# AN INDUSTRIAL AND CONSUMER PERSPECTIVE

Bill Lingren

President, Trece Inc., Salinas, Ca.

## ABSTRACT

This article represents my views gained through extensive personal experience in manufacturing, marketing, and actually using products based on pheromones and other chemical attractants to monitor and control insects. The focus of this article is on lepidopteran phytophagous insect pests (primarily those in the genera *Helicoverpa* and *Heliothis* of the family Noctuidae) which inflict heavy damage each year on row crops. Emphasis is given to (1) reasons for needing new pest management technologies, especially those that target the adult developmental stage of the pest, (2) the opportunities and obstacles associated with the development of technologies to manage adult noctuids, and (3) the potential for cooperation among representatives of industry and federal and state organizations in the development and commercialization of promising technologies.

## MANAGEMENT OF ADULT NOCTUIDS

There is a critical need for new or improved pest management technology to control the highly mobile, nocturnally-active, adult stage of the Helicoverpa/Heliothis complex of crop pests. There is no doubt that the overall management of this important group of insects could be substantially improved if all of the life stages (vs only the larval stage) could be effectively targeted by one or more control tactics. Pest management specialists have a mandate from the consumer to ensure the safety of our food supply while at the same time keeping farm to market costs at affordable levels. The farmers have a special interest in the development of new pest management technology. Their costs are advancing at a rapid rate despite the availability of new production technologies that have lowered input costs in recent decades. Insect pest control is one of those advancing costs. Farmers also have an image to preserve or to improve with the general public; they must be perceived as growing safe, high quality food at a reasonable cost to the consumer. However, increasing public concern about the potential for contaminating the environment with pesticides, as well as about unacceptable risks to farm employees who work in and around pesticide-treated fields, have compromised their image.

The nature of the Noctuid insect problem also mandates changes in existing control technology. Noctuid pest species are among the most destructive of all insect pests--clearly in the top five of the species that are considered to be the most economically important. The literature contains numerous accounts of the destructiveness of this family of insects and the difficulty in controlling its members. A very important factor that must be considered in planning control strategies is the ability of certain species in this family of pests to develop resistance to conventional insecticides.

Preservation of a clean environment must be a controlling factor in selecting pest management tactics. The pesticide load has not decreased as predicted twenty years ago by the advocates of integrated pest management (IPM) concepts. However, our food supply is

still by far the cleanest in the world from the standpoint of pesticide residues per se or over-tolerance residues. This country is one of the heaviest users of pesticides in the world and it is absolutely essential that these hazardous materials be used as carefully as possible. We must develop alternative, nonpolluting control technologies that can be incorporated in management programs in a way that ultimately reduces our current dependence on highly toxic chemicals. The pesticide industry and the regulators of that industry are reacting to a higher level of pressure from consumers to limit pesticide use and ensure that more innocuous pesticides are used in agricultural production. Thus the pesticide industry must meet the requirements of an intensifying regulatory environment while at the same time coping with the problems of insecticide resistance, consumer advocacy, and the necessity for providing growers a top value product.

All participants in the pest management process must continue efforts to modernize and improve pest control technology. We have greatly advanced our ability to monitor insects and make pest management decisions through the use of predictive computerized models based on information from population surveys using pheromones and other attractants. Unfortunately, the attractants that have been used for these efforts have, for the most part, been sex pheromones that affect only the male and provide very little information on the female, which deposits eggs on crops during critical periods of plant development. Because of the obvious inconvenience imposed by the nocturnal activity and cryptic behavior of noctuid moths, the major focus of pest management has been on the larval stages which are more accessible with our conventional control methods.

## ATTRACTANTS FOR ADULT NOCTUIDS: OPPORTUNITIES AND OBSTACLES

There is excellent potential for the effective use of chemical attractants as components of programs to control noctuid adults. The ability to monitor adult females and perhaps both sexes simultaneously in a noctuid population, either with or without the addition of pheromones or other commonly used attractants, is a highly desirable objective. Such an enhancement of monitoring technology could provide pest management specialists with timely and specific information on both immature and adult life stage activities, thereby providing a better estimate of total population dynamics that would facilitate establishment of a firm basis for making pest management decisions.

The potential for direct control of noctuid adults is probably the most important stimulus driving research to develop ways to incorporate volatile attractant chemicals isolated from plants (phytoattractants) into pest management programs. In developing this new technology, we must also maximize the use of pheromones and other attractants as pest management tools. Information on timing of the development of pest populations, and estimates of their magnitude obtained through the use of pheromones in monitoring systems, has provided invaluable input for use in decision-making models that are designed to guide the timing of applications of conventional pesticides. Pheromone-based formulations also have been used with some success in the field to control certain pest species through both the "confusion" and "attracticide" management approaches, as well as in mass trapping devices for certain insects.

Formulation technology based on pheromones has advanced to the point that pest management specialists can obtain, at the least, limited commercially-acceptable results in suppressing the pink bollworm. However, industry has not been successful in developing products based on this technique that can achieve acceptable control of the *Helicoverpa/Heliothis* complex of pests. This lack of progress has been a disappointment to state and federal researchers, as well as to industry. A major stumbling block is that available sex pheromone attractants can only be targeted against the male adult. Currently, we do not

have a commercially available chemical attractant that is effective against the all-important female adult noctuids. Successful development of a phytoattractant that would be effective against both sexes, or at least against females, would represent a major breakthrough that could facilitate advancement in monitoring and controlling numerous lepidopteran pest species, especially noctuids. Thus, there is strong motivation to proceed with vigorous research aimed at developing effective attractants for noctuid female moths. However, these opportunities cannot be seized without a substantial commitment of resources by state and federal research organizations and industry.

There are several key areas on which emphasis must be placed to optimize the development of control technologies that include the use of phytoattractants. The identification, quantification, and ability to synthesize active chemical components of a phytoattractant are essential to the entire process of development. Although a phytoattractant might be comprised of several components, there is always a chance that only one chemical in a multicomponent isolate may be needed to obtain cost effective results. Cost is a key issue in commercialization because the need for more than one chemical in an attractant formulation usually adds substantially to the cost of the final product. The cost of finished attractant products must be low enough to compete with alternative products that are used to control the pest insects. A favorable report on the toxicology of each component of a phytoattractant mixture is required to gain regulatory agency approval of an attractant formulation. Therefore, it is essential to identify bioactive components that would have the lowest potential biological hazard during either the manufacturing process or application in the field.

Formulation will be another major step in the development of phytoattractants for practical use. In fact, the identification and development of suitable formulations may eventually be the most costly and difficult obstacles. On the other hand, it is possible that the basic technology exists now for formulating attractive plant volatiles for use in monitoring as well as in control. In the last decade, several of the control technologies developed have included the use of formulations of insect pheromones and other attractants. In the past five years, a number of novel formulation approaches have been used in pheromone-based research programs. Obviously, more research and development must be done to optimize the use of available formulations for use with phytoattractants. Such formulations must have practical convenience for the end user (most likely a producer or applicator) to transport, mix, and apply to the crop. Any product that is significantly less convenient to use than established conventional products will face substantial obstacles in commercial acceptance unless it provides a major advantage in efficacy over those products. Another important guideline in developing attractant delivery systems is to determine beforehand potential limitations in the basic makeup of a formulation. There may be physical characteristics which could adversely affect deployment of a product in certain situations. For example, if a large number of point sources must be distributed over a crop area, then the formulation most likely would have to lend itself to effective deployment as a very small entity. It is also very important to ensure that chemicals comprising the delivery system will not react adversely with the phytoattactant. Phytoattracants to be used as a formulated product must also be tested to determine if there is potential for repellent activity against either sex of the targeted pest. Also, the release characteristics of the formulated phytoattractant must be established, preferably under both laboratory and field conditions, to determine the effective period of residual attractancy. It is essential to establish a clear relationship between the amount of the product applied, the amount released over time under different conditions, and the effect on the targeted pest. Such variables should be considered in view of the temperature, air movement, and moisture conditions that might be encountered in the field.

The objective of this article is to discuss the need for new pest management technology with emphasis on adult control strategies. The potential for cooperation between

industry and government in the development and commercialization of new technologies for pest management, and opportunities and obstacles for the development of an adult control technology for the Noctuidae will also be discussed.

The need for new technology, especially that for adult control, is often heard from different sectors of the U.S. economy affected by noctuid pests. There is clearly a need for better IPM strategies. In many cases, that means a mandate for improved technology. Some examples are discussed here. We especially have a mandate from the consumer to ensure, without fail, the safety of our food supply. This was highlighted to the author upon hearing a recent advertisement from a local food chain. The advertisement declared that the food commodities offered by the advertiser were tested 100% free of pesticides. This was stated in spite of the fact that the California Department of Food and Agriculture has quite adequately ensured the protection of the food supply originating from fields in California. However, this type of advertisement still sells food to consumers; even in such an intensive agricultural production area as the Salinas Valley, where much of the nation's supply of leafy vegetables is grown.

The growers provide another mandate for improvement. Their costs are advancing at a rapid rate despite new technologies that have lowered the cost of their inputs in recent decades. Insect pest control is one of those advancing costs. There is a critical need to stabilize or lower these costs. The grower also has an image to preserve or to improve with the general public. The grower must be perceived as growing high quality safe food, now more than ever. However, recent "out lashes" against pesticides have compromised their image.

The idea that there is also a mandate from the insect should not be overlooked. Members of the family Noctuidae are, if not the most destructive insect pests on earth, clearly are among top five of the most economically important. The scientific literature includes numerous accounts of the destructiveness of this family, the difficulty in controlling its members, and (perhaps the most important factor) the ability of these pests to develop resistance to conventional insecticides.

Obviously, we also have an environmental mandate. The pesticide load has not decreased as anticipated twenty years ago by the supporters of integrated pest management (IPM). Our food basket clearly is among the cleanest in the world with respect to pesticide residues or over-tolerance residues. At the same time, we remain one of the heaviest users of pesticides in the world. In many cases, pesticide use is increasing.

We have a mandate from the regulators and the pesticide industry. The regulators are reacting to a higher level of pressure from consumers to limit pesticide use and ensure that more innocuous pesticides are used in the environment. Correspondingly, the pesticide industry must deal with this intensifying regulatory environment. Also, they must cope with the problems of insect resistance, consumer advocacy, and the necessity of supplying growers an input of top value.

Finally, we have a mandate to modernize and improve our pest management techniques. We have greatly advanced our ability to monitor insects and to make pest management decisions through the use of systems based on pheromones and other attractants. However, these types of attractants usually affect the male and do not focus on the female "egg factory." Indeed, our pest management focus has not been on the destruction of the all important female insect; rather, it has been on the larval stage which is most susceptible to our control tools.

So what are the opportunities for using plant attractants for control of Noctuidae pests? The potential to monitor both genders of the population either with or without the addition of pheromones or other commonly used attractants is an immediate option. This approach to monitoring could provide pest managers a more definite sense of life stage

activities and population dynamics, thereby providing a sounder basis for making pest management decisions.

Direct Noctuidae control is possibly the most important opportunity, among others, for using plant attractants. In developing this technology, we must build on the basis of our past achievements. Indeed, our past achievements have been great but we need much more progress to optimize the use of pheromones and other attractants as pest management tools. We have successfully used pheromone monitoring systems for decision-making models for application of conventional pesticides. We have used pheromone based formulations to control insects through both "confusion" and "attracticide" approaches. We have also used pheromones and other food attractants as mass trapping devices for certain insects.

The results have been variable. For example, formulation technology based on pheromones has advanced to the point that pest managers can obtain borderline commercial results for pink bollworm control. However, industry has been unsuccessful in introducing commercial level Heliothis spp. control products based on pheromones. This has been a disappointment and an economic failure in respect to the industry and the government researchers involved. One of the key stumbling blocks has been the focused research on the male insect because we lack the capability to focus on the female.

With the ability to focus on the female with an attractant, the industry could make an advancement in controlling and perhaps eradicating numerous Lepidopterous pest species, especially noctuids. Further, there could be an opportunity to greatly improve the efficiency of conventional insecticides used to control noctuids.

There are opportunities to improve pest management through the development of adult Noctuidae female attractants. However, these goals cannot be realized without a substantial commitment in resources by government and industry. Through efficient cooperation, government and industry have an opportunity to optimize the development of female attractants. The extent to which government and industry understand the problems and the degree to which each party cooperates may determine the difference between success and failure.

There are several key areas on which emphasis must be placed for optimizing efficient product development at government and industry levels. The identification and quantification of the chemical components of female plant attractants are essential to the entire process. Often, there is a tendency to identify all the components and to advocate the use of each. However, there is always a chance that only one chemical, or a part of the total isomeric complement, may be needed to obtain cost effective results. Cost is the key issue, since each additional isomeric component usually adds substantial cost to the final product. Unequivocally, the finished product must sell within reason, competitively with current products.

Establishing the realistic quality of each component is very important. The degree of quality will translate directly to cost of manufacturing. If the job can be accomplished realistically with an 80% material there is clearly no reason to advocate a 99.9% quality specification. When there is a multicomponent attractant material, there is clearly a need to optimize the relationship of each component and, if possible, rely heavily on the lower cost material.

Finally, the toxicology of each chemical component is a substantial issue. We must be careful to identify components with the lowest potential hazard in manufacturing and application. Chemical components of plant volatiles which may eventually emerge as optimal female attractants are not known.

The foregoing aspects of identifying and developing the chemical components of the female attractants will largely be conducted at the government level, if history is an indication. However, it is essential that government and interested industry representatives frequently and

openly discuss on-going research progress. This clearly will lead to development of the most cost efficient chemistry for female attraction.

Formulation is another significant area for focus in research on female attractants/control. In fact, the isolation and development of the appropriate formulations may eventually be the most costly and difficult obstacle. However, there is good reason to believe that the basic technology exists today for formulating female attractive plant volatiles for monitoring and/or control. In the last decade, we have seen several technologies emerge that have been developed into formulations for insect pheromones and other attractants. In the last five years, we have seen a number of novel formulation technologies enter pheromone-based research programs.

Obviously, more efforts in research and development are needed to optimize the use of available formulation technologies for female attractants. It is important that these materials be screened and developed on the basis of a few important guidelines. The formulation must be practically convenient and it must be convenient for the end user (most likely a grower or applicator) to transport, mix, and apply the material. We must realize that any product that goes too far beyond the use pattern of established conventional products will face substantial obstacles in commercial use.

Another important guideline in formulation development is to establish beforehand the insect behavioral implications of the formulation chemistry in relation to the attractant which it is designed to carry. There may be physical or chemical limitations of the formulation chemistry. For example, if a large number of point sources are required over an area applied and spread, then the formulation should lend itself to delivery to such sources. Finally, the release rate of the formulation should be clearly defined in laboratory models. Conditions in the field constantly change. Therefore, we must develop a clear relationship between the amount of product applied, the amount released, and the effect on the target insect. Of course, the variables must be considered in view of temperature and moisture conditions.

Application equipment may be even more sensitive to conventional commercial boundaries than the formulation. The user will immediately rank and judge the products capacity to be applied by hand, ground rig, or air. In addition, if a machine application is used either on the ground or in the air, a product will further be ranked by the extent to which modifications will be needed. Obviously, modifications to aerial equipment are the most costly and least desirable. Any cost analysis of application methods or related equipment must also consider the cost effectiveness of the product. If the product contributes a verifiable improvement in insect management, developing a totally new approach to application may be justified.

Product performance in relation to product and application costs is the most significant guideline by which end users will decide to purchase a product. This may seem to be a simplistic concept at first, one that is understood by all. However, it is worth emphasizing that any new pest management technology/product will be subjected to the same rigid economic appraisal as conventional pesticides. This fact should not be a reason for alarm, but it should be a reason for industry and government researchers to develop sound economic evaluations of product performance and a clear method of communicating the results.

Government and industry could develop the most technically, economically, and environmentally sound product in history and, conceivably, it might never be used. If industry marketers and government extension do not communicate the right message to users, they will never buy. Further, if the wrong product use position is communicated, there will be failures and subsequent product rejection. Therefore, it is critical that user education and promotion of new technologies be closely related. A strong extension education program should be implemented for users and their advisors. Industry must carefully prepare

educational and advertising material. User meetings and demonstrations must all focus on building the correct level of expectation at the user level. These communications must also emphasize techniques for proper use, initiation, measurement of results, and related follow-up. Otherwise, the perception of failure will dominate the market.

Many pheromone-based technologies, though borderline, have been potentially useful but have failed commercially. The author believes these failures were because the foregoing approach was not closely followed rather than due to technical short falls. Marketing insecticides involves a good deal of hyperbole, but a "dead bug" is still a "dead bug." We are not dealing in "dead bugs" with pheromone or food attractant technology. Therefore, the communication of cost/benefit to users is more difficult.

Government and industry are at a crossroad. Do we let our disappointing experiences in the use of pheromone based insect control stop us; or do we press on toward the single most important technical step...female attractants? The author has stated why we need female attractants. But, as a final encouraging note, the author believes one success in this area will spur more short - term investment than the combined historical investments in pheromone-based products. The time is right, we have a mandate and we are close to having the technology. Let us combine the resources of industry and government and make insect attractant based technology realize its full potential through female attractants.