, *Entomophaga grylli*. While the more common pathotypes of *E. grylli* can now be successfully cultured and will attack selected species of our grasshopper complex, the moisture (humidity) requirements needed to trigger epiphytotics of the disease in grasshopper populations preclude effective use of these pathotypes in arid areas such as western North Dakota. Current and future research on an acquired Australian pathotype, with adaptation to more arid areas, may ultimately permit its introduction into areas where our incipient grasshopper problems exist.

Research directed to the ectoparasitic flies which attack livestock has focused on both biting and non-biting fly complexes. These studies have concentrated on the behavior, ecology, physiology and management of these species. Recent evidence of fly resistance to chemicals used in cattle eartags, which have been widely used for control of this complex, suggests the management is assuming greater complexity and will likely require other approaches to lessen the dependency on the chemical-impregnated eartag.

Similarly the department's recent research thrust to better understand the North Dakota mosquito complex, their behavior, ecology and disease transmission, is aimed at better definitions of the ecological parameters which regulate incipient populations. These studies, which involve interactions with established mosquito abatement districts as well as other state and federal agencies, will be expanded in the forthcoming years.

The decade ahead for we in entomology will be more challenging than ever as we attempt to understand, manage and live with those insect species that are considered deleterious to our food, fiber and quality of life. Management of noxious species must embrace economic efficiency yet be consistent with a need to preserve our environment as a natural resource and the beneficial biota which coexist with our pest species. The department's basic and applied research activities on many fronts recognize those needs and are addressing them. We will continue to do so through development and utilization of new technology in concert with proven methods.

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areas of interest to North Dakota because costs continue to rise and funding increases are not easily obtained. The key to future success in solving problems will be to integrate research activities with other departments to attack problems through team efforts. Integrated projects are expected to develop with plant science departments as we begin to unravel the pathogenic mechanisms of plant disease and continue to explore ecological questions. Biological control of plant pests using "safe" microorganisms will become increasingly more important as fossil fuel reserves continue to decline and agri-chemicals continue to increase in cost.

Integrated research with food processing departments will be enhanced as we begin to explore new uses for traditional agricultural products. Microbes are critical sources of enzymes and food additives necessary to the food and beverage industry. Genetic engineering has the capability to produce a variety of organisms with improved production efficiency.

A third area of emphasis will be in the area of animal sciences in terms of both health care and animal nutrition. Research in this area will focus on finding ways microbiologists can improve livestock operation efficiency and thereby decrease production costs.

To help keep NDSU on an aggressive and progressive path during the era of applied biotechnology, the Department of Microbiology must see two things happen. First, our research must have avenues to efficiently move from laboratory test facilities into test production facilities. This will happen by developing linkages with other departments at NDSU that have greater production orientation as well as nurturing biotechnology industry contacts to evaluate the production potentials of basic research discoveries. Second, there must be continued commitment from local, state and federal agencies to support the "high tech" basic research of a department of microbiology. Our department plans to add four faculty as resources become available to facilitate research efforts. This commitment is sometimes difficult to maintain since the rewards are often so long in coming. We are continually exploring the variety of options we have to establish partners in industry to help bring laboratory discoveries to the consumers more quickly. We also anticipate that these "business" relations have the potential to help provide future fundings for research projects. Our hope is that dedicated and visionary leadership will insure continued progress in these areas by seeing that adequate resources and unwavering commitment remain available to our department.