# Appendix: Poster Abstracts

Abstracts of posters presented at the Third National IPM Symposium/Workshop are pre-sented in this section. These abstracts were first printed in the Symposium/Workshop program and are reproduced without change here. Papers are in alphabetical order based on the last name of the first author.

**Developing and Delivering an IPM Program for Hot Pepper Growers in Mexico**. M. Saul Alarcon, Hasan A. Bolkan, Robert K. Curtis, and Dennis J. Larsen. Campbell Soup Company, 28605 Country Road 104, Davis, California 95616

Traditionally, pests and diseases of hot peppers (*Capsicum spp*.) are controlled with protectant fungicides and contact insecticides applied on calendar base. Depending on the target organism, the number of sprays can range from 5 to 15 per season per crop. The preventive strategy is successful in protecting yields and quality. Public concerns, however, about pesticide residues is forcing processors and growers to find alternative control strategies to reduce the use of synthetic pesticides. To help growers make the switch from calendar base pesticide applications to only when needed, Campbell Soup Company has initiated an aggressive IPM program for pepper weevil (*Anthonomus eugenii* Cano), yellowstriped armyworm (*Spodoptera ornithogalli* Guenee), and virus-transmitting insects. Campbell's Jalapeno IPM Program has three interrelated components: cultural practices, monitoring, and treatment. The cultural practices include crop rotation and field sanitation to eliminate weed populations to prevent potential migration and infestation of pests and viruses. The second component of the IPM program is monitoring and scouting for pest populations. Campbell's IPM specialists provide hands-on training to growers' field personnel and help them monitor twice a week for insects and diseases. When it is determined through monitoring and scouting, that pest populations have reached the level which will cause economic damage, the grower is encouraged to apply selective or biorational pesticides such as *Bacillus thuringiensis*. In 1995 growing season, overall pesticide reduction (kg. active ingredient/acre) for growers using IPM ranged from 27.1 to 55.3 percent compared to non-IPM growers. For the same IPM growers, the number of spray applications declined 15 and 30.6 percent, respectively, depending on the location of the field.

**Manipulation of Orchard Ground Covers for Enhanced Arthropod Management.** Diane G. Alston, Department of Biology, Utah State University, Logan UT 84322-5305

Diversity and density of species of ground cover plants influenced arthropod abundance and dispersal in Utah apple orchards. Certain broadleaf weeds present in ground covers increased densities of phytophagous and predaceous mites. Mite abundance and timing of their dispersal from ground cover into trees was strongly influenced by presence of certain broadleaf weeds and ground cover management practices, such as frequency and timing of mowing, herbicide application, and cultivation. In addition, the ground cover species composition and biomass were influenced by frequency of mowing. Percent horizontal cover of field bindweed a prominent host species for phytophagous mites, was greater in plots mowed every two weeks (10-23 percent of total cover) than in plots mowed every three weeks or left unmowed (1 -7 percent) during July and August. Ambulatory dispersal of phytophagous mites into tree canopies was two times greater in plots mowed every two weeks than in unmowed plots. The presence of apple rootsuckers on the base of tree trunks increased the abundance and dispersal of phytophagous mites into canopies. The type of ground cover in a tart cherry orchard was found to influence the pupation success of western cherry fruit flies in the soil, and the time and rate of emergence of adults in the spring. Ground covers of companion grass and weeds resulted in the least pupation. Greatest pupation success and earliest emergence of adults was seen in bare ground plots. Soil temperature may be a better predictor of adult emergence than air temperature.

**Consideration and Management of Pesticide Resistance by the U.S. Environmental Protection Agency.** Neil Anderson, Tobi L. Colvin-Snyder, Frank Ellis, Paul I. Lewis, Sharlene R. Matten, Robert I. Rose, Douglas W.S. Sutherland, and Steve Tomasino U.S. Environmental Protection Agency Office of Pesticide Programs Pesticide Resistance Management Workgroup 401 M Street S.W. Washington, DC 20460

Pesticide resistance management is a worldwide problem and is an important aspect of IPM. The U.S. Environmental Protection Agency has considered the development of pesticide resistance and pesticide resistance management in its regulatory decisions and believes that it is very important to implement effective resistance management strategies. How the Agency has considered pesticide resistance management under the Federal Insecticide Fungicide Rodenticide Act (FIFRA) when making emergency exemption, special review and registration decisions plus new Agency pesticide resistance management initiatives will be discussed.

**Management of Plant-parasitic Nematodes in Cotton Production Systems with Poultry Litter and Winter Rye.** K.R. Barker', S.R Koenning', RL. Mikkelsen[2], K. L. Edmisten[3], D. T.Bowman[3], and D.E. Morrison[4], 'Departments of Plant Pathology, [2]Soil Science, and[3] Crop Science, North Carolina State University, Raleigh, NC, 27695, and [4]North Carolina Cooperative Extension Service, Scotland County 231 E. Cronly St., Laurinburg, NC 28383

Cultural practices often are neglected as an option for nematode management in cotton. Use of animal wastes and other organic amendments or green manure crops such as a winter rye crop have promise for controlling many plant-parasitic nematodes. Field experiments were initiated in North Carolina to evaluate the influence of rates and dates of poultry litter application and (or) a winter rye cover crop on Columbia lance nematode, *Hoplolaimus columbus*, and cotton yield. Fertility levels for all plots were adjusted to those recommended by a soil test. A rye cover crop fertilized with various rates of chicken litter tended to suppress numbers of Columbia lance nematode, but also had a negative impact on cotton yield. There was a negative correlation (P=0.05) between seed cotton yield and the amount of rye incorporated into the soil. However, high rates of chicken litter increased (P=0.10) cotton yield and resulted in low numbers of this nematode in September. Early application (December) of litter tended to improve nematode control and enhance yield more than late application (April). Numbers of root-knot nematodes, *Meloidogyne incognita*, were lowest in plots receiving chicken litter, regardless of the date of application. The increased cotton yield in response to chicken litter application can be attributed to nematode control, since it is unlikely that fall-litter applications affected soil fertility during the growing season. Poultry litter also enhanced numbers of microbivorous (non-parasitic) nematodes, indicating increased microbial activity when this material was added to the soil. Overall, results from field as well as greenhouse tests show that these soil amendments were more effective in suppressing population densities of the plant parasites M. *Incognita* and *Paratrichodorus minor* than H. *columbus* and *Rotylenchulus reniformis*.

**Spatial Analysis Technology Applied to the Regional Assessment of Plant Pests and Diseases**. John H. Barnes, USDA/CSREES, Washington DC; Hasan Bolkan and Saul Alarcon, Campbell Corp., Davis. CA.; Merritt Nelson, David Byrne, and Tom Orum, Univ. of Arizona, Tucson, AZ

We have been assessing the benefits of analyzing plant disease and pest severity on a regional scale using the tools that are also being applied to precision farming, such as geographic information and global positioning systems (GIS and GPS). These two technologies are extremely useful in developing a computer map based record of the location of disease and pest outbreaks. In addition, these data may be analyzed spatially using geostatistics to show how and where regional patterns vary. When the concepts of "Landscape Ecology" are applied to the heterogeneous landscapes that are characteristic of most plant

dominated ecosystems, including agroecosystems useful conclusions regarding cropping pattern influences on the severity of diseases and pests may be generated and used in the design of management programs. This approach to the assessment of disease and pest risk requires that all data be associated with map coordinates. Inexpensive hand-held GPS units now available make this possible. Such data can be entered into the GIS database for geostatistical and other spatial analysis procedures. Outcomes of this approach to assessing plant disease and pests include an easily accessible record of disease occurrence, identification of recurring patterns and association of landscape features with recurring pattens of diseases and pests. Such information displayed in an attractive format can be a powerful tool in promoting a program that requires some significant cultural changes in pest management practices. Thus far this technology has been used in the management of tomato virus and fungal disease and insect pests, cotton viruses and whitefly vectors, and cotton aflatoxin occurrence. Computer hardware and software developments in the past five years of significance to these applications have been explosive. These developments herald a new era in the processing and analysis of information used in IPM programs.

**The Au-Pnut Peanut Leaf Spot Advisory: Effective Range And Control of White Mold and Limb Rot.** Ellen M. Bauske, Horticulture, Auburn University, AL 36849, Paul A. Backman, Plant Pathology, Auburn University, AL 36849, Larry Wells, Assistant Superintendent Wiregrass Substation, PO Box 217, Headland, AL 36345; and Stephen Adams, Meteorologist, Southeast Agricultural Weather Service Center, Wire Rd., Auburn, AL 36849

The AU-Pnut peanut leaf spot advisory uses the number of days with precipitation greater than 2.5 mm and five-day precipitation probabilities to predict periods favorable for development of leaf spot diseases (*Cercospora arachidicola* and *Cercosporidium personatum*). Studies were done to determine the effective range of the AU-Pnut advisory and to incorporate tebuconazole (Folicur 3.6F) for control of white mold (*Sclerotium rolfsii*) and limb rot (*Rhizoctonia solani*) into the spray program. Dry land and irrigated tests were done. Three AU-Pnut programs were generated using the regional five day precipitation forecast and precipitation measured on-site, 1.6 km off-site or 12.9 km off-site from both tests. The performance of the AU-Pnut spray programs was compared with a standard 14-day spray schedule. Half of the plots in each test were sprayed with chlorothalonil (Bravo 720F) at the recommended rate (1.0 kg a.i./ha) and half were sprayed with a chloro-thalonil-tebuconazole tank mix at 0.34 and 0.1 kg a.i./ha, respectively. All diseases were more severe under irrigation. The number of fungicide applications was 7, 6, 6, and 5 for a 14- day program, AU-Pnut on-site, AU-Pnut 1.6 km off-site, and AU-Pnut 12.9 km off-site, respectively. Spray schedules were identical in the on-site and 1.6 km treatment. Control of leaf spots, white mold, and limb rot was more effective and yields were highest when the chlorothalonil-tebuconazole tank mix was applied with AU-Pnut on-site or 1.6 km off-site. Disease control was less effective with AU-Pnut at 12.9 km. Treatments with tebuconazole were more effective against white mold and limb rot. Presently AU-Pnut uses rainfall data to schedule a 100 ha area. These studies indicate the potential for a control area larger than 256 ha.

**Development of a Strategic Plan for Implementation of Tomato IPM Practices.** Ellen M. Bauske, Horticulture; Geoffrey W. Zehnder, Entomology; Edward J. Sikora, Plant Pathology; and Joseph M. Kemble, Auburn University, AL 36849

An IPM planning project was initiated to increase the implementation of IPM practices on fresh-market tomatoes in the southeastern region. Tomato IPM teams were formed in Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina, and Tennessee consisting of researchers, extension specialists, producers and industry personnel active in and familiar with tomato production in each State. The teams met at Auburn University in early November 1995 to develop a

working definition of tomato IPM based on all currently available tomato IPM practices, and to discuss methods to measure the economic, environmental, social and public health impacts of IPM programs. This multi-state meeting facilitated a valuable exchange of information on tomato production practices in each State (i.e., States with established tomato IPM programs shared ideas on tomato IPM that benefitted States with less developed IPM programs). The list of available tomato IPM practices was used to develop a tomato IPM grower survey to (1) determine baseline levels of IPM adoption in each State, (2) develop a prioritized list of grower-identified research and extension needs, and (3) increase grower awareness of currently available IPM technology. The survey questions will be explained in detail to growers at a series of production meetings held in each State to increase producer awareness and understanding of tomato IPM practices. Thus the surveys will serve as an educational tool in addition to a means of collecting data on IPM adoption. Information from the surveys will be used to develop an overall plan to increase adoption of IPM by tomato growers in the southeastern region**.**

**ESCOP/PMSS Biological Control Working Group: Vision and Activities**. D. Michael Benson, Dept. of Plant Pathology, NC State University, Raleigh, NC 27695; and Harold W. Browning, University of Florida, Citrus Research and Education Center, Lake Alfred, FL 33850

The Biological Control Working Group (BCWG) fosters the development and implementation of biological control of pests, weeds, and pathogens as the central component of an ecologically-based approach for integrated pest management (IPM). The goals of the BCWG are to establish linkages among current operating regional committees concerned wholly or in part with biological control for pests and pathogens to improve information exchange, to define and give visibility to biological control for agricultural and urban pests and pathogens as distinct components of crop protection systems, to provide input in budget building processes, to encourage application of new molecular tools to biological control research, and to plan and organize interdisciplinary workshops and symposia.

Currently, four broad objectives, including promotion/communication, regulation, funding and coordination, have been developed and pursued by members of the working group. Discussion is underway to develop a linkage with industry in support of a workshop on commercialization of biological control agents. A web site (http:// ipmwww.nesu.edu/biocontrol/biocontrol. html) has been established to communicate working group activities and coordinate biological control efforts among groups and individuals. Members have promoted incorporation of biological control into extension programs by participation in workshops and discussion sessions with extension specialists at State and regional levels. The working groups developed a statement to discourage the approach taken by APHIS in the recent proposed rule for introduction of non-indigenous organisms that subsequently was withdrawn. The BCWG supports the development of biological control regulations wherein natural enemies are not defined as plant pests. The working group has been involved at the Federal level to assist in coordination of a National IPM Initiative. As commodity-based IPM initiatives develop in the next few years, the working group will assist in the setting of priorities for funding by technical evaluation of resources needed for inclusion of biological control in IPM strategies. Important activities of the BCWG have included sponsorship of an AAAS Symposium and a UCLA Symposium on biological control, a National Workshop on regulations and guidelines, and workshops on biological control at IPM Symposiums.

**Vermont Apple IPM Program: Integration of Research & Extension Produces Innovation and Success**. L.P. Berkett, J.F. Costante, A. Gotlieb, J. Clements, D. Schmitt, D. Heleba, J. Bergdahl, T. Bradshaw and G. Neff, Department of Plant and Soil Science, University of Vermont, Burlington, VT 05405

An active and effective research and extension program has been developed on apples using a team approach. The team includes faculty and staff representing the disciplines of horticulture, plant pathology and entomology. Members of the team have both research and outreach responsibilities. The team works directly with apple growers and knows first-hand the concerns and issues which confront the apple industry, both for the short-term and the long-term. The program involves:

- An extension program which includes one-on-one interactions with apple growers, workshops, meetings and publications. The University of Vermont's Apple Press newsletter, which has over 250 paid subscribers including commercial orchardists, consultants, extension agents, and researchers in 24 States and 3 Canadian provinces, contains a section entitled "IPM NEWS," which includes information on pest status, monitoring techniques, thresholds, life cycles, and management strategies. Our newest and most exciting information transfer tool is the "Virtual Orchard," a World Wide Web (WWW) site devoted to tree fruit production, marketing, and information exchange. Visit the "Virtual Orchard" at http://orchard.uvm. edu.

- An active horticultural research program which focuses on the commercial potential of new apple varieties that have been bred for resistance to apple scab, the major disease of apple.

- Pest management research and demonstration targeted at reducing pesticide use. An exciting, new project on apple scab was initiated in 1995 which for the first time utilizes crop insurance as a "safety net" in IPM implementation. Orchards in Vermont and New Hampshire are participating in this Apple Scab IPM Project. This new application of crop insurance is viewed as an important step in stimulating the adoption of new IPM techniques. This innovative project is made possible through the support of the Honorable Senator Leahy, the USDA, and the Consolidated Farm Service Agency.

**Vermont Extension IPM Program: New Initiatives.** Lorraine P. Berkett, Alan R. Gotlieb, Margaret Skinner, Sidney Bosworth, Ann Hazelrigg, Department of Plant & Soil Science, University of Vermont, Burlington, VT 05405

With the previous level of Smith-Lever 3(d) funding, Vermont has been able to develop an effective, interdisciplinary apple extension program. The Supplemental Extension IPM funding received in 1995 has enabled us to initiate two new IPM programs in Vermont: (1) a Diversified Vegetable and Small Fruit IPM Program; and (2) a Greenhouse Ornamental IPM Program. The overall objectives of these programs are to develop effective multi-organizational, interdisciplinary IPM Implementation Teams to identify extension and research priorities and to focus extension and research on those priorities.

*(1) Diversified Vegetable and Small Fruit IPM Program:* During this past summer, an interdisciplinary IPM Implementation Team was formed to develop a pilot extension program which targeted 8 diversified vegetable and small fruit farms. On-site farm visits were conducted throughout the growing season to provide education on disease, insect and weed identification and biology, and training on scouting techniques and IPM practices. Currently, an assessment is being conducted on what practices and techniques were adopted and their impacts. A short course is being developed for this winter, based on grower-identified educational needs.

(2) *Greenhouse Ornamental/ IPM Program:* This program addresses one of the fastest growing agricultural sectors in terms of grower cash receipts. Consumers are demanding high-quality plants. But since efficacious alternatives are few and often complicated to use, growers rely heavily on agrochemicals to suppress a range of pests and diseases. During the first year of this program, baseline data are being collected on current usage of

IPM practices and pesticides along with estimates of loss due to pest damage. From this information, an IPM implementation strategy will be developed for Vermont and the tri-state region (i.e., VT, NH, ME).

In addition to the above programs, we are developing a Forage IPM Program which focuses on management strategies to prevent premature stand decline of alfalfa due to a complex of factors. Future funding will enable this program to be fully implemented.

**Grasshopper IPM on Western Rangelands**. S. Berry, USDA, APHIS, 4125 E. Broadway, Phoenix, AZ 85040, W. P. Kemp and J. A. Onsager, USDA, ARS, Rangeland Insect Lab, Bozeman, MT 59717 and M.D. Skold, DARE, Colorado State University. Ft. Collins. CO 80523

Grasshoppers are the most important insect pest on over 770 million acres of rangeland in the western U.S. Since the 1930s, publicly assisted control programs used an intervention level of 8 grasshoppers per square yard as a guide to initiating control programs. A decision support system, Hopper, developed under the Grasshopper Integrated Pest Management project incorporates an economic threshold (ET) into the grasshopper management decision. The ET necessary to justify management programs varies between locations and over time. It changes with the grasshopper species (Berry, Kemp, and Onsager 1992), rangeland productivity, cost of replacement forage, and the cost and efficacy of treatment options (Davis et al. 1992). Implementation of grasshopper IPM will require full use of preventive actions such as: hot spot treatments of potential breeding grounds to prevent larger outbreaks, range management practices which maintain vegetative canopy and thereby prevent or delay microhabitats preferred by many pest grasshopper species (Onsager 1995), ranch forage management such as using additional hay stocks as a hedge against grasshopper outbreaks (Skold, Davis and Kitts 1995), and biological controls. Additional research and demonstration is needed to incorporate the options into an IPM strategy. If preventive actions are not successful, management would involve therapeutic action to use of one of the approved chemical control options. It can also be expected that if continued public funding of rangeland grasshopper programs is not available, alternative ways to finance these programs will have to be found (Skold and Davis 1995). Finally, once preventive and therapeutic strategies are included in the IPM for rangeland grasshoppers, IPM training for grasshopper program and land managers will be required.

**A Bioherbicide for Control of Dodder**. Dr. Thomas A. Bewick, Horticultural Sciences Dept., University of Florida, PO Box 110690, Gainesville, FL 32611-0690

An important component of IPM programs is to have available control measures for a specific target pest. Satisfactory dodder (*Cuscuta* spp.) control strategies do not exist for most horticultural crops. Two fungal pathogens of dodder were isolated in 1984. A patent was issued in 1990, and in 1991 HACCO, Inc, a subsidiary of United Agri-Products, signed a standstill agreement to develop a commercial bioherbicide for dodder control. Since that time, the IR-4 Project has provided funding and regulatory guidance that has served to move the product toward EPA registration. In 1995, a stable formulation of the bioherbicide was field-tested in Massachusetts and Wisconsin cranberry plantings. Dodder control exceeded commercially acceptable levels in both locations. Additional field tests are planned for 1996. An Experimental Use Permit is being sought with the guidance of IR-4 that will allow for large scale field testing. The registrant is projecting that a commercial product will be available for growers within three years. Without the efforts of IR-4, this project would not have advanced to commercial viability and there would be no possibility of IPM programs in horticultural crops for dodder control.

**Integrated Pest Management in Montana Cereal Grains Cropping Systems.** S. Blodgett, G. Johnson, Dept. Entomology, Montana State University, Bozeman, MT 59717; B. Maxwell, Dept. Plant, Soil & Environmental Science,

Montana State University, Bozeman, MT 59717; R. Stougaard, Northwestern Agriculture Research Center, 4570 MT 35, Kalispell, MT 59901; W. Kemp, USDA, ARS, Rangeland Insect Laboratory, Bozeman, MT 59717

Sixty four percent of Montana's 92.9 million acres is in farm or ranches, with total assets of $21.2 billion. The 17.5 million acres of cropland is responsible for about $ 1 billion in cash receipts for all crops; with 80 percent of the cash value from cereal grains. A recent survey (Blodgett et al. unpublished) indicated that wheat stem sawfly, grasshoppers, and wheat streak mosaic virus were the most damaging cereal grain insect and disease pests to Montana producers. Economic losses due to plant diseases and arthropods can be dramatic. In 1993 and 1994, wheat streak mosaic virus, vectored by the wheat curl mite, was responsible for losses estimated at $35.7 million (J. Riesselman, MSU personal communication). Wild oats have been identified as a significant weed pest, with annual herbicide costs of $10 million in Montana alone. Research at MSU has focused on these and other important pest concerns. Wheat curl mite *(Aceria toshicella)* research has focused on evaluating quality of alternative grass hosts, within plant mite distribution, and mite population dynamics in mixed cropping systems (Blodgett). Russian wheat aphid *(Diuraphis noxia)*, drought stress, and their interaction has been examined for effects on wheat yield and quality (Johnson). Preliminary results indicate that both wheat curl mite and Russian wheat aphid are influenced by a cover cropping system utilizing annual legumes. A strategic issue of the USDA, ARS, Rangeland Insect Laboratory (RIL) has been to develop sampling and forecasting strategies for integration of pest management options into farm/ranch and crop/range situations (Kemp). Non-chemical control of wild oats *(Avena fatua)* and within-farm distribution and population dynamics have been an important research focus (Maxwell & Stougaard). Plans in 1996 include spatial analysis of multiple pest distributions and interactions with implications for management.

**Corn Rootworm Beetle Emergence, Female Fecundity, and Egg Viability Associated with Labeled and Reduced Soil Insecticide Application Rates**. Mark A. Boetel and Billy W. Fuller, Plant Science Department, Box 2207-A, 219 Agricultural Hall, South Dakota State University, Brookings, SD 57007

Environmental concerns and the economics of agricultural production during the past decade have prompted evaluations of reduced soil insecticide application rates for managing northern (NCR) and western corn rootworm (WCR), *Diabrotica barberi* Smith and Lawrence and *D. virgifera virgifera* LeConte, respectively, larvae. These studies (conducted throughout the north central Corn Belt) have indicated that acceptable control can be attained using reduced rates. However, the long-term repercussions of such management practices on rootworm populations have not been investigated. Our objective was to assess the potential impacts of reduced application rates on corn rootworm sex and species ratios, fecundity, and viability of eggs collected from surviving females.

Field plots were established with full labeled (1X), and reduced (0.75 and 0.50X) application rates of three soil insecticides [I) terbufos, a traditional organophosphate; 2) tefluthrin, a pyrethroid; and 3) chlorethoxyfos, a phosphorous triester organophosphate], and an untreated check. Traps were used to live-capture emerging beetles from insecticide-treated soil zones in treatment plots for use in fecundity and egg viability assessments.

Female NCR emergence was reduced by 33.5, 29.7, and 46.9 percent using 0.5, 0.75, and 1X rates of tefluthrin, respectively, in comparison with the untreated check. These reductions provided by the insecticide treatments, however, were not significantly ($P > 0.05$) different from each other. No further sex ratio- or species-specific differences in survival were detected among treatments. Terbufos applications resulted in significantly more eggs produced per NCR female than that observed in untreated plots, however beetles surviving the high rate (1X) deposited 86 percent more non-viable

eggs than those emerging from reduced-rate and untreated soil.

Our results indicate that lower rates of these insecticides will result in no significant shifts in corn rootworm gender, species, or the production of viable eggs. Thus, with no apparent negative ecological implications, the lowest insecticide application rates that consistently maintain corn rootworm damage below the economic injury level should be considered for implementation into current corn production systems.

**Spatial Distribution and Sampling Plans for Cereal Aphids Infesting Spring Wheat.** Philip J. Boeve and Michael J. Weiss, Department of Entomology, North Dakota State University. Fargo, ND, 58105

Three cereal aphids, *Rhopalosiphum padi* (L.), *Schizaphis grarninum* (Rondani), and *Sitobion avenae* (F.) invade wheat fields in the northern Great Plains each spring and occasionally reach economic status. Cereal aphid populations need to be estimated for pest management decision making. This study was conducted to develop sampling plans based on either the number of aphids per stem or based on the percentage of infested stems. Forty-five population estimates were collected from eastern North Dakota spring wheat fields during 1993-1995. The number of aphids per stem were counted on 100-350 stems per field. Taylor's power law, Iwao's patchiness regression, and the negative binomial k were used to analyze the spatial distribution of the aphids. Taylor's power law provided a better fit to the data than the other methods. All three species exhibited an aggregated distribution. The slope from Taylor's power law regression for each aphid species ranged from 1.18 to 1.24, and were not significantly different from each other ($P > 0.05$). Sample size requirements for fixed levels of precision were estimated with Taylor's regression coefficients. Parameters from the regression of ln(mean aphids/stem) on ln[-ln(proportion of uninfested stems)] were used to develop a binomial sequential sampling plan. The sampling plan with a fixed level of precision should be used by researchers developing economic thresholds for cereal aphids in spring wheat. The binomial sequential sampling plan should be used by growers and crop scouts to determine if an insecticide application is warranted.

**Disease Resistant Variety Trial and Farm Demonstration Plots for Pepper IPM in New England**. Jude Boucher, Gianna Nixon and Richard Ashley, Department of Plant Science, University of Connecticut, U-67, 1376 Storrs Road. Storrs, CT 06269-4076

Since 1989, bacterial leaf spot (BLS) has occurred on 90 percent of the farms that have participated in the University of Connecticut's Pepper IPM Program and accounts for 66 percent of the pesticide used on this crop. *Phytophthora* blight (PB) and cucumber mosaic virus (CMV) are not as common on New England farms as BLS, but may reduce yields substantially when present. Resistant varieties offer an important new alternative to chemical controls for these diseases and are a crucial component of pepper IPM. In 1995, we compared the horticultural characteristics of one PB, one CMV and 12 BLS resistant varieties to two popular commercial peppers in a replicated trial at the University of Connecticut. Fruit were graded for size and shape and yields were separated into early- and late-season harvests. Other parameters measured were plant height, canopy width, and fruit wall thickness, length to diameter ratio, number, weight, and the percent marketable. Unreplicated demonstration plantings with three or four resistant varieties each were conducted at 12 commercial farms in 1994/1995 and yields were quantified at the University's research farm in 1994. Several resistant varieties were judged to be equal or superior to the two popular cultivars based on a combination of characteristics including observations on disease susceptibility at local farms. IPM program participants are encouraged to utilize a variety of techniques for pepper disease control including hot-water seed treatment, proper sanitation, crop rotation, resistant varieties, weekly scouting and chemical controls if necessary.

**New Pathways: an Education Proposal For IPM/ICM Practitioners.** Dan E. Bradshaw, CPCC-I, Crop Aid Agricultural Consultants. 2806 Western Acres, El Campo, Texas

Over the years, a number of constraints to the more widespread adoption of IPM have been identified. One constraint widely discussed is the lack of targeted education programs to attract and train future practitioners. With increasing environmental concerns, economic considerations, and the general complexity of agricultural production management, the need for this type of training for practitioners is greater than ever before. This is especially true if the stated goal of having 75 percent of the U.S. cropland under IPM is likely to be met with credible IPM. However, an important aspect of an education system is that the training must meet the applied needs of these potential practitioners. To be effective, practitioners must be able to function in a truly multidisciplinary setting. IPM is only one facet of the broader integrated crop management (ICM) environment in which most individuals actually must practice. Current doctoral level degree programs in the sciences related to crop production/ protection are all narrowly focused at the discipline and subdiscipline level. A new degree program (often called the Doctor of Plant Health) patterned after the veterinary medicine model is proposed for practitioners in crop production/protection. A new method of teaching is proposed -- the New Pathways concept -- based on programs at several medical schools. These programs recognize that it is impossible to teach everything a person might need to know in classroom programs. These medical schools emphasize problem solving and mastery of basic principles rather than extensive memorization. In the agricultural New Pathways proposal, training from agronomy, soil science, entomology, weed science, plant pathology, horticulture, plant physiology and other essential disciplines would be combined with the applied skills such as problem solving, communication, diagnostics, systems integration and management and other practical knowledge essential for practitioners to function in the business world. Teaching applied subjects would emphasize problem-based learning. Crop consultants would serve as adjunct professors and team teach with professors from the various disciplines using case studies, cap stone courses and internships. Pilot programs at several major universities are being discussed and developed with significant input from the crop consulting profession.

**Multi-disciplinary Study of Crop Production Systems for the Canadian Prairies**. S.A. Brandt, O. Olfert, & A.G. Thomas, Agriculture & Agri-Food Canada 107 Science Place, Saskatoon, SK, Canada S7N 0X2

Most of the grassland ecozone of the Canadian Prairies has been cultivated, with only small remnants of native prairie remaining. All of the cultivated land base has incurred soil degradation, over the past 100 years. To address the issues of profitability and soil degradation farmers are encouraged to diversify their production away from a cereal monoculture and to reduce fallow and farm inputs. Climatic limitations favor cropping options such as small grain cereals, cool-season oilseeds and pulses, and perennial forages. Economic constraints dictate that most of the land base is used for field crop production. Livestock production is restricted to marginal lands. The current study was initiated to monitor and assess alternative input use and cropping strategies for arable crop production on the Canadian Prairies with respect to (1) biodiversity, (2) insect, weed and disease dynamics, (3) farm level profitability, (4) soil quality, and (5) food safety.

The experimental framework is a matrix representing three levels of input use (organic; reduced; high) and three levels of cropping diversity (wheat based with fallow; diversified using cereals, oilseeds and pulses; diversified grains with perennial forages). Crops are wheat, barley, oats, rye, canola, flax, lentils, peas, alfalfa, sweet clover, brome grass. The design is based on a six-year rotation, and include all phases in each year. The study utilizes 40m X 77m plots in a split-plot design, replicated four times, and is located on the transition zone between semi-arid and sub-humid

prairies at Scott, Saskatchewan (52° 22; 108° 50 near the geographic center of the Canadian Prairies. Small areas in each plot are reserved for destructive sampling and detailed experimentation while the bulk of the plot area is retained to preserve treatment integrity.
Evaluations are either annual or on a cyclical basis (6-year) to determine direction and rate of change over time as a result of the treatments. The design, data collection and evaluation of the study are a result of the collaborative efforts of scientists representing soils, pests, crops, and economics The anticipated impact of these activities is to provide guidance for development of systems that maintain overall levels of food production and quality, without increasing inputs of non-renewable resources.

**Small Grains IPM in the High Plains: an Initial Russian Wheat Aphid Effort and Prospects for Expansion.** Michael J. Brewer, Univ. of Wyoming, PO Box 3354, Laramie, WY 820711, Frank B. Peairs, Colorado State Univ., Fort Collins, CO, 80523, Gary L. Hein, Univ. of Nebraska. Panhandle R&E Center. 4502 Ave 1, Scottsbluff, NE, 69361, and Stephen D. Miller, Univ. of Wyoming, PO Box 3354, Laramie, WY, 82071

In collaboration with related activities in the region, we are striving to integrate and implement host plant (resistance and enhanced competitiveness) and natural enemy regulation of pests that are sustainable and part of an economically viable production system. To best allow for short-term success while establishing an implementation structure to address multiple pests in a whole farm system, we partitioned our efforts into two overlapping parts.

PART I. Regulation of Russian wheat aphid by plant resistance and natural enemies occurs and is in various phases of implementation. Wheat resistant to Russian wheat aphid has been planted in one acre on-farm plots in the region side-by-side with preferred commercial varieties (in collaboration with the CSU on-farm testing program). Parasitoids have been introduced into the region, and spread of *Aphelinus albipodus* have been confirmed (in collaboration with USDA APHIS and ARS). In lab tests, this parasitoid performs well on Russian wheat aphids infesting resistant or susceptible commercial plants. Will such synergy of regulating agents occur in the on-farm system and lead to a more sustainable pest management system to control Russian wheat aphids? To address this issue, our team is composed of growers, researchers, and outreach educators.

PART II. Our team from the onset is also composed of weed scientists, plant pathologists, and economists. Creating an implementation structure using the well-focused structure of PART I, we aim to expand to other pests identified by growers and public sector personnel in our team: principally winter annual grasses and selected plant pathogens. Economics and Comprehensive Pest Management suggest comparing the traditional wheat-fallow system with a wheat-alternate crop-fallow system that uses pest management strategies such as host plant and natural enemy regulation of pests. We aim to partner our pest management team with existing interests in alternative crop systems to address viability of crop production and protection.

**Practical Surveillance for Resistance to Insecticides Is an IPM Responsibility: Onion Thrips And Lygus Bugs.** William A Brindley and Diane G. Alston, Department of Biology, Utah State University, Logan, UT 84322-5305

IPM for many crop systems will benefit from greater involvement of extension, pest managers, and growers in practical surveillance for resistance to insecticides. To help achieve this goal, simple resistance bioassay methods for use in the field were developed for onion thrips, *Thrips tabaci*, and western tarnished plant bugs, *Lygus Hesperus*. Individuals of both species were collected into disposable plastic bags with self-locking seals. The bags had been previously treated with microgram quantities of technical grade insecticides and provided with a bit of leaf material and a spacer. LC values were calculated from mortalities observed after 4 hours for the thrips and after 8 hours for the

lygus bugs. Probit analysis was based upon Finney's procedures via a new Excel spreadsheet format.

Tests of insecticide tolerance for onion thrips to cypermethrin, bifenthrin, malathion, or methyl parathion were conducted in 1992 and more intensively in 1993 in northern Utah. Spot checks with cypermethrin and methyl parathion in 1995 indicated major shifts in insecticide tolerance had not occurred. Results in 1993 suggested grower practices could influence insecticide LC values. Tests of metasystox-R and capture were conducted with lygus bugs in Washington, Oregon, Idaho, and California. Again, grower practices were strongly implicated in the extent of resistance selection.

The practical success of these bioassay methods and continued indication that grower practices influence resistance, makes it very clear that tests for and research on resistance to insecticides should begin before resistance appears. This, too, is an IPM responsibility, especially for those crop systems that continue to require insecticide use as part of an IPM program.

**Influence of Field Oviposition on Populations of Maize Weevils (*Sitophilus Zeamais*) in Stored Corn.** Steve L. Brown and Dewey Lee, Extension Entomologist and Extension Agronomist, The University of Georgia, Rural Development Center, P.O. Box 1209, Tifton, GA 31793

Maize weevils are a perennial pest of stored corn in the Southeastern United States. In Georgia, maize weevils have been commonly observed feeding on corn kernels in the field. Research is underway to determine when oviposition occurs in the field, the amount of oviposition that occurs and, therefore, to what extent corn is infested prior to harvest and storage. Observations of adult maize weevil populations in stored corn suggest that numbers of maize weevils emerging soon after storage are too large to be due to postharvest oviposition. In 1995, samples of corn were collected from replicated plots of four corn varieties planted on 6 different dates. After one month in plastic bags, adult emergence was as high as 700 adult weevils per 500 g of field-collected corn. Preliminary data also indicate that adult emergence differs by variety and that late-harvest is conducive to field infestation.

**Codling Moth Areawide Management Project Howard Flat**. 1995, Jay F. Brunner, Washington State University, 1100 N. Western Ave., Wenatchee, WA 98801

Codling moth (CM) is the KEY pest of pome fruit orchards in the western U.S. Use of broad spectrum organophosphate insecticides (OPs) to control CM represents 50 to 70 percent of insecticides applied to apples in Washington. Replacing OPs with selective alterative controls for CM would open a window of opportunity to radically change IPM in pome fruit. Five Codling Moth Areawide Management Projects (CAMP) were initiated in 1995 through funding from the USDA-ARS. The CAMP site at Howard Flat represents a grass roots initiated effort by growers and crop consultants in an apple-growing area near Chelan, WA. Howard Flat is a geographically isolated fruit production area of 1,200 acres with 36 growers served by 16 crop consultants. Following an organizational meeting in the fall of 1994 and funding of the proposed project, a management board of five crop consultants and three growers was formed. This board managed funding for the project and hired a project coordinator to manage daily activities. Slightly over 1,100 acres of apple and pear were treated with the Isomate C+ pheromone dispenser prior to the blossom period. The cost of the pheromone treatment was subsidized $50/acre by the CAMP; growers paid an additional $60/acre for the pheromone. Insecticides supplemented pheromone for CM control in the first generation in most orchards due to a history of high pest pressure. No insecticides were applied in the second CM generation, relying only on the pheromone for control. Average fruit injury by CM at harvest was less than 0.5 percent at Howard Flat; most orchards had less than 0.2 percent fruit injury. CM populations were reduced throughout the area. Cover sprays for CM control were reduced by 40 percent compared to 1994. Leafroller populations increased in many orchards, and this pest complex

will be a main concern for growers in 1996. Biological control of secondary pests, such as aphids, leafminer and leafhopper, was excellent.

**Pesticide Use by Chili Farmers in Ellewewa Block Sri Lanka**. J. R. Burleigh, V. Vingnanakulasingam, and W. R. B. Lalith, School of Agriculture, California State University, Chico, CA, 95929, and Regional Agricultural Research Center, Aralaganwila, Sri Lanka

Pesticide-use frequency and dose among all chili farmers in the eight units of Ellewewa block, Sri Lanka, are not normally distributed as previously assumed, but rather are aggregated, as evidenced by fit to the negative binomial distribution. That is, each field does not have an equal probability of being treated or nontreated, and information from one field provides information for others. Aggregation may arise from the action of a farmer being influenced by his/her neighbors or from clusters of farmers being influenced by a common factor such as pest intensity, advice from a local pesticide salesperson, or advice from a unit extension agent. We found no association between pest intensity and number of treatrnents. During the dry season (Yala) there was a linear relationship between field size and proportion of fields treated at least once and between field size and number of treatments per field. During the wet season (Maha) no such relationship existed. Sample size less than the population size did not permit accurate estimation of mean values for number of treatments and dose. Fifty-eight and 44 percent of farmers during Maha and Yala seasons, respectively, did not apply pesticides, and the maximum number of treatments by any one farmer was six. Among those who did apply pesticides most treated because of the perceived presence of aphids, mites, thrips, and armyworms. Farmers did not treat for whitefly, which is prevalent during Yala and vectors geminivirus. Few recognized and treated for the diseases, anthracnose and Cercospora leaf spot, which are severe during Maha. Virus symptoms from cucumber mosaic virus, tobacco etch virus and potato virus Y were recognized by farmers but seldom prompted pesticide application for the vectors. The most common pesticides used were the insecticides monocrotophos, profenofos, sulfur, endosulfan, pirimiphos-methyl and methamidophos. Fungicides were seldom used and had no measurable impact on disease incidence. Farmers generally eschew safety clothing while applying pesticides to chili. Of 106 farmers who applied pesticides eight used gloves and mask and one used rubber boots.

**Summary of the 2nd Livestock Arthropod IPM Workshop to Access Research and Extension Needs for Future IPM Implementation**. John B. Campbell, Research & Extension Entomologist, University of Nebraska, West Central Research & Extension Center, P.O. Box 46A, R.R. 4, North Platte, NE 69101, and Gustave D. Thomas, USDA, ARS, Research leader, Midwest Livestock Insects Research Laboratory, Dept. of Entomology, Lincoln, NE 68583-0938

Fifty-eight federal-university animal health industry scientists and livestock commodity representatives reviewed the current status of arthropod IPM for the commodities of beef, feedlot, dairy, poultry, swine, sheep and goats, and companion animals. The working group for each commodity prioritized arthropod problems and research and extension needs required to enhance or develop IPM strategies used in the management of arthropod pests. The executive summary of the workshop proceedings indicates that major needs are:

- Enhancement of livestock entomology extension and research efforts.
- Development and incorporation of IPM strategies into computer-aided decision management systems for animal production.
- Development of environmentally compatible control strategies/tactics.
- Biology-ecology studies to determine or support decision management systems.
- Develop surveillance/quarantine/control procedures for the introduction of exotic pests.
- Develop interdisciplinary research and extension interactions for development of

livestock arthropod pest management tactics/strategies.

**IPM Educational Resource Package With Separate Modules for Commercial, Landscape, And Structural IPM**. G.J. Cashion, University of Florida, Institute of Food and Agricultural Science, Palmetto, Florida 34221; and P.G. Koehler, University of Florida, Institute of Food and Agricultural Science, Gainesville, Florida 32611

Through the support of a USDA grant, IPM educational materials were developed for urban and commercial horticulture audiences. These materials are contained in three separate modules: (1) Commercial Horticulture IPM, (2) Landscape IPM, and (3) Structural IPM. Each module contains an array of materials, including slide sets, videos, flash cards, "how-to" manuals, and large color posters to promote the Extension education program to commercial, consumer, and youth groups. The boxed package of modules has been distributed to Extension offices in all 67 Florida counties and every State in the nation.

**Factors That Influence The Persistence, Demise, and Transformation of Cooperative Extension Service Integrated Pest Management Programs in Missouri**. Douglas H. Constance, J. Sanford Rikoon, and George S. Smith, Department of Rural Sociology, Integrated Pest Management Coordinator, College of Agriculture, Food, and Natural Resources, University of Missouri, Columbia, 65211

In response to the decertification of certain pesticides used for soil insect control on corn in the early 1970s, Federal programs established Cooperative Extension Service sponsored IPM programs in several Midwestern States to promote insect scouting on corn. This paper documents the various factors which facilitated the early growth and steady decline of this program in Missouri and the ongoing transformation of such services into the private sector and other agencies. Research in Missouri regarding pesticide use practices and water quality issues indicates that there is a considerably higher incidence of IPM use in counties that historically had, or still currently have, Extension-sponsored programs. Interviews were conducted with University personnel responsible for implementing these programs, county Extension agents responsible for overseeing the programs, private sector businesspeople who are currently offering IPM services, and farm operators who previously used, and/or now participate in, IPM Extension programs or private services. Interviewees were asked what factors contributed to the success, failure, and/or transformation of the county programs. Results indicate that these factors include quality and turnover of the scouts, commitment of the Extension agent, economic and climatological variables, availability of private sector services, institutional support, and packaging IPM programs with other programs such as irrigation.

**An Environmental Impact Assessment System for Judging the Agronomic and Socioeconomic Effects of the Inputs Used by Organic Farmers**. Lynn S. Coody, M.S., Principal Consultant, Organic Agsystems Consulting, 1241 E. Jefferson St., Cottage Grove, OR 97424

In 1990, the U.S. Congress passed the Organic Foods Production Act (OFPA) which mandated development of national standards for the production of organic foods. This poster presents the continuing development of an evaluation system designed to assist the Technical Advisory Panel of the USDA's National Organic Standards Board in their effort to develop a National List of materials which are appropriate for use on organic farms. The evaluation system provides a systematic approach to the assessment process and structures the daunting amount of information needed to satisfy the requirements in the OFPA. lts precepts are also firmly rooted in the principles and values which have underpinned organic agriculture for decades.

Design of the evaluation system encompassed three interrelated activities: the development of an Environmental Impact Assessment methodology, the collection of the data required for shaping

evaluation criteria and for fueling the evaluations, and the creation of a prototype expert system computer program to support the decision making process.

The program, called Organic Expert, provides a tool for development of evaluation criteria which employs a graphic interface for easy use. It evaluates materials by comparing data about the characteristics of a material against the evaluation criteria related to a wide array of agroecosystem and socioeconomic factors and uses a system of weighted values to produce a final rating for the product. The results of the evaluation are reported at three different levels of detail.

**Pesticide Use on Oklahoma Wheat Between 1981 and 1995.** Jim T. Criswell, Jerry Dunn,and Gerrit Cuperus, Department of Entomology, Oklahoma State University, Stillwater, OK 74078

Herbicide usage as measured in pounds of active ingredient decreased (603,150 to 263,400), however, acreage treated by herbicides increased greatly (877,000 to 4,825,000). The reason for the increased acreage vs decreased ai was the introduction of sulfonylurea herbicides.

Insecticide usage varied over this time span due to sporadic insect infestations. Insecticide usage measured in pounds active ingredient decreased (2,801,000 to 255,400 ) as did acres treated by insecticides (3,634, 000 to 902,500). The major shift in insecticide usage was the reduction of ethyl parathion and the increase usage of dimethoate. This was due to EPA regulation actions on ethyl parathion.

Fungicide usage on wheat is minimal in Oklahoma. The primary reason being most years the spring production season is not conducive to foliar fungal growth.

**The Cooperative Boll Weevil Eradication Program (BWEP): a Growing Success.** Gary L. Cunningham, Coordinator, Bill Grefenstette, Senior Operations Officer, APHIS, PPO, BWEP Coordinator, Plant Protection and Quarantine, 4700 River Road, Unit 138, Riverdale, Maryland, 20737

The cotton boll weevil, *Anthonornas grandis,* moved into the United States from Mexico in the late 1800's and has since cost the cotton industry more than $13 billion in economic losses. The grower-approved and funded boll weevil eradication program has been successful in the southeastern and southwestern portions of the United States and a plan has been developed by the industry to eradicate the pest beltwide by 2003. Program operations consist of trapping, careful and timely treatments, and cultural control. New technologies are being developed to improve control practices in environmentally sensitive areas. Boll weevil eradication results in significant economic and environmental benefits.

**Farmer Acceptance of Economic Thresholds For Weed Management.** George F. Czapar and Marc P. Curry, University of Illinois, Springfield Extension Center, P.O. Box 8199, Springfield, IL 62791 and Loyd M. Wax, USDA-ARS, Crop Sciences Department, University of Illinois, 1102 S. Goodwin Ave, Urbana, IL 61801

Although economic thresholds are used extensively by farmers to make insect control decisions, the use of economic thresholds for weed management has been limited. A direct mail survey of 988 farmers in central Illinois was used to identify how weed management decisions are made, acceptable levels of weed control, average herbicide costs, and factors preventing the use of economic thresholds for weed control. Of the farmers surveyed, 45 percent based their weed control decisions on the previous year's weed problem, 17 percent relied on dealer recommendations, while only 9 percent of farmers used economic thresholds as a basis for weed management. When asked to identify the major reasons for not using economic thresholds for weed management, the most frequent response was concern about weeds interfering with harvest. Landlord perception, weed seed production, and the general appearance of the field were also identified as limitations.

A survey of agricultural chemical dealers and applicators was also used to help identify the current barriers to adoption of economic thresholds for weed management. In 1994, 143 agricultural chemical dealers and applicators attending a pest management workshop were asked to rank the top five reasons preventing farmers from using economic weed thresholds. The most frequent response identified by commercial applicators was the general appearance of the field. Similar to farmer responses, concern about weeds interfering with harvest, landlord perception, and weed seed production were identified as current limitations. In addition, dealers identified the time required to scout fields as a major limitation to the adoption of economic thresholds for weed management.

**What's The Potential For Linking Precision Farming With IPM?** Stan Daberkow and Lee Christensen, Economic Research Service, United States Departrnent of Agriculture, Washington, DC, 20005-4788

Precision farming is emerging as a technology to tailor application of agricultural inputs at the sub-field level. Leading precision farming researchers and agribusiness firms were queried about the status and potential of precision farming as part of IPM. These individuals were selected from Universities, Federal agricultural research agencies, and agribusinesses dealing with precision technology, hardware and software, and consultative services. All were in agreement that precision farming applications in pest applications are far behind developments in seed and fertilizer applications, particularly for phosphorous and potash. The original precision farming/IPM focus was driven by water-quality concerns from soil-applied pre-emergence pesticides applied to environmentally fragile cropland. The focus in now on detecting spatial weed population density/species/size and varying the application rate accordingly. This focus fits the IPM philosophy to verify that a pest problem exists before treatment rather than a prophylactic approach. Precision farming is more applicable in fields with significant variation in soil characteristics, such as soil type or organic matter. However, reduced use of herbicides in fields is not guaranteed. Total field use with variable application rates may be greater, particularly if uniform application rates are below label rates. Precision farming offers a potential to apply pesticides on a very localized basis within a field. While scouting leads to an average application rate over an entire field, subfield information collected via hand-held locators used by scouts or yield monitors on harvesting equipment can be used to pinpoint areas within the field needing treatment. The applicability of precision farming to herbicide applications will likely vary with pre-and post-emergence applications and the weed species(s). The development of sensors and other techniques for differentiating size, species and density of pests in an on-the-go or other dynamic method or use in IPM is in its infancy. Federal and State funding of precision farming projects linked to pest management in FY 1994 are estimated at nearly $3 million.

**IPM Improves the Efficiency of Peanut Production in Oklahoma.** John Damicone and Ken Jackson, Department of Plant Pathology, Ron Sholar and Gerrit Cuperus, Depts. of Agronomy & Entomology, respectively, Mark Gregory and Wayne Smith, Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, OK 74078

The Oklahoma Peanut Commission and OSU IPM Program have supported field research which has served as the basis of IPM demonstration and implementation across the State. The major impact has been in the management of diseases, which are the principal limiting factors in peanut production. Sclerotinia blight is a disease that affects about 25 percent of the State's 100,000 acres. Prior to the release and demonstrated effectiveness of the resistant varieties Tamspan 90 and Southwest Runner, growers applied 4-6 lb./acre fungicide at a cost of $50-100/acre. Nearly total adoption of resistant varieties has increased yields by 20 percent and profitability by 33 percent in problem fields, and has reduced the tonnage of fungicide applied in the State by over 50,000 lb. Early leaf spot is a

problem state-wide. Historically, growers have either applied up to six fungicide applications per season on a calendar schedule, made fewer poorly timed sprays, or have not controlled leaf spot. A weather-based advisory program was developed and demonstrated which allows growers to time sprays to coincide with disease-favorable weather. The Oklahoma MESONET, a state-wide network of automated weather stations, has permitted broad implementation of the advisory program. Since 1994, daily advisories have been
available to growers in seven counties which contain 75 percent of the state acreage. Program adoption within counties has reached 65 percent, resulting in improved disease control for low-input growers and a 30-percent reduction in fungicide use for high-input growers. The Texoma Crop Management Program is a grower association established in the Red River Valley in 1987 that is dedicated to improving crop management practices in a five-county area historically plagued by low yields and profitability, and a declining grower base. Extension programs have focused on improving soil fertility and pest management. Program impacts have been a 50 percent increase in soil testing, an 84,000 lb reduction in needless usage of in-furrow fungicide. and an increase in yields from 75 to 83 percent of the State average.

**Impact of Manuring and Soil Insecticide Use on Corn Profitability in New York**. Paula Davis, Hamish Gow, & Wayne Knoblauch, Depts. of Entomology & Agricultural, Resource & Managerial Economics, Cornell University, Ithaca, NY 14853

The western corn rootworm, Diabrotica virgifera virgifera, is a key pest of corn, causing significant lodging and yield losses as a result of feeding injury on corn roots. Of chief concern to dairy farmers in the Northeast is the vulnerability of corn in a typical 4-year corn/4-year alfalfa rotation used by many dairy producers to supply high-quality feed. Although an extensive data base is available concerning the effectiveness of soil insecticides in reducing grain yield losses, relatively little on-farm data is available concerning economic benefits of soil insecticides in corn harvested as silage. In addition, recent findings concerning the ability of manure to lessen the impact of rootworm feeding on lodging and yield losses raise important questions as to if and when a soil insecticide is justified.

The primary goals of this project were to evaluate effectiveness and reliability of various combinations of manuring and insecticide use in reducing losses from western corn rootworm and to assess the economic impact of these control strategies on farm profitability. Field trials were conducted on 20 New York dairy farms in 1993-1994. Treatments were replicated four times at each field site and included (1) inorganic fertilizer, no insecticide, (2) inorganic fertilizer, soil insecticide, (3) manure, no insecticide, and (4) manure plus soil insecticide. Multiple regression equations were developed to predict silage and grain yield for the various treatments based on available macronutrients, soil characteristics (drainage, pH, soil suitability for corn growth), and planting information (planting date, plant populations, past manure use). To assess the economic impact of manuring and soil insecticide use on an individual field basis, a cost-benefit analysis was conducted which used a partial budgeting format. In addition, a stochastic simulation model is being developed to evaluate how manuring and soil insecticide uses affect long-term farm profitability. Initial simulations will be presented to illustrate the effects of cow numbers and land to cow ratios on profitability of our four management approaches.

**Research and Implementation of IPM Strategies at Gerber**. Todd De Kryger, Research Horticulturalist, and Jim Brienling, Agricultural Research Manager, Gerber Products Company, 405 State Street, Fremont, MI 49413-4001

A “whole-system" approach is the basis for the implementation of IPM strategies at Gerber. Concern over pesticide residues in our finished product has driven us to lake a look at our whole system to see where the critical areas of concern are hidden. We see Integrated Pest Management at the farm level as an integral part of our pesticide elimination program.

The Gerber IPM program stands on three strong legs: support for IPM research, demonstration at the farm level and "grower ownership" of an IPM program. The support for IPM research can be found in a number of different programs. Direct funding of research at the university level to study specific aspects of a certain pest and "whole-system" projects that piece together all of the parts of the IPM puzzle are two ways that we support research. Participation in the Michigan IPM Alliance through direct funding helped to secure the Statewide IPM Coordinator position at Michigan State University.

Demonstration at the farm level includes such programs as the azadirachtin efficacy trial on Pear Psylla and the Oriental Fruit Moth and Codling Moth mating disruption programs offered to our growers in both 1994 and 1995. The best approach that we have found to develop "ownership" in an IPM program is the crop management association concept. The Westcentral Michigan Crop Management Association (WMCMA) was formed by a small group of growers, MSU Extension agents, and processors. Gerber has provided leadership to the group from the beginning and has encouraged other processors to join the group. The WMCMA has received financial support from Gerber as well. Gerber has used the scouts directly for data collection and fruit maturity studies. The scouts have helped guarantee Gerber a high-quality raw product with as little pesticide residue as possible.

**Wisconsin Cranberry IPM and its Impact on Changing Growers' Perceptions of Insect Pest Problems.** T. Dittl & L. Kummer, Agriculture Scientists, Ocean Spray Cranberries, Inc. P.O. Box 155, Babcock, WI 54413

With the aim of developing a better understanding of Wisconsin growers' perceptions of insect pest problems and how IPM has impacted their views, we have compared surveys from 1985 and 1995. Since the inception of cranberry IPM in Wisconsin in 1986, our comparison of data provides some insight into how IPM has influenced grower perceptions, how well past pest concerns have been addressed, and what insect problems are becoming more important as cranberry culture and its pest complex continue to evolve. This study helps us in concentrating research efforts on problems perceived as important by growers.

**Forest Insects And Their Damage.** Photo CDS: Vol. I and 11, G.K. Douce, B.T. Watson, and D. J. Moorhead, The University of Georgia, Cooperative Extension Service, P.O. Box 1209, Tifton, GA 31793 and G. J. Lenhard, Louisiana State University, Department of Entomology, Baton Rouge, LA 70803

The Southern Forest Insect Work Conference (SFIWC) was organized by Federal, State, university and private sector southern forest entomologists and has met annually since 1956. The SFIWC has maintained a slide series of forest entomology-related images expanded by voluntary member contributions since the early 1970s.

*Forest Insects and Their Damage* contains two hundred images in Kodak Photo CD format that were selected from the SFIWC slide set. Photographer credits, image identification and descriptions, and a miniaturized representation of each image are given in the reference booklet enclosed in the double jewel-cased set.

Kodak Photo PCD format provides five resolutions ranging from 128 x 192 up to 2048 x 3072 pixels of each image, thereby providing users with images suited for a wide array of applications ranging from World Wide Web and on-screen multimedia presentations, to offset printing for both Windows PC and Macintosh platforms. PC files can be accessed directly by a number of software applications, or may be converted to other graphic formats as needed. For convenience, special arrangements have been made with Kodak to provide the Kodak Access Plus Software on each *Forest Insects and Their Damage* CD.

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any nonprofit, educational purpose provided that all reproductions bear appropriate references and credits. Commercial use of images requires the written permission of the SFIWC and the individual photographer or organization.

Southern Cooperative Series Bulletin 383, *Forest Insects and Their Damage* is available for $25.00 per two volume set from The University of Georgia through the senior author.

**Areawide Resistance Management of Codling Moth Using Pheromone Mating Disruption**. John E. Dunley and Stephen C. Welter, Washington State University TFREC, 1100 N. Western Ave., Wenatchee, WA 98801, and Dept. of ESPM, University of California, Berkeley, CA 94720

Azinphosmethyl (Guthion) has been used for over thirty years to control codling moth in apple and pear. Azinphosmethyl resistance in codling moth was first found in 1989 in pear orchards in the Sacramento Delta of California. While azinphosmethyl resistance is still at levels that do not confer field failures, growers in areas with resistance experience difficulty controlling codling moth, resulting in increased Guthion use. Lab and field studies have demonstrated a wide range of correlated cross-resistance, including pyrethroids, carbamates, chlorinated hydrocarbons, and insect growth regulators, making the use of alternative chemicals difficult.

The need to manage resistance regionally has coincided with areawide management efforts for codling moth using pheromone mating disruption. Use of pheromone mating disruption for codling moth control provides a nonchemical alternative to Guthion. This is useful in managing Guthion resistance in codling moth; complete reversion has occurred in the lab in 6 to 7 generations without exposure to Guthion.

The establishment of areawide pilot projects for the management of codling moth using pheromone mating disruption provides a unique opportunity to practice regional resistance management. To determine the effects of using areawide mating disruption on Guthion resistance levels, a western regional azinphosmethyl resistance monitoring effort was started in 1995. Cooperators in the five USDA Areawide Codling Moth Management Pilot Project were identified to bioassay resistance levels in each of the five areawide sites (WA: Oroville, Howard Flat, and Parker Heights; OR: Medford; CA: Randall Island). In four sites (all but CA), 1995 was the first year of areawide management, thus baseline resistance levels were obtained. The areawide project in California was in its third year.

**Undergraduate Education in Pest Management at The University of Florida**. R. A. Dunn and J. R. Strayer, Departments of Entomology and Nematology, F. W. Zettler, Plant Pathology, K. L. Buhr and D. S. Wofford, Agronomy, and P. G. Koehler, Departments of Entomology and Nematology, University of Florida, Gainesville, FL 32611

Merger of the undergraduate programs in Agronomy, Plant Pathology, and part of Entomology and Nematology has produced a unified Plant Science major, under which students can choose from among three specializations (Agronomy, Plant Pathology, Plant Protection), and which share a common core curriculum in General Education, Lower Division requirements, and selected Upper Division requirements. Students in the Plant Protection Specialization take courses in entomology, nematology, plant pathology, and weed science, emphasizing understanding of the crop/plant ecosystem. The curriculum, which also includes economics and agronomic and horticultural sciences and production, focuses on theory and application of biological, cultural, and chemical approaches to integrated pest management compatible with maintaining a quality environment. Those interested in the growing field of urban pest control have an Urban Pest Management Specialization in the B.S. Degree program of the Department of Entomology & Nematology with a similar intent as the Plant Protection Specialization in Plant Science. The curriculum requires courses in pest biology and identification, ecology of pests and

principles of pest management both surrounding and inside structures in the urban setting, and business and economics. All of the above curricula are designed to earn the student a B.S. degree in a standard 120-credit program. Demand for these curricula is high among students and employment prospects for their graduates are excellent.

**Implementation of IPM Strategies to Control Potato Late Blight in Maine**. James D. Dwyer, James F. Dill, Leigh S. Morrow, Heidi A. Currier, University of Maine Cooperative Extension, P.O. Box 727, Presque Isle, ME 04769

In 1993, the Maine Potato Industry experienced a major potato late blight epidemic. The University of Maine Cooperative Extension and the Maine Potato Industry undertook a major effort to implement a potato late blight control program in 1994 and 1995, based on integrated pest management strategies. The program focused upon grower education, which featured the development of a late blight video tape which was distributed to growers, plus a month-by-month grower check list which highlighted the strategies and timing of on farm control action. The program also emphasized inoculum reduction through seed testing, cull disposal and volunteer potato plant control. Within the program, a network of 150 weather stations for disease forecasting and fungicide scheduling was implemented in conjunction with formalized field scouting educational effort.

**Orchard Floor Management Systems to Reduce Herbicide Use and Improve Nitrogen Management in Tart Cherry Production.** C.E. Edson, Fruit and Vegetable IPM Program Leader; J.E. Nugent, NWMHRS Coordinator; G.E. Thornton, Fruit IPM Extension Agent; T.L. Loudon, Professor, Agricultural Engineering; G.W. Bird, Professor, Nematology; D.R. Mutch, Weed Science/IPM; J.W. Johnson, Associate Professor, Entomology; J.A. Flore, Professor, Horticulture: E.J. Hanson, Associate Professor, Horticulture; S.M. Swinton, Assistant Professor, Agricultural Economics; A. Middleton, IPM Research Technician, Michigan State University, East Lansing, MI 48824; D. Gregory, Fruit Grower; and F. Otto, IPM Consultant, Cherry Bay Orchards, Suttons Bay, MI 49684

Michigan is the leading producer of deciduous tree fruits in the north central region of the United States and is the national leader in tart cherry production. Tart cherry growers who report utilizing a formal IPM program emphasizing orchard scouting currently apply 5 to 6 total sprays compared to the industry average of 8 to 9. Further reductions in fungicide and insecticide use are likely to require new technology or the development of new IPM strategies. Interestingly, IPM practices used by Michigan tart cherry growers do not normally include alternatives to herbicides or ground applied nitrogen. Growers currently utilize herbicide strips under the tree row with sod row middles to minimize soil erosion, provide effective ground cover management at a reasonable cost, and maintain acceptable tree growth, yield, and cold hardiness.

In 1995, we initiated a study to examine alternatives to standard orchard floor management. Twelve alternative orchard floor management systems were established in a mature commercial tart cherry orchard (*cv* Montmorency) where an IPM program using intensive scouting was an integral part of orchard management. The systems include both mulch and ground covers and utilize legumes, compost, and variable fertigation scheduling to supply nitrogen. Lysimeters monitor herbicide and nitrate leachate. The objectives are to identify practical, effective, and economic alternatives to herbicides and improve nitrogen management. This study will determine the impact and interactive effects of the orchard floor management systems on: the arthropod complex (emphasis on mites); plant parasitic and entomophagous nematodes; plant species diversity; tree growth, yield, nutrition, and cold hardiness; total pesticide use; efficacy of target pest control; and production profitability.

**The Dramatic Shift of The Western Corn Rootworm to First-year Corn: IPM Responding to Changes in Pest Dynamics.** C. R. Edwards, L. W. Bledsoe, J. L. Obermeyer, and R. L. Blackwell,

Purdue Pest Management Program, 1158 Entomology Hall. Purdue University, W. Lafayette, IN 47907-1158

Over the past several years, agriculturists in Indiana and Illinois have observed a substantial increase in first-year corn fields (corn and soybean in rotation) showing economic damage due to western corn rootworm, *Diabrotica virgifera virgifera* LeConte, larval feeding. In the year prior to larval damage in corn, significant numbers of beetles have been observed in some soybean fields during the primary egg laying period. This represents a significant change from what was observed in the past. Since the late 1970's, crop rotation has been the primary pest management strategy used for managing this insect. With this change in pest dynamics, new pest management research and extension programs are needed to address this situation.

**Reduced-herbicide Weed Management Systems**. M. J. Else and P. C. Bhowmik, Dept. of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Weed IPM can result in reductions in herbicide use, but in a different way than insect IPM has produced reductions in insecticide use. Scouting, economic thresholds, and biological control agents have enabled insect IPM practitioners to reduce unneeded insecticide use and substitute biorational controls for chemical insecticides. Weed populations, however, are seldom below threshold. The decision growers make about weeds is not *whether* to control them, but *how* to control them. In addition, non-chemical controls are often either unavailable for weeds, or considerably more expensive than herbicides. The most promising means of reducing herbicide use in row crops, therefore, may be to develop methods of applying these materials at reduced rates. Several methods of using herbicides at greatly reduced rates have been tested in Massachusetts. In the *delayed application of reduced rates* (DARR) technique, herbicide application is delayed until shortly before weed emergence. Half rates of metolachlor and atrazine have been found to produce control of weeds in sweet corn when application is delayed until shortly before or after crop emergence. In herbicide banding plus cultivation, herbicide is applied in a band over the crop row. Weed control between rows is achieved with cultivation. Herbicide amount reductions of two-thirds are readily achieved. Combining DARR and banding results in even greater reductions. Tthese techniques have been found to be effective both in plot studies and in on-farm trials with growers. Adoption has occurred on some farms. A primary obstacle to adoption is the relatively minor savings achieved compared to the potential costs of a failure to control weeds. A third tactic studied was herbicide reduction with partial mulch cover. In this technique, a winter-killed oat cover crop is used to reduce weed growth. Corn is planted without tillage into the killed oats. Control of weeds emerging through the oats is obtained with reduced rates of postemergence herbicides. Research-farm trials of this method showed reduced herbicide rates to be less effective than full rates. Further study will be needed before this technique can be tested in on-farm trials.

**National Agricultural Pesticide Risk Analysis Implementation Trial in New York**. Anthony J. Esser, Water Quality Coordinator and Frederick B. Gaffney, Agronomist USDA-NRCS, Syracuse, NY and J. Keith Waldron, IPM Coordinator for Field, Forage and Dairy, Cornell Cooperative Extension. Cornell University, Ithaca, NY

The National Agricultural Pesticide Risk Analysis (NAPRA) risk screening process provides a climate-based probability of exceeding specific toxicity criteria as well as pesticide loading. NAPRA uses the Ground Water Loading Effects of Agricultural Management Systems (GLEAMS) water quality computer model to predict edge of field and bottom of root zone pesticide losses. The NAPRA process includes a toxicity analysis because small losses of highly toxic pesticide may pose greater risks than larger losses of less toxic products.

USDA-NRCS in New York has conducted a six-month implementation trial to test its applicability and acceptance as a held level planning tool. This tool would be used by both NRCS District Conservationists and Cooperative Extension Service (CES) Agents in order to provide growers and landowners alternatives to their current pesticide program. Seven crops and two sites for each crop were selected from various counties statewide. At each site growers were interviewed to obtain specific crop and pesticide information. NAPRA input yielded baseline results for each field or plot. Cornell Integrated Pest Management managers provided alternative chemical or chemical usages to provide variables for a second NAPRA run. District Conservationists, Agents, and growers were then revisited for reaction for comparison between the baseline and alternate results.

Farmer's pesticide use decisions are based on "The Three E's": Economics, Efficacy, and Environment. At present, farmers have ready access to hard and real numbers for the Economics and Efficacy but not for the Environmental component. The NAPRA process is one approach to attaching values to the third "E." Our preliminary findings conclude that there is great potential at the field office level for the NAPRA process. Although use at the growers' level may not be effective, DC and Agent use is. Additionally, NAPRA is most effective on field crops, and has limitations when analyzing fruit, vegetable, and other specialty crops.

**Adoption of Nebraska's Decision Aid for Weed Management in Missouri Soybean Production**. F. M. Fishel, G. S. Smith, and M. H. O'Day, University of Missouri, Integrated Pest Management, 45 Agriculture Bldg., Columbia MO 65211; D. L. Schuster and L. Kabrick, NRCS, Macon, MO

Computer software decision aids have become available from several sources in recent years. In Missouri, there has been some grower interest in this type of technology based on the increasing complexity of weed management. The University of Nebraska recently released its version of a decision aid software package, NebraskaHERB®. Several verification trials were established in private producers' soybean fields for evaluating the practical use of this software in Missouri. Based on species, densities, and growth stages of weeds present, the software recommends postemergence herbicides options either ranked by potential net gain or percent of the potential maximum yield. Several treatments, as recommended by the software, were evaluated in these trials. The treatment with greatest interest was that recommended by the software as greatest potential net gain. Although NebraskaHERB is an aid in sorting through the vast number of options for postemergence weed control, several aspects of the software may not make this particular package feasible for ready adoption in Missouri. Modification of the current software may prove to be a valuable decision tool available for Missouri producers.

**California's UC IPM Pest Management Guidelines: A Short History of Delivering Time-dated Information Electronically**. Mary Louise Flint and Joyce F. Strand, UC Statewide IPM Project, University of California, Davis, CA 95616

In the 1970s, the University of California's major publications relating to pest management were pest and disease control pamphlets listing pests in tabular format with suggested pesticides keyed into time of year or crop growth stage. These pamphlets were gradually taken off the shelves in the early 1980's because of the difficulty in keeping pesticide recommendations up-to-date and lack of author interest in revising them. In 1984, the UC Statewide IPM Project began to put brief pesticide guidelines on a central computer. Taken from 250 old or existing publications, the computer database helped confirm the problems inherent in the pamphlet system--information was often conflicting, inconsistent, incomplete or obsolete. Professional-looking, cohesive publications with a common format and style that would be easy to keep up-to-date, that could also be accessed through a searchable computer database, and whose authors would be recognized in the merit review process,

became a goal. The result was a new publication series, the UC IPM Pest Management Guidelines (PMGs), established in 1987.

PMGs were written and designed to appear simultaneously on the IPM Project's publicly accessible computer and as hard copies created on a desktop publishing system. Frequent updating, emphasis on an IPM program, peer review, and attractive hard copy versions stimulated interest but many potential users had no access to PMGs electronically, since computers were relatively rare and computer communications tools were difficult to use. Use increased after 1989, when a free program, CALLIPM, was distributed to automatically connect a PC to the UCIPM computer through a modem and phone line, and even more after 1993 when the database became available through the Internet. In 1990, subscriptions to the hardcopy version of the PMGs also increased visibility and accessibility. In 1995, the UC IPM Project made its debut on the World Wide Web (http://www.ipm. ucdavis. edu) with the PMGs as a central feature. Guidelines for more than 1,000 pests on 34 crops, turf and home and garden situations are represented. The WWW allows us to combine some of the best features of both electronic and hard copy publications
simultaneously in the same format. These include quick, easy access to a large audience; frequent updates; color photographs and graphics; attractive printed copies; ability to access in-depth information; quick search features; centralized pest management information; and low or no cost to users. Electronic IPM information has finally come of age!

**IPM and Sustainable Agriculture in Mid Atlantic Cash Grain Farming Systems.** Raymond Forney, DuPont Agricultural Products, Remington Farms 7321 Remington Drive, Chestertown, MD 21620 Joanne Whalen, University of Delaware, Department of Entomology, Townsend Hall. Newark. DE 1971 7-13()3. Michael Spray. Mikes Crop Scouting Service. 109 Lime Landing Road. Millington, MD 21651; Terry Patton IPM Extension Assistant, Department of Entomology, University of Maryland, College Park, MD 20740; and Charles Walthall, USDA/ARS, Remote Sensing Lab, Bldg. 7, Rm. 116, BARC-West, Beltsville, MD 20705-2350

Pest management is a critical component of most farming systems, including the four cash grain systems under evaluation at A Sustainable Agriculture Project at Remington Farms. These systems represent a continuum of increasing reliance on rotation diversity, in-season management and labor, and decreasing reliance on purchased inputs. They consist of corn, wheat, and soybean rotations that represent realistic production options for mid-Atlantic farmers. This long-term research, education, and demonstration project is conducted on four field-scale watersheds and a replicated small-plot experiment on Maryland's Eastern Shore. IPM scouting supplies data on the incidence and severity of crop pests in all four systems, and serves as the basis for pest management decisions in two of the systems. During two years of scouting, 21 insects, 8 diseases, 33 weeds, and 6 other pests have been monitored. Our two-year corn-wheat/soybean rotation, managed with IPM including total postemergence herbicides, leads in productivity (measured in cash grain receipts). Our corn-soybean rotation with preprogrammed management leads in profitability. Beginning in 1995, remote sensing is being explored as an aid to IPM scouting. Aircraft or satellite based devices capture images of the reflectance of various spectral bands of radiation, offering the opportunity to monitor vegetation type and health over large geographical areas. Geo-referenced data will be correlated with on-ground observations of crop stresses based on IPM scouting procedures, as well as soil types and, ultimately, crop yield. Substantial communications efforts expose large numbers of farmers, community members and agricultural policy decision makers, to the concepts of sustainability and the benefits of IPM.

**Status of IPM Implementation on Cotton in Texas.** Thomas W. Fuchs, Professor and Extension LPM Coordinator, Texas A&M University System, 7887 N. Highway 87, San Angelo, Texas 76901

Texas producers grow in excess of 6 million acres of cotton. Extension IPM programs in Texas began with a pilot program in 1972. This study was conducted to determine the percentage of producers that are IPM producers and the percentage of cotton acres they farm.

An IPM producer was defined as one who uses scouting for insects, weeds and/or diseases, uses economic thresholds in making treatment decisions and 70 percent of the weighted value of IPM tactics available.

A 1994 survey of 1,533 Texas cotton growers provided data on which IPM tactics are being used. A rating scale of the importance of IPM tactics in 4 production regions was developed from expert opinions of consultants, University IPM specialists and producers. A point system was developed which assigned a given number of points for using an IPM tactic based upon its importance to the IPM program in the region.

Producers who scored 70 points or more on a 100 point system and used scouting and economic thresholds were considered IPM growers. Based upon this definition 64 percent of Texas cotton producers are IPM producers and they farm 68 percent of the cotton acres in the State.

**Grasshopper IPM Research in South Dakota from 1989 to 1994**. Billy W. Fuller, Michael A. Catangui, Tie Wang, Mark A Brinkman & Mark A. Boetel, Plant Science Department, and Michael B Hildreth, Department of Biology & Microbiology, South Dakota State University, Brookings, SD 57007

South Dakota's rangeland grasses are often subjected to arid weather conditions that typify climate of the western plains of North America. Unfortunately, these conditions may coincide with severe grasshopper outbreaks. These grasses are often unable to rebound from grasshopper feeding damage due to stresses associated with low rainfall levels, thus, contributing to a rapid decline in forage quantity and quality. During major grasshopper outbreaks these problems spill over into nearby croplands. Our research from 1989 through 1994 has evaluated chemical and biological control alternatives to aid in control of these pests, there by offering ranchers and farmers the most economical and environmentally sound means of implementing grasshopper IPM in South Dakota.

Chemical control for rangeland grasshoppers is often costly. Additionally, a low profit potential for the vast areas that require treatment can prove economically unsound. To reduce costs, our efforts concentrated on: (1) lower rates (excellent control with carbaryl at 50 percent of standard rate), (2) buffer or barrier sprays (effective with liquid applications), (3) bran baits laced with 1 to 2 percent active ingredient (highly effective with several compounds, but little residual action) and (4) ULV application of diflubenzuron, a chitin-synthesis inhibitor (effective and safe to nontarget organisms). The biologicals investigated included *Nosema locustae* Canning,which failed to provide quality or consistent control, and *Beauveria bassiana* (Bals) Vuillemin, which provided excellent control (70 percent reduction) with little effect on most nontarget arthropods.

Comprehensive investigations into the impacts of carbaryl, difulbenzuron and *B. bassiana* on non-target arthropods in both laboratory and large plot (160 acres per treatment) studies were conducted. Laboratory bioassays with *B. bassiana* caused high mortality in leafcutter bees, *Megachile rotundata* F., however, this was not observed with other bee species found in field studies. Other tested materials appeared to have no significant impact on nontarget arthropods.

**IPM On the World Wide Web: The National IPM Network - Northeast Regional Server**. Carl Geiger**,** Dept. of Entomology, Purdue University, W. Lafayette, IN 47907-1158 http://info.aes.purdue.edu/ipm_index.html

The transfer of information from the researcher to the end-user is vital in facilitating the adoption of any new technology. World Wide Web (WWW)

sites on the Internet have rapidly become an important information tool for a wide variety of topics. This increased popularity results from a number of factors: the software to access the information on WWW sites is essentially free to noncommercial users, the software's interface makes the transfer of text and graphic information 'user-friendly' and simple, and access to the Internet through commercial providers is becoming easier and less expensive. Commercial interests are taking advantage of the WWW for a number of purposes but are motivated by economics; WWW is an inexpensive and effective way of reaching a widely distributed body of consumers. In addition, WWW sites are easily developed and rapidly modified. The increased popularity of the WWW presents an opportunity to provide information of Integrated Pest Management techniques to a wide audience of end users at a minimal cost.

The National Integrated Pest Management Network (NIPMN) has established a system of regional servers containing IPM information and resources. These sites also provide real-time weather data, market reports, and pest alerts; the most recent pesticide label information; and numerous other types of IPM-related data. In addition, they will incorporate interactive resources such as keys to pest species and expert systems for identification and decision support.

Demonstrations of the resources available on these servers will be provided and future resources and potential uses discussed. An assessment of the economic advantages provided through electronic publication of extension materials will be presented.

**Plant Banding: an Alternative Approach to Controlling Banks Grass Mites *(Oligonychus Pratensis)* in Corn**. Robert E. Glodt, Research Manager, Agri-Search, Inc., HCR 1, Box 20A, 3 l 36 Dimmitt Rd., Plainview, Texas 79072

Plant banding was developed by Agri-Search, Inc. in cooperation with the Texas Corn Producers Board as an alternative approach for controlling Banks grass mites, *Oligonychus pratensis* Banks, in corn. Plant banding differs from conventional mite control strategies in the following ways: (1) plant banding involves treating only a specific zone on the plant rather than the entire plant, (2) Comite, a registered miticide produced by UniRoyal Chemical Company, reduces mite populations to a low enough level that naturally occurring predators will prevent a late season mite resurgence, (3) Plant banding is applied by ground equipment, and (4) plant banding is less expensive than conventional mite control strategies.

In the early plant banding research it was discovered that Banks grass mites migrate to corn from alternate hosts over a relatively short period of time. This migration to corn normally occurs prior to the time that corn is three feet tall. Since the mites migrating from alternate hosts to corn only inhabit the undersides of the bottom leaves; miticide applications were directed only toward this zone on the plant. Plant banding therefore, results in a 50 percent reduction in the amount of Comite that is required to control mites under a conventional application approach. Research on plant banding has also shown that the miticide Comite provides the initial knockdown of mites while key predators prevent resurgence of the mites later in the season.

Plant banding has offered growers an economic alternative to controlling mites in corn where no economic alternative existed. As compared to conventional approaches used for controlling mites in the mid 1980's, plant banding has reduced miticide applications to corn by approximately 50 to 75 percent.

**Measurement of Knowledge and Miscomprehension of Integrated Pest Management**. Carroll J. Glynn and Daniel G. McDonald 315 Kennedy Hall, Cornell University, Ithaca, NY 14850

The Economic Research Service of the U.S.D.A. has identified four subject areas requiring multidisciplinary efforts to assess the impacts of IPM practices or policies: farm-level profitability, the environment, public health, and social structure. This paper addresses the fourth of these areas, with

particular attention to sources of information and access to information.

A number of studies have begun developing our knowledge about growers' behaviors and farm economics. A few have begun to explore growers' attitudes toward pesticides, the environment, and IPM. Very few have examined what the farmer actually knows about IPM. Instead, most studies are content to examine specific adoption behaviors and assume that the farmer knows what to do and how to do it when it comes to specific components.

The project's research objectives include four objectives. The first objective is to estimate New York growers' knowledge of four IPM components: (1) scouting/monitoring, (2) natural enemies (exotic species, augmented or conserved species), (3) cultural controls (rotation, plowing, resistant varieties, etc.), and (4) pesticides (thresholds, measurements, applications and selection). The second objective is to identify specific dimensions of comprehension and miscomprehension of IPM tool knowledge. The third objective is to correlate dimensions of comprehension and miscomprehension of IPM tool knowledge with the type of question (e.g., closed or open-ended) and with reliance on particular information sources. The fourth objective is to provide an overview of clusters of comprehension and miscomprehension and the information sources associated with each of the clusters to enable development of more appropriate questions in ascertaining growers' pest management practices.

This paper will analyze data collected through a United States Department of Agriculture Hatch Grant (accession 153595). Correspondence should be directed to the first author: Carroll Glynn, Dept. of Communication, 321 Kennedy Hall, Cornell University, Ithaca, NY 14850 (607) 255-8460.

**Bringing People Together to Address Complex IPM Issues: Cotton IPM in the San Joaquin Valley**. Peter B. Goodell, IPM Advisor, UC Cooperative Extension, Statewide IPM Project, Kearney Agricultural Center, 9240 S Riverbend, CA 93648

Cotton IPM in the San Joaquin Valley of CA has a long and respected history. The progress made during 50 years is based on communication and mutual respect between the public and private sectors. Research-based IPM technologies developed from input from producers and private consultants have provided the foundation of an IPM program noted for its intensive biological monitoring and low insecticide/acaracide usage.

This private/public partnership between research, extension, producers, PCAs, and allied associations and industries was called into action in 1995. After three years of increased arthropod pressure and costly chemical treatments, the cotton industry requested a review of current practices and identification of issues and needs. On November 1, 1995 a meeting was held which included 30 key producers and 30 PCAs in order to build a consensus which identifies the key pest management issues. This facilitated workshop was jointly sponsored by the University of California Cooperative Extension and California Cotton Growers Association

The meeting was well attended with over 80 percent response to the invitation and represented a cotton acreage greater than 500,000 acres. The participants first profiled individual growing regions within the San Joaquin Valley to identify any production and pest management practices which might be causing arthropod outbreaks. Next PCAs and growers were asked to identify solutions or knowledge gaps which might be constraints to solving the key issues identified in the first session. These were ranked by voting and the producer list was compared to the PCAs. A single list was developed and used as a basis for discussion of research and extension priorities for 1996. A summary of issues and results was provided to the industry. In addition, a list of specific extension and research programs and resources which address priority items was provided**.**

**Improving Forage Legume Persistence Through Ecologically Based Pest Management**. Alan R. Gotlieb and William O. Lamp, (respectively) Plant Pathologist, Plant and Soil Science Department, University of Vermont, Burlington, VT 05405, and Entomologist, Department of Entomology, University of Maryland, College Park, MD 20742

Pastures and hay crops are benefited by forage legumes which fix nitrogen, improve seasonal distribution of yield, and enhance animal nutrition. Although forage legumes such as alfalfa and birdsfoot trefoil are capable of persisting in stands for many years, ecological and physiological factors acting in concert with the pest community significantly shorten the life of a stand. The lack of persistence (caused by insects, diseases, and weed competition) has important economic ramifications. In severe situations, pests prevent the profitable use of legume species as forage crops.

A forage legume team, representing 12 U.S. States (central, southern, and northeastern), was organized as part of the planning process for the National IPM Implementation Program. The team has met and identified five pest complexes (competitive weeds, insects, root/crown diseases, foliar wilt diseases, and seedling diseases) which contribute to stand decline of six common legume species (alfalfa, red and white clover, common and sericea lespedeza, and birdsfoot trefoil).

To date, much of forage IPM has focused on short term (seasonal) effects of pests. Our team's goal is to expand forage legume IPM research and extension to focus on long-term strategies that will maintain strong healthy stands to resist pests and to postpone the cascade of events that result in stand deterioration.

**Pest Resistance Management and IPM**. L. Reed Green, Crops Consulting Director-Texas, SF Services, Inc., 824 North Palm Street, P.O. Box 5489, North Little Rock, AR 72119-5489

A completely integrated crop management (ICM) system was developed during the period 1976-1995 in response to resistance of *Heliothis/Helicoverpa* to organophosphate and pyrethroid insecticides in the Upper Texas Gulf Coast. This program is based upon the use of low rates of conventional and biological insecticides to manage the buildup of both beneficial and pest species found in cotton production. Resistance of tobacco budworms to pyrethroid insecticides in 1986 and 1987 resulted in the average number of applications rising from 2-3 at their introduction into cotton production, to 5-6 per season at highest labeled rates in 1987. The end result has been the formation of an environmentally friendly insect control program that reduces usage of pyrethroid and conventional insecticides by over 80 percent without sacrificing yields. Consequently, an effective ICM program should include the following basic principles: (1) No single individual has all the answers to the solution of a complex problem such as insect resistance at the farm level; (2) Cooperation of growers and private practitioners is necessary to successfully develop a pest management plan; (3) Control of the pest species should be completely integrated into the cropping system; (4) Whenever possible, natural selectivity of low dosages of conventional and biological insecticides should be used to enhance the buildup of beneficial insect predators of pest species, while effectively controlling the damaging pests; and (5) The solution to the problem is ever evolving and must be altered as the agronomic system changes with time.

**Apple Production Without the Input of Broad-Spectrum Insecticides.** Larry Gut, Jay Brunner & John Brown, Washington State University, Tree Fruit Research & Extension Center, Wenatchee, WA 98801

This was the initial year of a 3 to 5 year SARE (Sustainable Agriculture Research & Education) project investigating the production of apples without the input of broad-spectrum insecticides. The study is a direct comparison of the ecology and economics of Delicious apple orchards managed without using broad-spectmm insecticides (NBSI) or managed conventionally (CONV). Six orchards were selected for the study, three in north central

Washington (Bridgeport, Chelan, Orondo), two in the Yakima Valley (Wapato,Yakima) and one in Oregon (The Dalles). Each orchard was divided into a 10-acre CONV block and a 10-acre NBSI block. In addition, a no class I (NOC1) management program was evaluated in a third l0-acre block at the Bridgeport, Orondo and Wapato sites. Pheromones were used as the primary control for codling moth (CM) in the NBSI orchards. This treatment alone was as effective as conventional azinphosmethyl sprays at two sites. High CM population densities at the other four sites necessitated supplementing the pheromone treatment with two other "soft" controls, mineral oil and parasitoid releases. This combination provided good control of CM in two orchards, but greater than 2 percent CM fruit injury was recorded at harvest in the other two NBSI orchards. Adjacent CONV orchards sustained over 1.0 percent fruit injury at harvest. Most of the CM damage in NBSI blocks was found along the orchard edge. Insufficient control of CM in NBSI orchards was primarily associated with the inability of selective materials to control border infestations of this pest. Leafroller populations were well controlled in all of the CONV orchards but reached damaging levels in half of the NBSI orchards. Detecting the build-up of leafroller populations in time to control them with Bacillus thuringiensis (B.t.) was difficult. Development of effective methods for sampling leafroller populations will be a major research component of the SARE project over the next two years. Other secondary pests were generally at low levels in NBSI orchards. Natural enemies contributed to the suppression of many of these potential pests. Three species, white apple leafhopper, green apple aphid and tentiform leafminer, reached population densities that required intervention with insecticides in at least one of the CONV orchards. Detailed yield, packout and spray records have been kept for each pair of NBSI and CONV orchards and will be used to compare the economic risks and benefits of these two management programs.

**Influence of Selected Management Practices on the Severity of Southern Stem Rot and Peanut Root-knot Nematode and the Yield of Peanut.** A. K. Hagan, J. R. Weeks and L. Sanders, 106. Extension Hall. Auburn University, AL 36849-5624

Studies were conducted in 1993, 1994, and 1995 to determine the influence of planting date, cultivar, and rate of Temik 15G on the severity of southern stem rot *(Sclerotium rolfsil)* and peanut root-knot nematode *(Meloidogyne arenaria),* and the yield of an early (Andru 93), intermediate (Florunner), and a late maturing (Southern Runner) peanut *(Arachis hypogaea)* cultivar. Planting dates were mid-April (early), late April to early May (optimum), and mid-May (late). Temik 15G was applied either in-furrow at 0.9 kg a.i./ha or at 1.35 kg a.i./ha banded over the row center at-plant and 40 DAP. A non-treated control was included. A RCB, split-plot design with planting date as the main plot, cultivars as subplots, and Temik 15G rate as sub-subplots was used. The hull-scrape method was used to determine optimum digging date. Planting date, cultivar selection, and Temik 15G rate had a significant impact on the severity of stem rot and peanut root-knot nematode as well as yield. Of the three cultivars, Southern Runner generally suffered the least stem rot and heaviest nematode damage. Despite similar levels of nematode damage, stem rot severity was lower in 1994 and 1995 on Andru 93 than Florunner but not Southern Runner. In two of three years, Andru 93 yielded higher than Florunner and both cultivars out yielded Southern Runner all three years. Stem rot severity generally declined from the first through the last planting date on Andru 93 and Florunner. In 1993 and 1995, the least nematode damage was seen across cultivars at the optimum planting date. Across cultivars, yields at the early and optimum planting dates in two of three years were similar, but sharply lower yield was noted in 1994 and 1995 at the late planting date. Among peanut cultivars, planting date had no influence on the yield of Southern Runner but did impact on the yield of Andru 93 and Florunner all three years. Temik 15G had little effect on stem rot severity but nematode damage and yield were inversely related to application date.

**IPM in Texas Schools.** Philip J. Hamman, Associate Head and Extension Program Leader, Dept. of Entomology; and Suzanne Deatherage Hyden, Extension Pesticide Applicator Training Coordinator, Texas A&M University, 412 HEEP Bldg. MS 2475, College Station, TX 77843

As of 1995, public school districts in Texas must make a written policy commitment to IPM as the basis for all pest control operations at school facilities. In addition, Texas law requires that (1) each school district appoint an on-staff IPM coordinator; (2) pest control treatments be conducted by a licensed pesticide applicator; (3) a 12-hour child re-entry period be observed after all pesticide applications; (4) a pesticide selection be based on the conditions of a state classification system, which places products on one of three lists:

- Green List--EPA Category III and IV pesticides that are among the following: botanical insecticides, insect growth regulators microbials, containerized baits or low-toxicity inorganics (i.e, silica gels, boric acid, diatomaceous earth).

- Yellow List--Category III and IV pesticides excluded from the Green List.

- Red List--pesticides with Danger or Warning signal words.

To help schools adopt IPM, faculty of the Texas Agricultural Extension Service, including Michael E. Merchant and Don Renchie, produced instructional video conferences, a resource guide and one-day training programs for school IPM coordinators. Curriculum modules for national distribution are in production and should be available by late 1996.

**California's Integrated Pest Management Innovators Program**. Lyndon Hawkins and Madeline Brattesani, Department of Pesticide Regulation, Environmental Monitoring and Pest Management Branch, Room 161, 1020 N Street Sacramento, California 95814-5624

As a leader in agricultural production, California has a longstanding commitment to the development of IPM. Since the 1880's, the State of California, the University of California, and the United States Department of Agriculture have pioneered biological approaches to pest management in California. In 1972, the State was charged with developing and implementing pest management systems and in 1977, California formally established its IPM program.

More recently, the IPM Innovators program was established as part of Department of Pesticide Regulation's (DPR) commitment and legal mandate to encourage the development of environmentally-sound pest management programs and to give recognition to groups that have demonstrated leadership in voluntarily implementing reduced-risk pest management systems. By giving recognition to "innovators," we hope to encourage others to form IPM groups. To identify IPM Innovators, DPR developed guidelines to characterize innovative systems. Each IPM Innovator is typically a voluntary association or public organization that employs IPM practices and stresses the application of biological, mechanical, and cultural pest control techniques. The association has good pest managers who not only look at the pests at a particular site, but considers the influences of neighboring crops and landscapes and other pest control practices in the same region. This is why some of the best pest management systems involve growers working together to share ideas and practices.

Once an IPM Innovator has been identified, DPR works with them to strengthen their program and to increase adoption of their approach DPR also identifies groups that would like assistance in developing reduced-risk pest management systems. In addition, DPR strives to help established groups share their knowledge and methods with others so that new groups will form.

DPR also administers a competitive grants program to provide funds for implementation and demonstration of new pest management systems.

**A Multi-disciplinary Approach to Managing Agronomic and Pest-induced Stress During Alfalfa Establishment.** G. D. Hoffman, D. B. Hogg, C R. Grau, D. J. Undersander, J. D. Doll, K. A. Kelling, J. L. Wedberg, Dept. of Entomology, Dept. of Plant Pathology, Dept. of Agronomy, Dept. of Soil Science; Univ. of Wisconsin, Madison, WI 53711

We examined the direct and interactive effects of two agronomic practices and pest-induced stress on the vitality and competitiveness of three alfalfa stands at the end of the initial growing season, the following spring, and after a year in production. The four treatments were establishment method (direct seeded, and three variations on companion seedling with an oat crop), a preplant manure application (20T/a), *Empoasca fabae* (potato leafhopper) control, and a late summer application of a spore suspension of *Phoma medicaginis* (spring black stem) to increase disease severity. Plots were established in 1994 and 1995 at three sites in southern and central Wisconsin. We used a spit-split-split plot design with four blocks to incorporate the four experimental factors and the constraints imposed by their application.

Results from Hancock, WI, seeded in 1994, and a 1995 site (to be selected) will be presented in detail. At Hancock in 1994 the amount of alfalfa harvested during the seeding year was: influenced by establishment method (direct seeded>oatlage, herbicide>grain); lower in the manured plots; higher in the leafhopper control plots. The significant establishment method by manure interaction resulted from the fact that higher oat and weed abundance in the herbicide and grain plots suppressed alfalfa growth. When Hancock was harvested in spring 1995 we found that plots with less plant stress (minimal oat competition, high fertility, leafhopper control) had higher yields than plots with higher levels of stress. However, plots with higher levels of stress had more roots, but they were smaller and had fewer stems than plants from low-stress plots. Because of this pattern, stem densities were similar among treatments. These differences in plant population structure may have implications for the long-term persistence of alfalfa stands.

**Integrated Pest Management For Diversified Fresh Market Vegetable Producers in New Jersey, New York & Pennsylvania: An IPM Initiative Project**. M. Hoffmann, Dept. of Entomology, Cornell University, Ithaca, NY 14853, C. Petzoldt, NY IPM Group, NYSAES, Geneva, NY 14456, D. Prostak, Dept. of Entomology, Rutgers University, New Brunswick, NJ 08903, S. Fleischer and S. Spangler, Dept. of Entomology, Pennsylvania State University, University Park, PA 16802, T. Zitter, Dept. of Plant Pathology, Cornell Univ., S. Reiners, Dept. of Hort. Sciences, NYSAES, Geneva, R. Bellinder, Dept. of Fruit & Vegetable Science, Cornell Univ., and A. Shelton, Dept. of Entomology, NYSAES, Geneva

Fresh market vegetable producers in New York, New Jersey and Pennsylvania produce an array of valuable crops that are sold through many channels. The demand for these fresh and wholesome vegetables has been increasing in recent years because of their known health benefits. But at the same time, vegetables are plagued by a complex of pests that often requires intensive pesticide intervention. Progress has been made in developing and implementing cost-effective and environmentally-sensitive IPM programs for this system, but many challenges remain. Increased development and adoption of IPM practices is needed and could be achieved with a concerted public-private sector effort.

The objectives of this project are to assess the pest management needs of the producers and build teams of consultants, grower associations, environmental groups, researchers and Extension staff, producers, and others that will foster the development and adoption of IPM. To achieve the first objective, a survey has been sent to >1,000 vegetable producers in the three States to determine the vegetables they grow and the pest management (insects, weeds, diseases, vertebrate) needs of each. This information will be valuable in strategic planning and resource allocation for the region. The second objective is

being achieved through a series of meetings that place IPM in the context of other issues of importance to producers (labor, marketing, etc.) and through constructive dialogue with environmental groups, produce buyers, and others attending these meetings, identify opportunities that can help address grower needs.

**Toward the Development of Regional Apple IPM Guidelines in New England**. Craig S. Hollingsworth, Department of Entomology, University of Massachusetts. Amherst. MA 01003; William M. Coli, U. Mass.; Lorraine M. Los, U. Conn.; Alan T. Eaton. U. N.H.; Heather Faubert U. R.I.; James M. Dill, U. Maine; Glenn Koehler, U. Maine

Extension-led committees of apple growers in five New England States were provided with copies of the 1994 Massachusetts IPM guidelines. From these guidelines, each committee developed a set of IPM guidelines which they felt was appropriate to their State. One grower from each committee was selected to demonstrate the applicability of their State's guidelines during the 1995 growing season.

Sixty-three different IPM practices were identified. These were classified into the categories of soil management and cultural practices, pesticide application and records, insect management, disease management, weed management, vertebrate management, weather and crop monitoring, and education. Twenty-three practices (37 percent) were cited by all five States as appropriate in their locality and 34 practices (54 percent) were cited by four or more States. Eleven practices (17 percent) were identified by single States.

Four States maintained the weighted point system of the original guidelines, which allow a grower to be assessed as practicing IPM or not. Growers in New Hampshire, citing apprehensions of government regulation of IPM, chose only to list applicable pest management strategies.

**Long Range Tracking of Spray Drift**. Ellis Huddleston, New Mexico State University, Las Cruces, NM 88003, David Miller, University of Connecticut, Storrs, CT 06269, Max Blieweiss, US Army Research Laboratory, BED, White Sands Missile Range, NM 88002

New technologies show considerable potential for tracking spray drift. The technologies are scanning LIDAR (Light Detection and Ranging) and thermal sensors (ATLAS). The LIDAR works similar to a scanning radar but uses laser light rather than microwaves. A laser beam is scanned through the spray cloud and the back scattered light from the droplets is received in a telescope. The time of return of the light is used to determine the distance to the target droplet. The system will detect droplets of all sizes down to a fraction of a micron in diameter. Its range is from 2 to 20 KM, depending on the power of the laser. The prototype LIDAR was developed by Los Alamos National Laboratory. The ATLAS was developed by the US Army Research Laboratory. It is a wide angle video system that records light in the infrared wave lengths (8-14 microns). The picture recorded of a moving spray cloud can be quantified as the integrated cross-plume concentration. Preliminary projects to date have demonstrated that a portable LIDAR can easily and accurately detect and map, in three dimensional space, the smallest droplets of spray materials released from spray planes out to distances of several kilometers from the LIDAR location. The ATLAS system has been used to visualize the spray in wingtip vortices and resulting drift. Two different LIDARs will be used this summer in an EPA sponsored project on Visualization and Quantification of Spray Drift from Orchards.

**Aerial Spray Drift Mitigation.** Ellis Huddleston, Mark Ledson, Robert Sanderson and James Ross, New Mexico State University, Las Cruces, NM 88003

Data are presented on several factors affecting aerial spray drift. The single most important factor is the judgment of the applicator. Flying height has been shown to be a very important variable in sensitivity analyses using the FSCGB model.

Droplet size is highly significant and can be modified by correct choices of nozzle type and orientation. Pressure is less important in aerial application than in ground application.

Adjuvants and their concentrations can affect droplet size and, under certain circumstances, lead to increased drift. Certain polymers make the big droplets bigger, reducing coverage, and make the little droplets smaller, increasing drift. Non-ionic surfactants vary greatly in their effect on droplet size.

**Classical Biocontrol of the Citrus Blackfly in Corpus Christi, Texas**. Raymond Huffman, Extension Agent-Entomology, Texas Agricultural Extension Service, P.O. Box 871, Robstown, TX, 78380 and J. Victor French, Texas A&M University Citrus Center P.O. Box 1150, Weslaco, TX 78599

The citrus blackly (CBF), *Aleurocanthus woglumi* Ashby, has been a pest of citrus in Florida and southern Texas since the middle 1950's. In 1992, the CBF became a serious pest for the first time on dooryard citrus in the large urban area of Corpus Christi. A database of citrus owners in the city was established. Two parasitoids *(Encarsia opulenta* and *Amitus hesperidum)* specific for the CBF, which had been previously used in other areas with success, were transported to Corpus Christi from the Texas A&M University Citrus Center in the Lower Rio Grande Valley after it was determined that these parasitoids most likely did not occur in Corpus Christi. Using volunteer Master Gardeners, a total of 4 releases at 27 different citrus locations over a 16 month period from 5/93 to 9/94 were made. Subsequent collections and evaluations indicated that by 9/94, the parasites had dispersed widely and populations had become established Parasitized CBF samples were collected at several locations where releases had not been made. Numerous citrus owners noted a dramatic improvement in the CBF situation during this period. Continued evaluation and monitoring is planned.

**Strategic Planning for Enhancing IPM Adoption in Processing Vegetable Crops: The National IPM Initiative**. William D. Hutchison, Coordinator, Department of Entornology, University of Minnesota, St. Paul. MN 55108

This IPM project for processing vegetable crops (sweet corn, snap beans and peas) is one of 23 funded planning projects of the National IPM Initiative. Because of close cooperation with the Midwest Food Processors Assoc. (MFPA), the geographic focus for this project is the upper midwest, specifically Minnesota, Wisconsin, Illinois and Indiana. The project includes decision-makers and all major parties involved in assisting growers and processing companies in making IPM decisions. Specifically, representatives from all major processing companies in the upper midwest (active mernbers of MFPA), growers, Departments of Agriculture (MN and WI), and research and extension specialists covering all pest disciplines from each of 4 universities (Minnesota, Wisconsin, Illinois & Purdue) are involved. The IPM team met January 3-5, 1996 in Madison, Wisconsin, to begin the formal planning process, with specific goals of identification of current obstacles for implementation in processing crops, a review of the current status of IPM, and priorities and action plans for research and IPM implementation and assessment over the next 5 years. Specific needs included: hybrid-specific response (tolerance/ resistance) to insects, pathogens and herbicide-insecticide-pest interactions, region-wide use of standardized forecasting models (e.g., degree days), centralization of models, weekly insect monitoring (e.g., trap networks) info., use of GIS-based pest maps, adaptation of WISDOM decision-making software (Univ. of Wisconsin) for sweetcorn/snap beans, and more use of internet resources (e.g., WWW) to deliver information to decision makers in a timely manner. Planning for a complete 5-year project is in progress.

**Alternative Pest Control for the Home Garden**. Douglas W. Johnson, Department of Entomology, Patty L. Lucas, Integrated Pest Management Program, Winston Dunwell, Department of Horticulture and Landscape Architecture, University of Kentucky Research and Education Center, P.O.

Box 469, Princeton, KY 42445 and Ricardo Bessin, Department of Entomology, University of Kentucky, Lexington, KY 40546

As society places more emphasis on pesticide reduction, IPM programs are making pesticide reduction a major goal. To aid commercial producers in reducing pesticide usage, Kentucky offers Integrated Pest Management information and formal trainings for field crops, apples and tomatoes. Tho IPM information and training programs are provided free of charge and are open to everyone, however, the information provided has been geared toward commercial producers. Based upon the number of requests received by specialists, it was determined that a need existed for IPM training and demonstration programs for the home garden. Two popular crops, tomatoes and sweet corn were selected for use in demonstrations. Tomato plots were used to allow home gardeners to view different types of mulch, their ability to control weeds and their durability. Additionally, the techniques of applying rubber bands (for ear tip closure) and mineral oil were demonstrated as alternatives to insecticides for control of earworm in sweet corn. Seeing is believing has become the guideline for developing home garden demonstration programs.

**Small Grain Cover Crops as an Alternative Method of Weed Suppression in Soybeans.** Thomas N. Jordan and Brad A. Miller, Department of Botany and Plant Pathology. Purdue University. West Lafayette, IN 47907

Environmental concerns as well as State and Federal regulations have caused an increase in both the awareness of pesticides in the environment and the need to produce soybeans without tillage to prevent soil erosion. These two contrasting concerns have lead to research investigations into the use of small grain cover crops to reduce erosion as well as reduce weed species which are common in soybean fields. Earlier research has shown that small grain cover crops will suppress weeds in no-tilled soybeans while eliminating the need for many of the soil applied residual herbicides. The objective of this research was to compare different small grain crops for their weed control properties when compared to tilled and no-tilled conventional soybean production systems using herbicides. Four small grains were used in no-tilled systems: spring planted winter wheat spring planted winter barley, fall planted winter wheat and fall planted rye.

**The Relationships Between IPM Adoption and Natural Resource Characteristics in Corn Production**. Catherine Kascak and Sharon Jans, Natural Resources and Environment Division, Economic Research Service/USDA, 1301 New York Avenue, NW, Washington, DC 20005-4788

The overall objectives of this project are to: 1) identify if environmental factors influence the decision to adopt integrated pest management (IPM) techniques for corn producers in different regions of the U.S. and (2) to identify those areas that would realize the greatest environmental benefits from adopting IPM practices. Because not all areas are equally vulnerable to pesticide leaching, the effectiveness of any reduced chemical use associated with IPM practices will depend in part on the distribution of soil, land, and climatic properties facing a farmer.

Using data collected from the USDA Area Studies Survey, we will explore how IPM adoption varies by resource base. The Area Studies data is unique in that it coincides with National Resource Inventory (NRI) points. The NRI provides data on soil, water, and related natural resource properties. This link to a resource base will enable us to identify areas prone to leaching and the probability that they would voluntarily adopt IPM practices. Using GIS technology, we will then display areas with vulnerable soil and land properties that are not currently using IPM technologies.

**Planetor: An Environmental and Economic Planning System.** Kevin Klair, Department of Applied Economics, University of Minnesota, St. Paul, MN 55108

Planetor is a comprehensive environmental and economic farm planning software program. It combines site specific environmental models with individual farm economic planning data to evaluate the impacts of changing pesticide, nitrogen, phosphorus and manure applications, tillage systems, and crop rotations.

Planetor evaluates alternative management plans for individual farms and compares the impacts on soil erosion, nitrate leaching, phosphorus runoff, pesticide movement, and whole farm profitability.

**Implementing Integrated Farm Management Systems for Winegrape Production**. Karen Klonsky, Extension Specialist Dept. of Agricultural Economics and Frank Zalom, Extension Specialist. Dept. of Entomology, University of California-Davis

This project is being conducted with growers of the Lodi-Woodbridge Winegrape Commission and researchers from the University of California. The Lodi-Woodbridge Winegrape Commission is comprised of more than 600 winegrape growers producing dozens of varieties of grapes on 45,000 acres in California's San Joaquin Valley. In 1992, the Commission embarked on an IPM program with the dual objectives of promoting effective and rapid adoption of sustainable winegrape production practices, and promoting economic and social development in San Joaquin County by implementing a marketing program designed to create a market niche for winegrapes which are produced using environmentally sound viticulture practices. The purpose of this project is to determine energy and production costs for vineyards of growers who are high users of energy efficient and sustainable production practices, to implement sustainable practices on vineyard blocks of growers who are not currently high users of such practices, and to educate all growers within the District on how they may adapt these findings to their operations. To accomplish this, ten vineyards have been selected on which replicated trials of innovative insect and weed control practices could be demonstrated. Cultural operations performed by the cooperating growers were recorded to estimate production costs for economic comparisons and to characterize vineyards in terms of high use to low use of both energy efficient and sustainable practices.

The cost of disease and insect control pesticides ranged from $13 to $507 per acre across the project vineyards. We had anticipated this extreme variance as the growers were chosen based upon their variation in production practices. High costs were attributable to the use of sterol-inhibiting fungicides rather than sulfur. Floor management costs ranged from $34 to $185 with most of the variation due to herbicide treatments along the vine rows. The total cost of production ranged from $1,487 to $2,664 per acre, averaging $1,998. Net returns averaged $1,176 per acre with only one vineyard showing a negative return. Interestingly, the vineyards with moderate costs showed higher net returns than the high-or low-cost vineyards.

**Dispersal of Diamondback Moth, *Plutella Xylostella* L., From Cruciferous Weed Hosts.** Peter Kmec and Michael J. Weiss, Dept. of Entomology, North Dakota State University, Fargo, ND 58105

Cruciferous weeds are suitable hosts for the first generation of the diamondback moth (DBM) in the northern U.S. We studied the dispersal of DBM from field pennycress, *Thlaspi arvense* L., into neighboring weed patches and the crop host, *Crambe abyssinica* Hochst. Adult males marked with Uvitex OB and Blaze Orange powders were released and recaptured in pheromone traps. The first release of 1,200 males was done before the crop emergence when the weeds were in the flowering stage. A total of 35 moths were recaptured, out of which five were recovered in the neighboring weedy patches. On the second release of 2,400 males, the crop was in the fourth leaf stage and the weeds were fully mature. A total of 20 moths were recaptured, out of which one was found in an adjacent weedy patch and two were found in the crop. During the second recapture experiment, there was an increase in trap captures of unmarked moths in the crop, which coincided with a period of

southerly winds. The population in the crop may have been established be immigration rather than by dispersal movement from the weeds.

**Applying Trichogramma to Cotton for Control of Bollworms in Texas**. Allen Knutson, Extension Entomologist. Texas Agricultural Extension Service, Texas A&M University, 17360 Coit Road, Dallas, TX 75252

Several species of minute wasps of the genus Trichogramma parasitize eggs of bollworms and budworms in cotton. However, these beneficial insects are often not abundant enough to significantly reduce pest numbers. Several commercial insectaries promote and sell Trichogramma for release in cotton, although there is little research information on how to use best use these natural enemies. With the reduction in insecticide use in the southeast following boll weevil eradication and the continued problems of pesticide resistance and secondary pests throughout the Cotton Belt, there is renewed interest in biological control of cotton insect pests. One constraint to the evaluation and use of Trichogramma has been the lack of a machine to apply Trichogramma to field crops such as cotton.

Recently, the USDA invented a tractor-mounted machine, termed the biosprayer, that can be used to rapidly and uniformly apply Trichogramma to row crops. This machine, now under commercial development, was evaluated in this study. Results showed that application through the sprayer reduced Trichogramma emergence from host eggs by about 22 percent. Modifications of the sprayer are underway to reduce this mortality. Additional mortality resulted from predation, primarily fire ants. In the absence of predators, rain and dew, 88 percent of the applied host eggs were retained on cotton leaves for three days. Most (79 percent) of the host eggs recovered in the cotton canopy were deposited in the plant terminal. Application of 100,000-200,000 Trichogramma per acre twice a week did not consistently increase parasitism of bollworm eggs in field plots. The high cost of Trichogramma and the variable level of control are current constraints to the adoption of this practice by cotton producers.

**Cropping Sequences With Resistant And Susceptible Soybean Cultivars And Nonhost Crops For Management of The Soybean Cyst Nematode.** S.R. Koenning and K.R. Barker, Researcher and Professor, Box 7616, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616

The soybean cyst nematode, *Heterodera glycines*, (SCN) is the most serious soybean pathogen in North Carolina. Rotation with nonhost crops (corn, tobacco, cotton or peanuts) and the use of soybean cultivars resistant to soybean cyst nematode are currently the primary means for managing this nematode. A recent survey of 10 North Carolina counties with significant soybean acreage indicates that more than half of the populations of SCN can be classified as race 2. Cultivars resistant to race 2 of SCN, however, are not generally available. A new soybean variety, Hartwig, has a high degree of resistance to all North Carolina populations tested thus far, including *H. glycines* race 2. A rotation study was initiated in 1993 on a farm in Washington County, NC, on land infested with race 2 of soybean cyst nematode to evaluate the durability of the Hartwig type resistance to SCN. Rotational sequences of Hartwig with a susceptible soybean cultivar and (or) a nonhost crop have been evaluated over 3 years. A total of 24 treatments, arranged in randomized complete blocks with 4 replications, are being used to monitor soybean yield and population densities of H. *glycines* in seven cropping sequences. The yield of resistant Hartwig was slightly greater than that of susceptible Deltapine 105 in 1993, but numbers of SCN eggs were much lower following corn or Hartwig than after Deltapine 105 ($P = 0.05$). In 1994, yields of Hartwig or susceptible Hutcheson were greater following corn than yields of either variety following soybean. The lowest soybean yield occurred in plots with 2 years of Hutcheson. Numbers of cyst nematodes were much lower following corn or Hartwig in 1994, compared to susceptible Hutcheson. Data from 1995 indicated that yields of

Hutcheson soybean were greatest when this variety was grown in a 3-year rotation with either 2 years of corn or corn and SCN-resistant Hartwig as the previous crops. The lowest soybean yield of any rotational sequence in 1995 was with continuous Hutcheson. Although these data are preliminary, the sequence of corn-resistant soybean variety-susceptible variety appears to be a viable rotation when soybean must be grown 2 out of 3 years.

**Communicating IPM: a Picture Is Worth a Hundred Words**. Carrie Koplinka-Loehr, Writer/ Editor, New York State Integrated Pest Management Program, Box 28 Kennedy Hall, Cornell University, Ithaca, NY 14853 [phone, 607-255- 8879, e-mail, ckk3@Cornell.edu]

Visual aids are essential for conveying IPM methods to all audiences. Yet photographing and drawing such concepts as "pest-resistant varieties" or even "pesticide resistance" is extremely challenging. The New York State IPM Program educates producers, legislators, extension personnel, consumers, and others with the help of drawings, photographs, slides, videotapes, and the World Wide Web. With this interactive poster session I will show some wares and address specific challenges. Workshop participants will be invited to suggest resources that could be of use to IPM educators. After the symposium, the resulting list will be shared with those interested

**Role of BPPD/EPA in Regulatory Relief of Biological Pesticides**. John Kough, Freshteh Toghrol, Frank Ellis & Roy Sjoblad, U.S. Environmental Protection Agency, Office of Pesticide Programs, Biopesticides and Pollution Prevention Division (7501W), Washington, DC 20460

Two major functions of the Biopesticides and Pollution Prevention Division in the Office of Pesticide Programs at EPA are to apply the best scientific information to the regulation of biological pesticides (biopesticides) and to promote the implementation of reduced risk pesticides. EPA defines biopesticides to include biochemical pesticides, microbial pest control agents and transgenic plants. The criteria used to delineate groups of biopesticides are discussed. Because many biopesticides are essential tools in IPM programs, OPP's efforts to facilitate their registration are presented. Current policy developments to streamline the registration of pheromones include expanding the acreage limit for experimental uses and reducing data requirements for registering lepidopteran pheromones. Rationales for the reduced data requirements for biopesticides are presented. Some biopesticide active ingredients, along with a number of chemical pesticidal active ingredients, are being exempted from health and environmental safety requirements due to their widespread use for non-pesticidal purposes, non-toxic modes of action, lack of probable environmental persistence, insignificant exposure as a pesticide, and/or a previous determination of safety by the Food and Drug Administration. The generic food tolerance exemptions for plant growth regulators and polymeric inerts for pheromones are explained.

**Research, Extension, and Implementation of IPM in the Major Apple Production Regions of New York State.** Joseph Kovach, NYS Fruit IPM Coordinator, IPM Program, Cornell University, NYSAES, Geneva, NY 14456, Harvey Reissig, Dept. of Entomology, Cornell University, NYSAES, Geneva, NY 14456, Dan Donahue. NYS Horticultural Society, NYSAES, Geneva, NY 14456

The primary goal of this planning project was to increase the adoption of biointensive IPM methods through a public and private partnership so that growers can reduce applications of conventional pesticides while maintaining abundant yields of high-quality fruit. New York has approximately 53,000 acres of apples that are concentrated in three different regions: western New York along Lake Ontario, the Hudson Valley, and the Champlain Valley. Each of these regions has a different climate, soil, pest complex, apple cultivar mix, and marketing strategy. These combined regions form a

unique apple production unit compared to other fruit growing areas in the United States and in the northeastern U.S. The NY apple industry has worked actively during the last several years with the International Apple Institute to develop a plan in response to the national commitment by various Federal agencies to develop and implement integrated pest management methods on 75 percent of the total USA crop acreage by the year 2000. Also, Cornell University, in cooperation with NY State Department of Agriculture and Markets, developed a long-range plan to identify research projects and set extension priorities to enhance IPM implementation in apple orchards. To more fully develop a unified plan, an implementation team was created that included Cornell research and extension personnel, growers, private consultants, State regulators, and environmental and consumer representatives with the goal of defining IPM and prioritizing research and extension needs. Growers in the three regions were then surveyed on which of these practices they currently use, so baseline adoption rates could be established. Outputs from these implementation team meetings and grower survey results will be presented.

**A Method for Assessment of Integrated Pest Management Practices.** Ronald D. Lacewell, Professor, Dept. of Agricultural Economics; George L. Teetes, Professor, Dept. of Entomology and Richard A. Frederiksen, Professor, Dept. of Plant Pathology and Microbiology, Texas A&M University, College Station, TX 77843

To evaluate an IPM program, there must be a baseline for comparison. This is the basis of benefit/cost analysis and quantifying changes in environmental indices. It is important that the test reach over several seasons. Essential to the process is involving a cross-section of disciplines, research and extension at the beginning. It is convenient to discuss evaluation alternatives separately, such as economic, environmental, and technology transfer.

**Economic.** A basic economic method applicable for IPM evaluation is budgeting. At the level of most detail is a per unit budget (enterprise budget). Partial budgeting involves quantifying only the outputs and inputs that change with the IPM practice. Whole farm analysis involves a firm level study. Watershed or regional level analysis is useful for an environmental evaluation. Macroeconomic analysis provides the expected impacts on cropping patterns across the U.S., potential commodity price impacts and quantification of effects of the IPM program on farmers, profit (surplus) and consumers, well-being (surplus) for major regions, the nation and the world.

**Environmental.** The art of simulation of natural processes has evolved dramatically in the last few years. Application of simulation models allows estimating a distribution of crop yields over weather patterns as well as percolation and runoff of agricultural chemicals, nutrients and soil erosion. The measurements on chemicals and nutrients leaving a plot of land is best taken as a relative measure between the conventional and the IPM practice rather than absolute estimates. Hydrologic and transport models can then take the micro location simulated data and track fate and transport across a watershed and/or river basin. Again this provides insight into the effect of the IPM program on relative amounts of pollutants leaving the watershed or reaching major watercourses.

**Technology Transfer.** A recommended goal to be incorporated into transfer of an IPM program is a users, decision aid that includes pest management, agronomic issues, economic and other disciplines as dictated by the specific region and IPM program. The decision aid can be dynamic using interactive compact disk technology.

**A Survey of Homeowners to Determine Landscape And Garden Pest Management Practices, Water Quality Awareness, and Preferred Learning Methods**. S.E. Lajeunesse, G.D. Johnson, and J.S. Jacobsen, Johnson Hall, Montana State University, Bozeman, Montana 59717

Adult education materials and programs that are designed, produced, and delivered to specifically address areas of learner interest and need can

provide incentive for active participation in the learning process. As an initial step in designing a new Urban Pest Management Program at Montana State University-Bozeman, a mail survey of 1,040 households was used for audience analysis and needs assessment. Questions focused on management practices for pests, pesticides, and fertilizers, water resource protection, and preferred methods of learning. Non-response bias was estimated by telephone follow-up. Combined survey response rate was 56 percent. Results show homeowners' primary source for problem-solving information is businesses selling landscape supplies (56 percent). Most are aware (54 percent) or somewhat aware (32 percent) of related water quality issues, and pest control products are considered "safe if used properly" (45 percent) or "somewhat safe if used properly" (40 percent), but few precautions are taken when using pesticides. Most homeowners are "very interested" (43 percent) or "somewhat interested" (38 percent) in learning more about least- toxic methods of pest management. Methods of learning considered most effective are printed materials, hands-on participation, educational videos, and demonstrations by specialists. Workshops, salespeople, radio, and personal computer programs are rated least effective. Preferred types of instructional programs are self- taught (51 percent) and least preferred is learning in a group setting such as a workshop or a short-course (19 percent). As a result of the survey, our audiences' needs and interests have been identified, enabling program design, development and delivery to concentrate on areas with greatest potential for results.

**Montana State University Outreach Pest Recommendation Network: Delivering IPM Solutions**. Will Lanier, Dept. of Entomology, 324 Leon Johnson Hall, Montana State University, Bozeman MT 59715; Jack Hanson, Agricultural Experiment Station, 213A Linfield Hall, Montana State University, Bozeman MT 59717; and Greg Johnson, Dept. of Entomology, 324 Leon Johnson Hall, Montana State University, Bozeman MT 59715

The importance of information regarding agricultural pest control is evident from the diversity of handbooks, manuals and Extension publications. Historically pest identification and IPM recommendations have been delivered via interactions with specialists and county agents using written, verbal descriptions and advice. These interactions may use static information like publications, or dynamic information, which allows recommendations to be based on current conditions as interpreted by a specialist.

Currently, delivery of dynamic information is limited by physical location and personal interaction. The objective of the MSU Outreach Pest Recommendation Network (PRN) is to remove the physical limitations of dynamic pest recommendation delivery. The PRN facilitates the use of dynamic aspects of IPM recommendations for individuals concerned with pest control. The PRN method employed describes relevant factors leading to a recommendation, general facts about the pest and timely control measures. Comparing old situations to new cases, using a method known as Case Based Reasoning, it is possible to match the user's current situation with IPM solutions.

At MSU there are limitations to delivering pest recommendations to remote users. Currently the PRN project is looking at two delivery methods using the World Wide Web. One option is to deliver the PRN using an Oracle database, PEARL SQL scripts and interactive forms using HTML code. The other option is a Windows 95 Web server, Visual Basic interactive forms and ODBC drivers querying an Oracle database.

**A Weather-based System for Scheduling Fungicide Sprays for Control of Alternaria Leaf Blight of Muskmelon**. R. Latin and K. J. Evans, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-1155

A weather-based system for scheduling fungicide sprays for control of Alternaria leaf blight of muskmelon was developed and implemented in Indiana during the 1994 and 1995 growing seasons.

The system is based on a statistical model that defines the effects of temperature and leaf wetness duration on disease establishment. The number of hours of wetness during a day (24 h) and the mean temperature during the wetness period are used to compute a daily environmental favorability index (EFI). Daily EFI values are accumulated throughout the season. Fungicide sprays are recommended at intervals of 20 cumulative EFI values. The model was programmed into a battery operated microprocessor attached to leaf wetness and temperature sensors in the field. All of the hardware is mounted on a portable frame. The MELCAST (Melon Disease Forecaster) system was tested in commercial fields and experimental research plots. In all field tests, use of the weather-based system resulted in fewer fungicide applications than a conventional 7-day spray schedule, without an increase in disease severity The system was implemented in 1994 and 1995 throughout the melon-growing region of southern
Indiana. A communications network was established to post cumulative EFI values on a voice-mail device every day so that area farmers could access MELCAST via a toll free phone number.

**The Role of Natural Enemies in Developing Sustainable Landscapes: A Lesson From Azaleas**. Paula Leddy-Shrewsbury and Michael J. Raupp, Department of Entomology, University of Maryland, College Park, MD 20742

An analysis of pest occurrence revealed that *Rhododendron* was one of the most pest-prone genera of landscape plants found in the mid-Atlantic region, often with excess of 50 percent of the plants under pest attack. The single most important pest of azaleas in Maryland's landscapes is the azalea lace bug, *Stephanitis pyrioides*. Theories concerning factors that control the abundance of herbivorous insects have been prominent in the history of ecology. Particular attention has been paid to habitat diversity and its effect on phytophagous insects and their natural enemies. The more complex and heterogeneous an environment, the more kinds of species it will hold. Little work has been done on the influence of habitat diversity on herbivores and natural enemies in landscape systems. However, we have found that azalea lace bug infests and damages azaleas located in sunny habitats more frequently than in shady habitats. Preliminary studies have shown that light exposure is strongly, negatively related to architectural complexity (a measure of habitat
diversity) in landscape habitats. We examined four hypotheses that explain the distribution of lace bugs in home landscapes. First, we tested the hypothesis that direct or habitat-mediated effects on the host plant influenced the distribution of lace bugs on azaleas and found no support for this hypothesis. Next, we examined the direct effect of temperature on lace bug survival and development and found this too could not explain patterns observed in the field. Previous studies revealed that habitat-related plant stress also did not explain lace bug distributions. Finally, we determined that differences in the abundance and structure of natural enemy communities differed between simple and complex habitats and that these factors combined with slower development of lace bugs in complex sites explained well the distribution of lace bugs. Our study will provide landscape architects and managers with knowledge to facilitate the design of sustainable landscapes that require fewer inputs of pesticides.

**A Program That Stimulates Collaborative IPM Efforts in Urban IPM.** Anne R. Leslie, Estella Waldman, US Environmental Protection Agency, Biopesticides and Pollution Prevention Division (7501W), 401 M St., S. W. Washington, DC 20460

Concern over the magnitude of urban use of pesticides and resulting effects on human health and the environment have led to a number of community and corporate efforts to establish IPM programs. Community organizations have successfully lobbied for legislative requirements for IPM programs in the schools and are designing training programs for pest control personnel. Many homeowners are questioning the American landscaping ethic that relics on extensive use of pesticides on lawns that occupy more land than any single crop in the United States. Nevertheless, there are great environmental

and health benefits to urban landscaping, through the ability of grass to modify extreme temperatures and filter pollutants from the air. IPM programs that reduce pesticide use are a solution to the problem. One program that has been enthusiastically adopted by citizens and by corporate organizations is the Audubon Cooperative Sanctuary Program, designed and implemented by the New York Audubon Society. The program encourages property owners, both corporate and private, to improve wildlife habitat on their property, and to adopt IPM programs to control problems that may occur. The U.S. Golf Association (USGA) Green Section Research Committee, seeking ways to improve stewardship of the environment, initially endorsed and funded the program for golf courses. It has been enthusi-astically adopted by the Golf Course Super-intendents Association of America (GCSAA). More than 1500 golf courses have enrolled, and a growing number have obtained certification as sanctuaries. In addition, the Professional Lawn Care Association of America (PLCAA) is exploring implementation of the program for their member companies. Both PLCAA and GCSAA have become Partners in EPA's Pesticide Environmental Stewardship Program (PESP), and the IPM component of the Sanctuary program is a key part of their strategies to reduce the risk and use of pesticides in the turfgrass industry.

**A Criteria and Indicator Matrix of Environmental Impacts: A Tool for Use in Assessing Agricultural Pest Management Products and Strategies**. Lois Levitan and Ian Merwin, Dept. Fruit & Vegetable Science, Cornell Univ., Ithaca, NY 14853

What factors should be taken into consideration in assessing agricultural systems? Typically, an accounting is made of direct economic costs, productivity, and the quantity and efficacy of pesticides and other inputs. With the growing concern about non-target environmental impacts of plant protection products and methods, we are now being challenged to develop accounting systems which can assess environmental impacts as well. This raises several non-trivial questions: (1) what parameters should be included as descriptors of the environment? (2) which indicators should be used to register effects on the selected environmental variables? and (3) how should these impacts be measured?

This 'Criteria and Indicator Matrix' provides a framework for organizing information pertinent to answering these questions. The Matrix compiles relevant information about a wide range of environmental indicators that have been proposed for inclusion in assessment systems. It highlights data sources, pinpoints data gaps, and stimulates discussion about how and if missing data can be supplied or imputed. The Matrix is a means of organizing a confusing array of information useful for environmental impact assessment into a transparent format that retains clarity about the assumptions and criteria upon which judgments are based.

For each environmental variable listed as a row item in the Matrix, information is provided in the cells of the Matrix to identify (1) the toxicity tests or other bases for judging the impact of a pest control method; (2) the criteria for assigning a pest treatment to a given category of impact (positive, neutral, or negative); (3) the source of the information provided for each row item; and (4) the source and reliability of datasets relevant to each variable.

Criteria or algorithms for delineating between and describing each category of impact are based upon the expert judgments of specialists, as reported in the scientific literature or personal communication. Categories of impact can be scored to reflect functional impacts on the environment. and compiled scores can be used to index the relative extent and severity of impacts of different pest control products and systems.

**Pest Control Environmental Impacts Index: A Method for Assessing Apple Pest Management Practices in the Northeast**. Lois Levitan, Ian Merwin, Joe Kovach, Department of Fruit and

Vegetable Science, Cornell University, Ithaca NY, 14853

Conventionally-produced apples in the Northeast US often receive more than twenty pesticide applications annually -- among the highest rates used on food crops. This pesticide use can pose risks to human beings and other non-target biota. However, high temperatures and humidity during the growing season, as well as cultural factors, cause heavy pest pressure and a large pest complex in apple orchards in the Northeast. We describe an assessment system being developed to aid growers and those who advise them in choosing effective plant protection methods which take the least toll on the environment and public health. The system provides information and a relative ranking of the environmental impacts of different pesticides and non-chemical plant protection methods.

The assessment procedure involves (1) specifying the environmental parameters to be considered; (2) identifying criteria for categorizing the extent and severity of impacts; (3) determining scores for the categories; (4) assigning relative weights to the environmental indicators, depending both upon the priorities and exigencies of users and also upon site-specific variables; and (5) establishing a formula for compiling ratings for each impact into a composite score for each pest control product or practice. The list of composite scores constitutes the Pest Control Methods Environmental Impacts Index.

The methodological approach outlined in this five-step process is used to evaluate the relative environmental and economic impacts of alternative apple pest management strategies. The framework of this assessment system is intended to keep the assumptions of the assessment transparent, and to enable situation-specific modifications. This decision model is being applied to an assessment of apple pest management practices in the Northeast U.S. by simulating alternative production scenarios.

**Expert System for Integrated Management of Wheat Diseases And Sustainable Wheat Production**. Roland F. Line, Agricultural Research Service, U.S. Department of Agriculture, Pullman, WA, 99164-6430

An expert system for managing wheat diseases referred to by the acronym MoreCrop (Managerial Options for Reasonable Economical Control of Rusts and Other Pathogens) was developed for the U.S. Pacific Northwest. The purpose of MoreCrop is to present outcomes that may happen and options for control. The user evaluates the provided information and by a process of reasoning determines the most economical control. MoreCrop was developed using the enormous knowledge base on wheat diseases together with tools from recent technological advances in the computer industry. It provides information, options, and suggestions to help the user make decisions regarding management of wheat diseases. MoreCrop predicts what diseases are likely to occur based on selected geographical regions, agronomic zones, crop managerial practices, cultivar characteristics, prevailing weather, crop history, and disease history and provides the reasons for the disease outcome. The classical disease triangle is used as the overriding principle in predicting the diseases; i.e. a susceptible host, a virulent pathogen, and a favorable environment must exist for the disease to develop. It considers the diseases that are likely to occur and evaluates integrated disease management (IDM) options. It can suggest an IDM program or provide an opportunity to develop a customized IDM program. It evaluates the IDM program, provides a list of diseases that can and cannot be controlled, and provides the rationale for control or absence of control. MoreCrop also provides disease-related information for teaching, research and extension. The concepts of MoreCrop can be extended to include fertility management and management of other pests. Thus, MoreCrop can serve as a prototype in developing a total wheat management program. Its programming structure, visual controls, and principles should be easily adapted for use in IDM of other crops or in other regions of the world. For details about MoreCrop, contact Roland F. Line, Agricultural Research Service, U.S. Dept. of Agriculture, 361 Johnson Hall, Washington State

University, Pullman, WA, 99164-6430, telephone: 509/335-3755. To purchase MCP22 MoreCrop, contact Washington Cooperative Extension Bulletin Office, Cooper Publication Building, WSU, Pullman, WA 99164-5912, Telephone: 509/335-2857.

**Influence of Rye and Hairy Vetch Residues On herbicide Fate and Establishment of Selective Broadleaf Weeds.** Martin A. Locke and Reid J. Smeda, USDA-ARS, P.O. Box 350, Stoneville, MS 38776

Production of agronomic crops using cover crop residues is one practice of conservation management. The fate of herbicides in soil is affected by their interception on cover crop residues. We evaluated sorption of four herbicides (2,4-D, alachlor, acifluorfen. and fluometuron) to rye *(Secale cereale),* hairy vetch ( *Vicia villosa),* and Dundee silt loam soil. Initial characterization of herbicide sorption in Dundee soil and partially decomposed rye and hairy vetch involved simple batch experiments. For all four herbicides, sorption was greatest in rye and lowest in soil. In rye, the relative sorption of herbicides was acifluorfen > alachlor > fluometuron >> 2,4-D. Sorption to hairy vetch was the same as to rye, except that alachlor sorption was greater than that of acifluorfen. The order of sorption in soil was alachlor > fluometuron > acifluorfen = 2,4-D. Herbicide sorption in soil was attributed primarily to humic components, but interaction with clay minerals in soil has been observed in other studies. In another experiment. residues of rye and hairy vetch were compared with no cover for suppression of pigweed *(Amaranthus sp.),* common cocklebur *(Xanthium strumarium* L.), hemp sesbania *(Sesbania exaltata* (Raf.) Rydb. ex A. W. Hill), morning glory *(Ipomoea sp.)* and sicklepod *(Cassia obtusifolia* L.), five significant broadleaf weeds in soybeans. Both rye and hairy vetch were seeded in the fall of 1993 and 1994 and desiccated the following spring with paraquat. In both 1994 and 1995, rye and vetch residues reduced the mean density of the 5 weeds compared to the no cover plots up to l 00 and 64.7 percent, respectively, 4 weeks after desiccating the cover crops. By 6 weeks after desiccation, rye suppressed weed establishment up to 90.5 percent while vetch only provided up to 7.1 percent suppression. Eight weeks after desiccation, rye residues suppressed weed densities up to 46.2 percent, but no differences were measured between vetch residues and no-cover plots. Despite differences between years, residues of rye were clearly superior to vetch and the no cover plots. Full-season weed management in crop production systems using cover crops will require the application of selective herbicides, depending upon the weed species present.

**Insecticide Resistance Action Committee**. John Lublinkhof, Vice Chairman/Secretary - IRAC, c/o AgrEvo USA Company, 2711 Centerville Road. Wilmington, DE 19808

The Insecticide Resistance Action Committee (IRAC) was formed in 1984 to provide a coordinated agrichemical industry response to the global development of resistance in insect and mite pests. IRAC has been instrumental, along with other groups, in surveying product failures due to resistance; developing practical monitoring methods; publishing management guidelines; and sponsoring fundamental and applied research in several countries. IRAC is now concentrating its resources on local implementation of resistance management strategies by growers; establishing the relationship between monitoring data and level of control in the field; and educating all involved in crop protection.

**IPM on The World Wide Web: The National IPM Network - Northeast Regional Server**. Ian MacRae & T.O. Holtzer, Dept. of Entomology, Colorado State University, Ft. Collins, CO 80523 [http://www.colostate.edu/Depts/IPM/IPM.html]

The transfer of information from the researcher to the end-user is vital in facilitating the adoption of any new technology. World Wide Web (WWW) sites on the Internet have rapidly become an important information tool for a wide variety of topics. This increased popularity results from a number of factors: the software to access the

information on WWW sites is essentially free to non-commercial users, the software's interface makes the transfer of text and graphic information 'user-friendly' and simple, and access to the Internet through commercial providers is becoming easier and less expensive. Commercial interests are taking advantage of the WWW for a number of purposes but are motivated by economics; WWW is an inexpensive and effective way of reaching a widely distributed body of consumers. In addition, WWW sites are easily developed and rapidly modified. The increased popularity of the WWW presents an opportunity to provide information on Integrated Pest Management techniques to a wide audience of end users at a minimal cost.

The National Integrated Pest Management Network (NIPMN) has established a system of regional servers containing IPM information and resources. These sites also provide real-time weather data, market reports, and pest alerts; the most recent pesticide label information; and numerous other types of IPM- related data. In addition, they will incorporate interactive resources such as keys to pest species and expert systems for identification and decision support.

Demonstrations of the resources available on these servers will be provided and future resources and potential uses discussed. An assessment of the economic advantages provided through electronic publication of extension materials will be presented.

**The Role of Incentives in the Success of IPM Implementation Projects**. Michele C. Marra, Department of Agricultural and Resource Economics, Box 7509, North Carolina State University, Raleigh NC 27695-7509

There have been millions of public dollars expended to attempt to influence farmer decisionmaking in the area of pest management. Strategies for implementation include development of area- wide cooperative plans, such as the cotton boll weevil project, promotion of Best Management Practices, establishment of IPM positions within extension, to name a few. Some efforts have been highly successful, while others have not. The reasons for the unsuccessful efforts may include failure to recognize and allow for the incentive structure involved among the various participants in the process. This poster illustrates the incentive structure in operation when an interdisciplinary group composed of academics, technology transfer personnel (both public and private), personnel from other government agencies and farmers interact. These incentives can be very different, even though the societal goals are the same. Differences can exist even between members of the same subgroup. An assistant professor may have different incentives than a tenured professor in influencing the design and implementation of the project. Both extension and chemical supply per-sonnel have incentives that may be in conflict with researchers and farmers, as well as with each other. Farmers may have motivations not immediately apparent, but that affect the success of the implementation strategy. This disparity must be taken into account when devising strategies for IPM implementation. Several questions should be asked periodically as a project progresses. For instance, when is it appropriate to redirect or aban-don a particular strategy? The goal of the presenta-tion is to outline participants' incentives and institutional factors, such as the tenure system, liability rules, and the market influencing those incentives.

**Levels of Analysis in Integrated Pest Management Research**. Daniel G. McDonald, Carroll J. Glynn, Michael Hoffmann, Curt Petzoldt, 315 Kennedy Hall, Cornell University, Ithaca, NY 14850

The implicit assumption in promoting interdisciplinary research is that information from disparate sources can be combined so that the conclusion of the study is stronger than any which could have been done if the researchers had each done separate studies. The techniques for the Combination of Information (CI) have been developed and applied in many fields, and a number of these have gained prominence in their usefulness in summarizing large bodies of information (e.g., meta-analysis). However, little work has helped

develop or provide application of CI approaches in strengthening interdisciplinary research, where it may be needed most of all.

In addition to being nontraditional, and thus controversial, the use of different levels of analysis may take the researcher into areas in which there is little theoretical or empirical guidance about a particular concept. Even worse, the unit of analysis of data collected by a second scientist may be incompatible with that collected by the first scientist, so that CI cannot be done easily, or may even provide misleading information. In such cases, so-called interdisciplinary research offers little more than a collection of scientists from different disciplines, each doing their own studies. Results of each scientist's efforts then remain within the confines of his or her own discipline and the promise offered by interdisciplinary effort remains largely unfulfilled.

This paper examines the effects which may be obtained in research that attempts to be inter-disciplinary or multidisciplinary in accommodating for various levels of analysis. We examine and describe methodological difficulties and potential solutions for combining information in inter-disciplinary research on Integrated Pest Manage-ment. The paper will describe the types of inform-ation which can be combined, fixed effects and random effects models, similarity judgments, exchangeability, robustness and sensitivity analysis, and the conditions under which interdisciplinary data should not be combined.

The research described herein relies upon data collected through United States Department of Agriculture Hatch Grant (accession #153595). Correspondence should be directed to: Daniel G. McDonald, Department of Communication, 315 Kennedy Hall, Cornell University, Ithaca, NY 14850 (607) 255-2603.

**Efficacy of *Rhinocyllus conicua* Froellch on Seed Reduction in *Carduus nutans* L.** Richard C. McDonald and Aaron O. Robbins, NCDA Plant Industry Division, PO Box 27647, Raleigh, North Carolina 27611

In May of 1993, a total of 1970 flowerhead weevils were released at the Spruill Farm in Franklin County, N.C. The site was characterized as being heavily infested with numerous dense stands of musk thistle. Data were collected from May through July of each year (1993 to 1995). The site was divided into four replicates, based on adequate stands of thistle for sampling. From each replicate, twelve plants were randomly selected and labeled. As flowerheads matured, they were taken from the plant, labeled and placed into envelopes for transport back to the lab. Terminal and the first through fifth lateral flowerheads were sampled. Flowerheads were dissected in the following manner: First, any pappus was removed in order to measure the receptacle diameter; next the outer bracts were cut off with scissors. Using a bone knife, thin slices were made through the receptacle in order to count and record the number of pupal cells and seeds. In 1994 and 1995, seeds were tested for viability using equipment in the NCDA Plant Industry Division's Seed Testing Laboratory. Thistle seeds were placed in a General seed blower, which removed excess debris and light seeds. The remaining seeds were counted again, weighed, and the weight and number was recorded. To determine seed viability, up to 100 seeds were placed in petri dishes on two layers of germination blotter paper. Petri dishes were placed in germination chambers with a photoperiod of 16:8 light:dark hours and alternating day/night temperatures of 25/15 degrees Celsius. Seeds were removed from the petri dish and their numbers were recorded every 48 hours. The mean number of seeds for all flowerhead types was 57.96 in 1994 and 20.90 in 1995 The percentage of viable seeds was 27.13 percent in 1994 and 44.71 percent in 1995. In 1994 the mean number of viable seeds for all flowerhead types was 15.72 and for 1995 it was 9.35 seeds, which is a 40.52-percent reduction in viable seeds per flowerhead. Flower-heads which are not infested with *R. conicus* have an average of 1,000 seeds per terminal and 850 seeds in the laterals with an average viability of 69 percent (Rees 1982). The weevils have brought the

average number of viable seeds down from 607.2 (69 percent of average uninfested lowerheads) to 9.35 seeds, which is a 98.46-percent reduction The absolute thistle plant count for 1993, 1994 and 1995 was 3,284, 1,504 and 5,885 respectively. The average number of pupal cells for all flowerhead types combined was 6.23 in l 993 9.35 in 1994 and 21.20 in 1995. This is an increase of 340.29 percent in weevil numbers over a three-year period.

**Further Development of an IPM Program for Powdery Mildew of Cucurbits**. Margaret Tuttle McGrath, Department of Plant Pathology, Long Island Horticultural Research Laboratory, Cornell University, 3059 Sound Avenue, Riverhead, NY 11901-1098

Research conducted in 1994 and 1995 provided information to improve the IPM program presented at the Second National IPM Symposium/Work-shop. Host resistance is becoming more important for IPM programs. Resistant cucumber and melon varieties are commercially available. Recently developed resistant yellow summer squash varieties yielded as well as fungicide-treated susceptible varieties and had the early yielding ability that other resistant varieties lacked. Genetic control was more effective than chemical control for suppressing mildew on under leaf surfaces. Maximum yield was obtained with chemical plus genetic controls. Economic benefits of genetic and chemical controls were documented. Fungicide resistance is a challenge to chemical control especially since the pathogen population can change drastically over a short time. Between 1991 and 1995, the proportion of fungicide-resistant isolates detected before treatment shifted from zero to the majority for triadimefon and vice versa for benomyl. Consequently, triadimefon, the main fungicide currently used in the United States for cucurbit powdery mildew, has become less effective while benomyl has regained its efficacy. Chemical control recommendations are to start treatment after disease detection (examine both surfaces of 50 old leaves), apply both protectant and systemic fungicides (never apply systemics alone), and maximize spray coverage on under leaf surfaces. Based on fungicide resistance data, apply benomyl first and triadimefon subsequently to a crop. Additional disease suppression may be achieved with more than 1 application of benomyl but probably not with triadimefon. Reduced-sprays IPM programs were effective. In summer squash, 4 weekly sprays after disease detection during the first half of the harvest period protected yield as well as full-season IPM programs with 6 to 7 sprays. Biocompatible fungicides have not yet found their niche in IPM programs. Neither AQ-10 (antagonistic fungus), Kaligreen (potassium bicarbonate), nor JMS Stylet-Oil applied every 7 days beginning after disease detection adequately suppressed mildew or protected yield when disease pressure was high. Biocompatible fungicides may be sufficiently effective when used at higher rates, applied more frequently, and/or used in a program with conventional fungicides. Frequent scouting for other diseases is needed because these materials are only effective against powdery mildew.

**Certifying Professionals in the Crop Consulting Industry.** W.M. McLawhorn, Jr. and R.E. Etheridge, Jr., McLawhorn Crop Services, Inc., P.O. Box 370, Cove City, NC 28523

In recent years, interest in certification programs in agriculture has been increasing rapidly. Officials in government, as well as the general public, want assurance that those recommending and applying pesticides have adequate training and education to do so in a responsible manner. Historically, certification programs for agriculturalists have been oriented to very specific disciplines. The more established of these programs have focused on education and experience with a continuing education requirement, but have been so discipline specific, they often best served only the needs of those in academia. The past twenty years or so has been a time of rapid advances in technology with some pretty dramatic changes down on the farm. New species-specific pesticides that require intensive scouting programs for proper management have allowed IPM principles to be adopted on a wide range of situations, and genetically engineered crops and precision agricultural systems will soon

require more intensive management than any changes we have seen yet. The need for more intensive management has caused the young profession of crop consulting to explode. There has never been greater demand for well trained crop production specialists with educational backgrounds in fields ranging from microbiology to agronomy to entomology. Most of these specialists or crop consultants integrate a great number of disciplines into their daily routine, including soil science, agronomy, entomology, plant pathology, weed science, meteorology, etc. The unique needs of this group of professionals led the National Alliance of Independent Crop Consultants to develop the CPCC, or Certified Professional Crop Consultant, and the CPCC-I designation for the Certified Professional Crop Consultant-Independent. This program meets or exceeds the other major programs' requirements in terms of education, experience, continuing education, and adherence to a code of ethics. Further, the CPCC-I is the only designation which certifies independence from product sales. Perhaps most importantly, these are the only programs requiring the applicant to solve a case study essay dealing with specific situations encountered in the field, and thereby demonstrating an ability to integrate various disciplines in the process.

**Susceptibility of Adult Western Corn Rootworm Populations to Three Insecticides Used in Nebraska Field Corn.** Lance J. Meinke, Blair D. Siegfried, Robert J. Wright, Department of Entomology, University of Nebraska, Lincoln, NE 68583; Laurence D. Chandler, USDA-ARS, Northern Grains Insects Research Lab, Rt. 3, Brookings, SD 57006

Bioassays were conducted to estimate the susceptibility of adult western corn rootworm, *Diabrotica virgifera virgifera* LeConte, populations to technical grade methyl parathion, carbaryl, and bifenthrin. Beetles were collected from 26 July-24 August 1995 from 16 sites in Nebraska. Sites were selected from major corn production areas, from low vs. high insecticide use areas, and where control problems had occurred. Collections were made before any insecticide had
been applied and after a significant amount of emergence had occurred. Bioassays were con-ducted from 1 August-1 September, beetles were randomly selected from each colony and insect-icide dilutions in acetone were applied topically to each beetle. Each bioassay per colony consisted of five serial dilutions per insecticide plus an acetone control, replicated four times; this procedure was repeated on two different days. Methyl parathion, carbaryl, and bifenthrin $LD_{50}$ ranged from 0.46-7.83 ng/mg, 7.40-69.77 ng/mg, and 0.248-0.868 ng/mg, respectively (N = 400 beetles / $LD_{50}$). The maximum methyl parathion $LD_{50}$ and LD resistance ratios were 17 and 21.4 respectively. Maximum carbaryl $LD_{50}$ and $LD_{90}$ resistance ratios were 9.28 and 52.39 respectively. The maximum bifenthrin $LD_{50}$ resistance ratio was only 3.5 although five populations has $LD_{90}$ resistance ratios ranging from 4.7-9.5. The highest methyl parathion and carbaryl $LD_{50}$ and $LD_{90}$, values were from the same populations in Phelps and York counties and correlate well with reports of unsatisfactory control with formulated organophosphate or carbamate products in these counties during 1994 or 1995. Carbamate and organophosphate insecticides have been used for beetle control in Phelps County for over 20 years. Bioassay data, historical insecticide use patterns and associated selection pressure, and field reports of unsatisfactory control in some locations collectively indicate that adult western corn rootworm resistance has developed to methyl parathion and/or carbaryl in areas of Nebraska.

**Management and Dispersal of *Thrips palmi* in Florida.** H. Charles Mellinger, Galen Frantz, and Felicia Parks, Glades Crop Care, Inc., 949 Turner Quay, Jupiter, Florida 33458

Our involvement with the melon thrips, *Thrips palmi*, exemplifies the role of consultants in dealing with pest movement and dispersal. During routine scouting activities, Glades Crop Care, Inc. (GCC) personnel discovered this pest in Puerto Rico (1986) and in Florida (1990) These discoveries were the first recorded finds in the western hemisphere and

continental U. S. respectively. We reported to and cooperated closely with State and Federal agencies (FDACS and USDA) responsible for this quarantinable pest. Following the 1986 discovery, GCC developed IPM tactics which are still the cornerstone of today's control efforts. Considering the magnitude of crop damage and economic loss this pest has caused worldwide, GCC established three goals to keep our clients up to date on further *Thrips palmi* spread and its threat to their crops:

1. Increase alertness for *Thrips palmi* in our ongoing thrips monitoring program. This involves routine bloom and growing point collections from thrips-susceptible crops for thrips speciation. Field scouts are also trained to make tentative field characteristic-based identification.
2. Increase our knowledge of *Thrips palmi's* host range. We routinely survey weed hosts in and around infested areas.
3. Evaluate seasonal population trends.

The pest is now of major economic importance and endemic in south Florida. In pursuing our goals we have identified factors that decrease the likelihood of thrips injury. These include pesticide choice and use patterns; conservation of predators, such as minute pirate bug; conservation of less damaging thrips species, which compete with *Thrips palmi*; and timing of cultural practices, such as field sanitation and crop destruction.

**Integrated Biological Control of Strawberry Botrytis in the Annual Hill Culture of Chandler Strawberry**. R. Walker Miller, Professor and Extension Plant Pathologist, and Mike Hood, Extension Apiculturist, Dept. of Plant Pathology and Physiology, 206 Long Hall, Clemson University, Clemson SC 29634-0377

Sutton et al. demonstrated that *Gliocladium roseum* provided adequate control of grey mold (*Botrytis cinerea*) in matted row culture of strawberries in Canada. The biocontrol agent was applied both as inundative sprays and using honey bees to vector the biocontrol agent to the flower. Previous work had shown that primary inoculum for flower infection comes from senescing leaves that become infected alter planting during the fall or winter. Fungicides applied to either prevent or suppress Botryris sporulation were effective in reducing initial inoculum and resulted in less disease. The objective of this work was to produce Chandler strawberries in the annual hill culture system without putting fungicide on fruit by integrating fall/winter sprays to reduce initial inoculum and vectoring the biocontrol agent to the blooms by honey bees.

Three matched pairs of growers were selected in 1992-93 and six matched pairs of growers were selected in 1994-95. Each matched pair represented a replication. In a single blind study, each site received 4 treatments with one of the two matched pairs receiving the biocontrol agent and the other a blank talc. Gliocladium roseum was isolated from all fields in both tests, and the isolate from a specific site was used as the biocontrol agent for that site. Sutton determined that all 16 G. roseum isolates collected for the first test were equally effective against Botrytis. Four treatments were no fungicide sprays, fall/winter fungicide sprays, fall/winter and normal spring sprays, and spring fungicide sprays only (grower standard). In the first experiment, disease pressure was very light and no differences between treatments were observed. Observations during this test indicated that the growers did not suppress initial inoculum, that bees did not appear to work the flowers, the inoculum dispensers did not work as well as hoped, and loss of data made analysis difficult. Disease pressure was better in the second lest with significant differences between treatments and times of observation but no differences with respect to the use of the biocontrol agent. Bees do not appear to be effective vectors of G. roseum in Chandler annual hill culture. A case study is in progress using bumblebees as vectors of the biocontrol agent.

**Biological and Ecological Basis for Managing Arthropod Populations by Augmentation of Parasitoids and Predators.** Juan A. Morales-Ramos, Research Entomologist, USDA-ARS Biological Control of Pests Research

Unit, 2413 East Highway 83, Weslaco, Texas 78596

Ecological and biological interactions among the host plant, arthropod pest and its natural enemies are highly complex. Understanding such interactions requires many years of expensive field research. An alternative to such an expensive and time consuming solution is the use of simulation models. With basic knowledge on the reproductive and developmental biology and the behavior of the arthropod pest, its natural enemies, and the host plant, a simulation model can be developed. Such a model can be used to simulate interactions among environmental factors allowing a greater understanding of this complex system. The knowledge obtained in this manner can be applied to dictate strategies on the use of the natural enemies against the target pest. An example is presented on the use of simulation models to release *Catolaccus grandis* in an augmentation program against the boll weevil, *Anthonomus grandis*.

**Landscape Ecology as a New Framework for Improved Management of the Health of Agroecosystems.** Merrin R. Nelson, Department of Plant Pathology, University of Arizona, Tucson, AZ 85721, and John M. Barnes, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Washington, DC 20250-2220

Recurring patterns of crop damage due to biotic agents are common on a regional scale. Crop protection and systems science specialists are collaborating on an improved understanding of such patterns with respect to how this understanding may be exploited in the design of improved agroecosystem management programs. Geo-statistics, geographic information systems (GIS), and global positioning systems are rapidly expanding tools that comprise the core of emerging new information processing and analysis technologies. Previous studies on plant pest and disease severity and risk assessment have largely been at within- field scales. The spatial characteristics of plant disease and certain insect pest population dynamics can be studied on any scale, including regional, with the advent of the above technologies. Collaborative studies on the occurrence and spread of tomato virus diseases involving University of Arizona, Mexican and Campbell Corporation scientists in the Del Fuerte Valley of Mexico, focused on a diverse group of viral pathogens. These viruses, except for tobacco mosaic virus, are of a general ecological type characterized by a dynamic aerial insect vector with multiple sources of virus for infection in a climate in which alternate hosts of both virus and vector exist year round. Because of these similarities, a risk assessment process was developed based on general (or landscape scale) virus infection hazards rather than specific viruses. The risk assessment helped to focus on actions that could be taken both locally and regionally to reduce early and damaging infections. Risk assessment and virus disease- incidence data were collected from selected fields in two separate study areas during two production seasons. Geostatistical analysis of risk and incidence showed that both were spatially dependent variables with a variogram range of 20 to 25 km. There appeared to be contrasts in underlying landscape features between two study areas which made one area more conducive to epidemics of plant virus diseases than the other.

**Comparison of Simulated and Actual Flea Beetle Injury to Water-stressed Oilseed Rape**. Timothy M. Nowatzki & Michael J. Weiss, Department of Entomology, North Dakota State University, Fargo, ND 58105

The crucifer flea beetle, *Phyllotreta cruciferae* (Goeze), is the principal pest of seedling oilseed rape, *Brassica napus* (L.). in the Northern Great Plains when the weather is hot and dry. Crop resistance may be a viable management alternative to chemical control, and identification of an accurate simulated injury technique would improve the resistance screening procedure. This study compared a technique for simulating flea beetle injury to actual flea beetle injury on oilseed rape seedlings grown at three soil moistures. Simulated injury was applied to the cotyledons with a 0.5 mm mechanical pencil and

actual injury was obtained by placing seedlings in a chamber with 500 flea beetles for 12 hours. The fresh weight of the seed-lings was measured after seven days of growth. The actual injury reduced the fresh weight more than the simulated injury did at all soil moisture and injury levels tested. There was a curvilinear reduction in growth due to the simulated injury, while the reduction in growth after actual injury was linear. Without the incorporation of a correction factor, the simulated injury technique was not an accurate tool for screening lines of oilseed rape for flea beetle resistance.

**Demonstration of IPM in Jordan Valley Greenhouses**. Ronald Oetting, Bassam Al-Edwan, Nadi Farraj, Yaacov Hameiri, Abdullah Madi, Yigal Magrill, Ghassam Zuhod, Dennis Kopp. Address correspondence to: D. Kopp, USDA/CSREES, Ag. Box 2220,Washington DC 20250-2220

This multi-national Integrated Pest Management (IPM) program is a cooperative effort by research, extension, and private sector scientists in Israel, Jordan and Palestine. Study, demonstration, and scout training sites are located in each country. The initiation and facilitation of this project arose from a joint effort by the U.S. State Department through the USDA/Foreign Agricultural Service in conjunction with the Ministries of Agriculture and experts from each participating country. The goal of this project is to enhance IPM implementation in greenhouse production systems throughout the Jordan Valley, north of the Dead Sea, and to reduce health risks related to pesticide usage. The whitefly, *Bemisia* sp., is the pest which has accounted for a major increase in pest management inputs in greenhouse tomato production. A scout training component of this project and a pesticide resistance monitoring program has already been initiated. Under development is a communication network and producer information delivery programs.

**Commodity Groups Ally to Spur Expansion of IPM Programs at Michigan State University**. Larry G. Olsen, IPM Coordinator, Charles E. Edson, Fruit and Vegetable IPM Program Leader, and Joy Neumann Landis, IPM Communications and Publications Associate, 11 Agriculture Hall, Michigan State University, East Lansing, MI 48824

Historically, Michigan State University (MSU) has been a leader in developing and implementing IPM programs. Both extension and research programs have been considered models for the rest of the nation. These efforts contributed to grower success in reducing pesticide use during the decade of the 1980's. However, due largely to cutbacks in Federal funding, MSU lost some momentum during the last decade. While individual researchers and extension personnel continued to address specific critical pest management issues, a coordinated statewide program did not exist.

A consortium of fruit and vegetable commodity groups and processing firms, the Michigan Department of Agriculture, and MSU formed the Michigan IPM Alliance in 1994. The Alliance pledged over $65,000 annually for three years to help spur expansion of IPM efforts at MSU. This pro-active industry response to pesticide issues has strengthened the partnership between industry and MSU and has helped to provide a framework to enhance IPM education and implementation in Michigan. Given Michigan's many minor crops, it is important for commodity groups to band together to deal with critical pesticide and pest management issues.

Recent program expansion includes: a new Statewide IPM Coordinator, a Fruit and Vegetable IPM Program Leader, and an IPM Communications and Publications Associate; $50,000 to fund ten IPM implementation projects; over $133,000 in additional funding for IPM research and education in 1995; increased activity for the MSU IPM Task Force; an assessment of grower IPM needs in Michigan; and increased interaction between MSU scientists, field staff and industry. The Alliance also helped develop an industry-driven legislative proposal to raise over $8 million to support plant-based agriculture in Michigan. If funded, the proposal will include significant support for IPM and food production programs.

**Private Efforts Help Develop and Deliver Integrated Potato Management Services in Michigan.** Mark A. Otto, Agri-Business Consultants, Inc. 2720 Alpha Acess, Lansing, MI 48910-3608, and Ben Kudwa, Michigan Potato Industry Commission, 13109 Shavey Rd., DeWitt, MI 48820

As potato production systems have become more complex, the need for technical services among potato growers has increased. Public sector efforts have not been able to meet the demand, but private consultants are responding to the opportunities. Agri-Business Consultants, Inc. aims to bring science and service to their clients. Growers adopt IPM research because they profit from it and protect the environment at the same time. We continually work to adapt new technology and integrate it into our clients' management systems. We have tested variety response to chemigation and identified relative varietal tolerance to the potato early dying complex. This has allowed us to reduce the amount of chemigation. We helped develop Colorado potato beetle insecticide resistance test kits and used them widely to improve our ability to select the most appropriate insecticide. Late blight genotype analysis now helps us decide on fungicide use as well. Grower organizations should be looked to for more than just funding research. The Michigan Potato Industry Commission's (MPIC) research committee does an excellent job of communicating industry needs to scientists, regulators and policymakers. MSU hired a visiting professor to work on late blight when the MPIC agreed to backstop the funding. It has been instrumental in convincing growers to respond to pesticide use surveys that have been used to support Section 18 requests.

**Adoption of Pest Control Practices in U.S. Agriculture.** Merritt Padgitt, David Shank, Economic Research Service, 1301 New York Ave., N.W., Washington, DC 20005

The USDA Cropping Practices Survey provides data about several weed management practices and other production characteristics along with measures of herbicide use. Estimates from this survey provide an indication of how strategies targeted to specific kinds of weed management practices may or may not affect the intensity of herbicide treatments. Nearly all corn, soybean, and cotton acreage receive some form of herbicide treatments whether measured as acre-treatments or total pounds of all active ingredients applied per acre, the totals applied do not differ greatly across most production practices or characteristics analyzed. Land with field cultivations had fewer herbicide acre-treatments for corn and soybeans, but more acre-treatments occurred for cotton. Land using no-till systems had more herbicide acre-treatments than land using moldboard plowing and other conventional tillage systems. Previous crops, including winter cover crops on corn and double-cropped soybeans with wheat, had minimal effect on the number of herbicide acre-treatments. Continuous cotton received more acre-treatments than cotton grown in rotation with other crops. Land that was scouted for any type of pest tended to have more herbicide acre-treatments than land not scouted. Little difference occurred in the number of herbicide acre-treatments between land by erodibility, ownership, or farm program participation categories. For corn and soybeans, the more humid States of Ohio, Indiana, and Illinois, applied larger quantities of herbicides than States to the north and west. For cotton, the quantity of herbicide applied per acre in Arkansas, Louisiana, and Mississippi were double the quantities applied in Texas, Arizona, and California.

**Founding of a Non-profit Weather Association to Support a Network of Weather Monitoring Equipment**. Curtis H. Petzoldt, T. Weigle, J. Gibbons, C. TenEyck, New York State IPM Program, NYSAES, Geneva, NY 14456

The New York State IPM Program is establishing an affiliated non-profit Weather Association that will ensure the continuity of a growing weather and pest information network. The network has developed over the last 6 years as an informal cooperative venture among several private and

public organizations and individuals. The network now includes electronic access to weather instruments at over 20 sites and is rapidly expanding through purchases of instruments by growers, processors, and private consultants. Information on the network includes weather data, pest forecasts, and pest information. The Weather Association will be a membership organization that will collect user fees to ensure the continuation of these services. It will operate across a broad spectrum of crop and commodity groups including grapes, apples, onions, potatoes, processed vegetables, and field crops. It will have a Board of Directors and an Advisory Committee operating in partnership with the IPM Program to make policy decisions including setting fees, determining locations for instruments and computer servers, and applying for grants. The Weather Association will be responsible for the employment of at least one full-time person and possibly several part-time individuals, will pay for phone connections to the weather instruments, will purchase new equipment, and update old equipment and software.

**Implementation of a Complete Mating Disruption Program for Oriental Fruit Moth and Peach Twig Borer in Cling Peaches.** Carolyn Pickel, Area IPM Advisor, Sacramento Valley, Janine Hasey, Farm Advisor, UC Cooperative Extension, 142-A Garden Hwy, Yuba City, CA 95991 and Bill Olson, Farm Advisor, UC Cooperative Extension, 2270-B Del Oro Ave, Oroville, CA 95965

There are two key insect pests, Oriental fruit moth (OFM) and peach twig borer (OB), in the cling peach orchard system. Commercial products for controlling OFM with pheromone confusion have been available since 1989. About 20 percent of growers have been using OFM pheromone for control. However, the mating disruption program has not expanded past the initial growers, using mating disruption. In 1995, the first commercial PTB product for pheromone confusion became available. The goal of this project is to introduce mating disruption to new growers and to demonstrate a complete mating disruption program to expand adoption resulting in a 90 percent reduction of insecticides. In the first year of the project, there were 16 cooperators representing 155 acres with 10 in Sutter/Yuba and 6 in Butte Counties. Two teams worked on the project. The Demonstration Team consisted of grower cooperators a UCIPM area advisor, farm advisors, researchers, IPM field assistants and pheromone suppliers. The Support Team consisted of the Cling Peach Advisory Board, Canning Peach Association, and processors. This team worked to get an EPA-Partnership Education Grant to expand the program in 1996. Eleven of the growers completed the season without sprays. Four growers with high populations had to spray one time before harvest. None of the growers had damage at harvest. However, the direct costs of this program, including materials and applications is considerably higher, averaging $75-100 more per acre than a conventional spray program. The EPA-Partnership grant will be used to offset the costs giving growers the chance to test the practice while learning about the benefits.

**Effects of Lambda-Cyhalothrin on Natural Enemies of Rice Insect Pests.** E. D. Pilling and F. J. Lewis[2], [1]ZENECA Agrochemicals, Jealott's Hill Research Station, Berkshire, UK, [2]ZENECA Ag Products, 1800 Concord Pike, Wilmington, DE 19897

The effects of lambda-cyhalothrin applications on natural enemies of rice insect pests were investigated during the wet season of 1994 in central Luzon, Philippines. The primary objective of the stud was to evaluate the potential for using lambda cyhalothrin within integrated pest management (IPM) programs in paddy-rice systems. Three application input regimes were studied: low (mid and late season sprays at 6.25 g ai/ha), medium (early, mid and late season sprays at 6.25 g ai/ha) and high (early, mid and late season sprays at 6.25, 9.0 and 12.5 g ai/ha, respectively). Assessments were made on large plots (>l000$m^2$) for conservation of natural enemy populations, degree of pest control, cost effectiveness and yield production. In general, applications of

lambda-cyhalothrin resulted in a limited reduction in the total number of natural enemy populations immediately after treatment. Population densities however started recovering between 7 and 14 days post-treatment and were estimated to completely recover to control levels after 28 days. Of the 40 plus beneficial species identified during the study, 5 groups were obviously important in terms of abundance; spiders, damselflies, ladybeetles, parasitoids and the remaining beneficial species placed in an additional group termed other natural enemies. In all lambda-cyhalothrin treated plots, the predator to pest ratio remained similar to control plots, there by maintaining beneficial capacity. Treatments had very little effect on the relative proportion of the five natural enemy groups and on individual species composition throughout the season. Applications of lambda-cyhalothrin provided good pest control with no hopper resurgence, and significantly increased yield production above the control proving to be highly cost-effective. On a cost-benefit analysis, the small investment in lambda-cyhalothrin provided substantial return to the farmer, and insurance against crop failure from pest damage. It is concluded that lambda-cyhalothrin can be used within an IPM program in rice agriculture, provided farmers are made fully aware of correct use patterns for maximum economic benefits and minimum environmental impact.

**Potential Herbicide Savings Using a Light-Activated Sprayer.** Timothy S. Prather, UCCE Statewide IPM Project, Kearney Agricultural Center, 9240 S Riverbend Ave. Parlier, CA 93648

Postemergent herbicide applications target weeds but often spray large areas that are not occupied by weeds. Sprayers that are activated by light wavelengths reflected from chlorophyll should increase the efficiency of herbicide application. A light-activated sprayer was tested for efficiency by placing live plant material on a fabric grid to obtain plant cover of 5, 10, 20, 40, 60, 80, and 100 percent. Two field studies were conducted to contrast the amount of herbicide used by the light-activated sprayer and a grower's cotton row crop sprayer. Spraying under controlled conditions demonstrated herbicide use reductions of 85 percent with the light-activated sprayer operating over a plant cover of 5 percent versus 100 percent plant cover (100 percent cover equaling a broadcast application). Spraying of furrows under field conditions resulted in a 78 percent reduction with the light-activated sprayer when contrasted to a broadcast application and a 60 percent reduction when compared to a manual spot-treatment application.

**World-Wide-Web Interactive Text For Teaching IPM: a Resource For Students. Educators, Consultants And Growers**. Edward B. Radcliffe and William D. Hutchison, Department of Entomology, University of Minnesota, St. Paul, MN 55108

We have initiated development of a new IPM text for the World Wide Web (WWW) that we believe will become an exciting new comprehensive tool for teaching IPM worldwide. This project is co-sponsored by The Consortium for International Crop Protection (CICP) and the National IPM Network (NIPMN). To date, more than 100 nationally and internationally recognized experts have agreed to prepare lectures on various aspects of IPM. Although the current emphasis is with insect and mite pests, we are presently soliciting new contributions from weed scientists, plant pathologists and nematologists. Our purpose is to provide: (1) a venue for easily maintaining up-to-date lectures ("chapters") on all major IPM principles (e.g., sampling, economic injury levels) and applications (e.g., commodities, urban IPM, etc.), (2) student access to an international network of IPM experts, (3) the ability to provide one resource for all possible topics in IPM (i.e., no limits on number of chapters), (4) inexpensive ability to enhance lectures with color photographs, video, sound, down-loading of decision-aid software, (5) an interactive discussion-group forum to facilitate interaction among students, teachers and authors of selected chapters, (6) convenient access to other useful WWW links about IPM, and (7) a resource to facilitate long-distance delivery of IPM courses. Our

goal, by the end of 1996, is to have over 200 lectures posted, including all pest disciplines. Discussions have been initiated to obtain continuing education credits (CEC) for agricultural consultants. More information about this site can be found at "Ted Radcliffe's Gopher State IPM Site", URL: <http://www.ent.agri.umn.
edu/academics/classes/ipm/ipmsite.htm>.

**IPM on the World Wide Web: the National IPM Network - Southern Regional Server**. F. William Ravlin, Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061
[http://ipm_www.ento.vt.edu: 8000/nipmn/]

The transfer of information from the researcher to the end-user is vital in facilitating the adoption of any new technology. World Wide Web (WWW sites on the Internet have rapidly become an important information tool for a wide variety of topics. This increased popularity results from a number of factors: the software to access the information on WWW sites is essentially free to non-commercial users, the software's interface makes the transfer of text and graphic information "user-friendly" and simple, and access to the
Internet through commercial providers is becoming easier and less expensive. Commercial interests are taking advantage of the WWW for a number of purposes but are motivated by economics; WWW is an inexpensive and effective way of reaching a widely distributed body of consumers. In addition, WWW sites are easily developed and rapidly modified. The increased popularity of the WWW presents an opportunity to provide information on Integrated Pest Management techniques to a wide audience of end users at a minimal cost.

The National Integrated Pest Management Network (NIPMN) has established a system of regional servers containing IPM information and resources. These sites also provide real-time weather data, market reports, and pest alerts; the most recent pesticide label information; and numerous other types of IPM-related data. In addition, they will incorporate interactive resources such as keys to pest species and expert systems for identification and decision support.

Demonstrations of the resources available on these servers will be provided and future resources and potential uses discussed. An assessment of the economic advantages provided through electronic publication of extension materials will be presented.

**Cooling as the Basis for Stored-grain IPM.** Carl Reed & Tim Herman, Department of Grain Science and Industry, Kansas State University, Manhattan, KS 66506-2201

In 1994, demonstrations were established on farms in 16 Kansas counties to show how an inexpensive aeration controller helps the storage manager control insects in wheat by controlling the environment within the grain mass. In each county, a local team (county Extension agent, the farmer, an elevator manager, and the FSA director) monitored the progress of the trial through the storage season. University specialists collected technical data including indices of insect
populations in the demonstration wheat and in a comparison bin. The results were summarized and extended to neighbors the following spring. Average grain temperatures were reduced about 10°C within two weeks of harvest (July), and to below 10°C by November 1. In September, pitfall traps placed in demonstration wheat captured about one-fifth as many insects as traps placed in comparison grain, some of which was treated with residue-producing insecticides. Extension materials describing the use of sanitation, aeration, and monitoring (SAM) as an IPM approach support the ongoing efforts of University workers and local teams to promote the substitution of IPM techniques for scheduled applications of insecticides in Kansas stored grain.

**Presentation of The Dutch Pesticide Yardstick.** Dr. Joost Reus, Centre for Agriculture and the Environment P.O. Box 10015, 3505 AA Utrecht, The Netherlands, Mark Ritchie, President, Institute for Agriculture and Trade Policy, 1313 Fifth Street SE, Suite 303, Minneapolis. MN 55414 [(612) 379-5980, fax (612) 379-5982, iatp@iatp.org]

The Centre for Agriculture and the Environment (CLM) in the Netherlands developed an important and effective new farm management tool, the "yardstick," which farmers all over Holland, and now in France and England, are using to voluntarily reduce the pesticide impact on the environment. Yardsticks are a simple and extremely effective way for farmers to assess the environmental impacts of their current farming practices. They can be used to reduce impacts in relatively easy and straightforward ways. Here is how they work: Farmers keep records of their pesticide application practices, including the kinds of chemicals used, the amount of applications, methods of application, soil type etc. Each factor is given a numerical score which signifies the estimated negative impact on the environment. At the end of each growing season, farmers add up their total scores for a numerical representation of their impact. They then have a "baseline" to begin planning for their next crop season. Using this information, farmers can make specific changes in their farming practices which can reduce their overall score. For example, mechanical weed control (tillage) can sharply reduce the overall impact and thereby lower (improve) a farmer's "score." In the Netherlands, this system has been in place for over four years, with remarkable results. Farmers have been averaging a 10 percent reduction in score each year, with some achieving as high as 70 percent reductions. This progress has not gone unnoticed. For example, water companies who supply drinking water to towns and cities have begun to pay farmers a bonus for reductions in their "scores." The Institute for Agriculture and Trade Policy is working with CLM to adapt the pesticide yardstick to U.S. farming conditions.

**Translating Vision Into Action:**
**A Massachusetts Case Study in the Promotion of Integrated Pest Management**. Iliana Rivas-Picon, Environmental Analyst, Massachusetts Department of Food and Agriculture, 100 Cambridge Street, Boston, MA 02202

At a time when downsizing has become the norm, governmental agencies are under increased pressure to demonstrate a capacity for leadership, vision, and innovation in order to adapt to current conditions and fulfill their public mission. Key to these efforts is an organizations ability to build on existing infrastructures, foster alliances, and provide the flexibility required to meet rapidly changing needs. A case in point is the Massachusetts Department of Food and Agriculture's (MDFA) demonstrated commitment toward enhancing the knowledge and practice of Integrated Pest Management (IPM) within the State.

To this end, the MDFA relies on a consensus-driven approach as part of its decision-making process accounting for the specialized leadership of affected parties. Focus groups and advisory committees are examples of this participatory drive. Additionally, an in-house strategy comprised of both educational and marketing principles serves to complement IPM-related initiatives. Components of this dual strategy include the development of a communications plan involving media events, the publication of educational and promotional materials including how-to kits and posters, as well as the use of Geographic Information Systems (GIS) mapping technology. This collaborative approach and use of selected tools aim to complement and advance statewide IPM efforts.

This poster provides a visual presentation of these various initiatives, including detailed information on the State's unique IPM grower-certification program. IPM efforts within less traditional, urban settings are also examined. Additionally; this visual case study walks the reader through a number of educational and promotional tools. In so doing, this poster presentation provides a view into the world of one State government agency and its approach at translating vision into action for the advancement of Integrated Pest Management.

**Working Smarter on the Land to Restore the Chesapeake Bay**. Lorie S. Roeser, U.S. Environmental Protection Agency, Region III, Chesapeake Bay Program, Annapolis City Marina, 410 Severn Avenue, Annapolis, Maryland 21403, with contributors from Land Grant Universities, and

State and District of Columbia agencies within the Chesapeake Bay basin

The Chesapeake Bay Program is a partnership of governments, citizens, and businesses directing the restoration of the Bay. Leading the program are the signatories to the 1983 and 1987 Chesapeake Bay Agreements: U.S. Environmental Protection Agency, Pennsylvania, Maryland, Virginia, Washington, DC and Chesapeake Bay Commission (a tri-state legislative body). In 1994 the signatories committed to a strategy that will:

- By the year 2000, establish voluntary IPM practices on 75 percent of all agricultural, recreational, and public lands within the Chesapeake Bay Basin.

- By the year 2000, develop and conduct basin-wide education and outreach programs for commercial and household pesticide applicators to promote voluntary IPM practices on 50 percent of the commercial land and 25 percent of the residential land within the Chesapeake Bay basin.

Working together, the State, Federal and District of Columbia partners, with some funding available form the U.S. Environmental Protection Agency are contributing to the IPM program enhancements to accomplish the objectives of the strategy.

**Biological Pesticides And IPM**. Robert I. Rose, Frank W. Ellis, Jr., Gail S. Tomimatsu, William R. Schneider, Cindy R. Schaffer and J. Thomas McClintock, U.S. Environmental Protection Agency, Office of Pesticide Programs, Biopesticides and Pollution Prevention Division (7501W), 401 M Street, SW, Washington, DC 20460

The U.S. Environmental Protection Agency (EPA) realized the unique characteristics of biological pesticides for IPM more than 15 years ago. Subsequently, EPA published Subdivision M of the Pesticide Testing Guidelines for Microbial and Biochemical Pest Control Agents in 1982 and 1989 to facilitate their registration. This approach has allowed expeditious registration of over 50 microbial pesticides, such as *Bacillus thuringiensis*-based products, and more than 40 biochemical pesticides including pheromones, plant growth regulators, attractants and repellents. Biologically-based pesticides currently registered by the EPA and their use in IPM are presented.

**Modeling the Supply Response of Perennial Fruits to Loss of Pesticide Alternatives**. Susan G. Rozanski and Scott M. Swinton, Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1039

Producers of "minor use crops" such as tree fruits are particularly susceptible to decreased pesticide availability due to manufacturer withdrawal of chemical compounds due to regulatory pressures from the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Delaney Clause of the Federal Food, Drug and Cosmetic Act and natural pest resistance. Elimination of pesticide alternatives through regulatory and natural causes could seriously impair the efficacy of pesticide-based conventional and integrated pest management strategies for minor use crops after FIFRA reregistration must be completed in 1997.

Fewer and costlier pest management alternatives will reduce the supply of minor use horticultural crops at any given price and quality level. This research estimates the likely supply and price effects of losing selected pesticide alternatives in apple and tart cherry. Our study explicitly models perennial fruit supply over time using a dynamic recursive programming-econometric model. This framework can be used to predict changes in aggregate and regional supply of tart cherry and apple due to pesticide policies. Changes in pest management practices and the resulting implications for fruit yields, proportion of fruit allocated among fresh and processed markets, crop prices, and farmer profitability can also be examined with this model.

The hybrid mathematical programming-econometric approach explicitly incorporates viable alternative crops and several pest management

strategies for each crop. It permits production and input substitutions in response to pesticide availability and associated expected net returns. Interregional and intra-regional effects of pesticide policies can also be investigated through the use of heterogeneous representative farms in the programming model. This framework also addresses the effect of pesticide policies on fruit quality by allowing the proportion of fruit allocated to fresh versus processed markets to vary by pest management strategy. Apart from the economics of supply response, the model can also be used to track chemical emissions into the environment by using pesticide accounting rows in the mathematical programming model.

**Site-Specific Weather Forecasts For IPM Decisions**. Joseph M. Russo, SkyBit. Inc., P.O. Box 10, Boalsburg, PA 16827-0010

Integrated pest management (IPM) programs are increasingly relying upon pest models and expert systems to support decision making in the field. An important component for the success of such models and systems is the availability of timely and reliable weather data. Today, weather data are available in many forms and for many periods. From text to images and from climatology to outlooks, data reveal historical, present, and future trends and extremes of weather variables. Most important of these forms and periods are weather forecasts serving as numerical input into IPM models and expert systems. The inclusion of forecasts into models and systems gives managers and other decision makers lead time for planning an action. SkyBit, Inc., a provider of an electronic meteorological service for agriculture, has been a leader in the use of mesoscale analysis and forecasting techniques for the generation of short-term weather predictions. Their Mesoscale Atmospheric Simulation System (MASS), a set of computer programs which ingest and process "raw" weather data from the National Weather Service (NWS), serves as the "engine" for their electronic or E-Weather service. The power of MASS is in its ability to manipulate weather information in much the same way as a trained meteorologist but at a much greater speed and efficiency. MASS is capable of generating site-specific weather forecasts for intervals as short as one hour and for periods as far ahead as two days. Site-specific mesoscale forecasts can be generated for weather variables important to IPM programs. These variables include temperature, precipitation, solar radiation, evaporation, relative humidity, wind speed and direction, cloud cover, and leaf wetness. Besides serving as input into pest models and expert systems, forecast data for these variables can also be employed to compute integrated indices such as for drying and spraying decisions. With their capability of revealing hourly changes in weather patterns at the scale of a farm, and their potential to provide input for numerous IPM programs, mesoscale forecasts are truly ushering in an era of new weather information.

**Resistance to Zimmerman Pine Moth and Marketability of Scotch Pine Christmas Trees in a Choose and Cut Plantation**. Clifford S. Sadof, Department of Entomology, Purdue University, West Lafayette, IN 47907-1158

Zimmerman pine moth bores into Christmas trees and disfigures them by killing the central leader or side branches. Nine varieties of Scotch pine were assessed for their susceptibility to Zimmerman pine moth, and their marketability. Trees were planted in 1986, in a randomized complete block design with 36 trees per plot and 3 replications. Plots were evaluated for insect resistance in August of 1992, 1993, and 1995. Trees were open for sale in 1992, 1993, and 1994. Unsold trees were counted in August of 1995 to compare marketability. Varietial rates of infestation varied between 11 and 75 percent in 1993. Both Belgian and Lake Superior Blue were found to highly resistant to Zimmerman pine moth with < 13 percent of trees infested. Belgian, however, because of its tendency to yellow in the fall, had 54 percent of its trees unsold in 1995. Among the non-yellowing varieties, percentages of unsold trees ranged from 6 to 26 percent. The variety most susceptible to Zimmerman pine moth had 20 percent more trees remaining than the most resistant variety. This study demonstrates

the need for marketability studies when breeding for pest resistance.

**Fostering IPM Adoption in the Marketplace**. Abby J. Seaman, Area Extension Specialist, Cornell Cooperative Extension, 1581 Route 88N, Newark, NY 14513; Curt Petzoldt, Vegetable IPM Coordinator, IPM Support Group, NYSAES, Geneva, NY 14456; Bill Pool, Wegmans Food Markets, 1500 Brooks Ave., Rochester, NY, 14692; and Tom Facer, Comstock Michigan Fruit, Rochester, NY 14602-0670

Wegmans Food Markets, a family owned chain of grocery stores with 47 locations in New York and three in Pennsylvania, has made a corporate decision to encourage growers supplying their fresh "home grown" and store-labeled processed vegetables to adopt IPM practices. In response to a request from Wegmans, a group of Cornell Cooperative Extension field staff and faculty put together a fresh market sweet corn IPM course, which was presented to a group of 12 growers in 1995. The course consisted of three pre-season meetings covering insect, weed, and disease identification and management, cultural practices, nutrient management, post harvest handling, and sprayer setup and calibration among other topics. During the growing season, three in-field meetings provided the opportunity for hands-on scouting, experience with using thresholds for making decisions, and in-field identification of pests and beneficials. A series of split-field demonstrations comparing IPM and grower pest management practices provided a focus for the in-field meetings, and allowed growers to see the results of using IPM practices. Sweet corn from the IPM areas of the demonstration fields was marketed at one Wegmans store under an IPM label. Consumers surveyed in the store responded very favorably to the concept of IPM and the idea of encouraging growers to adopt IPM practices. As a result of this favorable response, Wegmans has expanded the program and initiated a cooperative venture with Comstock Michigan Fruit, the processor supplying their store-labeled processed vegetables. Currently, a series of "Elements of IPM" for six processing and one fresh market crop are being formulated for use next season by Wegmans and Comstock Michigan Fruit, with assistance from the NYS IPM program. The "Elements" enumerate IPM practices for each crop, and include annual goals for adoption of particular practices and a point system for evaluating grower practices to confirm that a minimum level of IPM adoption was met for IPM labeled food.

**Recent Research on the Epidemiology and Management of Apple Scab.** Robert C. Seem, David, M. Gadoury, Arne Stensvand, and Stuart P. Falk Department of Plant Pathology, Cornell University, New York State Agricultural Experiment Station, Geneva, New York 14456

The apple scab pathogen *(Venturia inaequalis)* produces fruiting bodies (pseudothecia) during winter on fallen infected leaves. Management of apple scab has historically centered upon fungicide use to prevent infection by ascospores from these pseudothecia. Our overall objective has been to exploit certain aspects of pathogen biology to better reconcile fungicide use to the risk of infection. For example, a degree-day model of ascospore maturity was combined with simple rainfall- and temperature-based rules to predict ascospore release. This system allows apple growers to obtain daily on-site estimates of ascospore maturity and discharge; in particular it detects the exhaustion of the ascospore supply. The scab warning system was further revised by incorporating the suppression of ascospore release by darkness, and the reduced rate of infection below 6 °C. Even with these and other refinements (e.g., delay of first application in low-inoculum orchards), current fungicide use patterns do not reflect the large changes that occur in tree growth and tissue susceptibility during the growing season. Our most recent research integrates daily changes in target size (tree growth), target susceptibility (leaf and fruit tissue susceptibility to infection), and inoculum dose (ascospore maturity and release) to yield a quantitative estimate of the risk of infection. First-year results demonstrated a near perfect (>98 percent) correlation between the numerical risk of infection and development of apple scab on the cultivar McIntosh. The numerical

risk will eventually be used to adjust the frequency and rate of fungicide use to better reflect the need to suppress infection.

**Integrated Pest Management Workshop: Developing a California Strategy**. Steve Shaffer, Senior Agricultural Biologist, California Department of Food and Agriculture, Office of Pesticide Consultation and Analysis, 1220 N Street, Sacramento, California 95814

A facilitated workshop was held on December 8, 1994 in Sacramento, California, to develop a strategy to support wider adoption of Integrated Pest Management (IPM) in California. The workshop was sponsored by the California Department of Food and Agriculture (CDFA), the California Department of Pesticide Regulation (CDPR), and the University of California Statewide Integrated Pest Management Project (UCIPM).

Over 90 people representing growers and commodity groups (17), agricultural processors (12), agricultural chemical and service providers (17), government agencies (27), educators and researchers (10), and consumer and environmental organizations (7) participated. In facilitated breakout sessions, participants developed strategies on how to improve (1) basic and applied research, (2) technology transfer, (3) delivery of services, (4) the pesticide registration process, and (5) grower acceptance of IPM.

Key recommendations concerning Federal policy development included: (1) The funding allocation formula for Cooperative Extension should be revised in the new Farm Bill. (2) The USDA IR-4 program must be expanded to meet the pesticide registration data requirements to ensure timely registration and reregistration of minor crop/minor use pesticides, and new, safer pesticides. (3) Strategic planning, program development, and resource allocation to support IPM must include strong grower participation. (4) The new Farm Bill should include USDA and USEPA funded programs for real world on-farm demonstrations of IPM technologies and systems. (5) The new Farm Bill should not only continue, but expand, the Consolidated Farm Services Agency SP-53 Program. (6) More efficient means of developing and disseminating information to the grower and crop protection professionals must be supported. (7) Tax incentives must be provided for companies developing new, safer pest management technologies, and for those who use the new technologies. (8) Consistent interagency coordination between USDA and USEPA, combined with strong stakeholder input, is the most effective means to target limited resources.

**How Do Non-chemical Pest Management Practices Affect the Use of Herbicides in Corn Production? Insights Gained from the 1994 Cropping Practices Survey**. David Shank and Merritt Padgitt. Natural Resources and Environment Division, Economic Research Service/USDA, 1301 New York Avenue, NW, Washington, DC 20005

There is a common belief that non-chemical pest management practices can substitute for chemical use in production. However, these pest management practices were designed to increase the profitability of a farm through increases in input efficiencies. Determining the effect of these non-chemical pest management practices on the use of herbicides in com production is the focus of this poster. Statistical analysis of production and chemical use data from the Cropping Practices Survey for 1994 are conducted and relationships between production practices and chemical use analyzed. Important practices like tillage, scouting and crop rotation are included in the analysis.

The use of aggregated chemical amounts presents a challenge since the chemicals often have different levels of efficacy and application rates which blur regression results. To account for quality differences and avoid this pitfall, chemicals are grouped by their family or action allowing the analysis of use patterns for a particular group of chemicals. A Heckman two stage system of equations is used to avoid any bias due to latent variables impacting on chemical selection and use. The system uses a Probit analysis of chemical selection to obtain the inverse

Millis ratio which is then included in the OLS estimation.

**Analysis of Gypsy Moth Spread in The Central Appalachians.** Alexei A. Sharov, Virginia Polytechnic Institute and State University. Blacksburg, VA 24061-0319

Gypsy moth, Lymantria dispar (L.), was introduced into North America near Boston in 1869 and since that time it has been slowly expanding its range to the west and south. In attempting to slow its spread, USDA Forest Service has established several barrier zones in which isolated colonies are detected and eradicated. To evaluate the effect of barrier zones on the rate of gypsy moth spread, I suggested measuring the rate of spread by the average distance between regular population boundaries (regular boundaries have no "islands," gaps or folds) in consecutive years. Population boundaries were estimated using male moth counts in pheromone traps, egg mass counts, and defoliation maps in the central Appalachian Mts. in 1988-1995.

Gypsy moth spread rate declined from 1988 to 1995 by ca. 30-60 percent, as measured from (1) time series of spread rates and (2) boundary "compression" (reduction of the distance between adjacent boundaries). Reduction of gypsy moth spread rate may have been due to eradication of isolated infestations in the barrier zone.

The boundary of 1 moth/trap was on average 110 km from the boundary of defoliation, and male moth capture rate increased 10 times per 29 km perpendicular to the population front. Approximately 11 years separated the time when traps caught 1 moth/trap until defoliation first occurred in the same area. Spread rates estimated using different population thresholds changed almost synchronously from year to year. Local spread rates measured at different locations along the same boundary were significantly correlated within the range of 50 km but they were not correlated in time.

**Pheromone R&D for Management of Western Bark Beetles.** Patrick J. Shea, Principal Research Entomologist, USDA Forest Service, Pacific Southwest Research Station, Davis, CA 95616

Many insects, including bark beetles, use chemical messages as a means of communication between individuals of the same or different species. Collectively, these unique and biologically powerful compounds are called "semiochemicals." Some compounds attract members of the same species (aggregation pheromone") and some compounds block the aggregation pheromone (anti-aggregation pheromone"). The existence and functional role of some bark beetle semiochemical systems have been known to science for over 25 years. However, research by USDA Forest Service scientists has only recently begun to develop strategies that use these unique compounds to manage forest pests, particularly several species of bark beetles. These beetles are significant pests of forests in the western United States and can have devastating effects on recreational areas, wildlife habitat, and the economic stability of forest dependent communities. Specifically, this research and development effort has concentrated on: (1) understanding the behavior of bark beetle populations and their chemical ecology; (2) isolating, identifying, and synthesizing new aggregation pheromone; (3) field-testing new formulations and delivery systems of pheromone for pest management purposes; (4) and advancing our knowledge of the functional role and impact of bark beetles in forest ecosystems.

**Baseline Susceptibility of the European Corn Borer from North America and Europe to *Bacillus thuringiensis*.** Blair D. Siegfried and Paula C.R.G. Marcon, Dept. of Entomology, University of Nebraska Lincoln, NE 68583; John F. Witkowski, Northeast Res. & Ext. Center, University of Nebraska, Concord, NE 68728; Kevin L. Steffey, Illinois Natural History Survey, 172 Natural Resources Bldg., University of Illinois, Champaign, IL 61820; R.J. Wright, Southcentral Research and Extension Center, University of Nebraska, Clay Center, NE 68933

Susceptibility to a purified CryIA(b) toxin from *Bacillus thuringiensis* (B.t.) was determined for 12 populations of the European corn borer (ECB), *Ostrinia nubilalis*. Field collections were made from 9 States across the U.S. corner belt. A field population from Italy and two laboratory colonies in culture for at least 10 generations were also tested. Most collections originated from locations where the bivoltine Z strain predominates, but samples of other ECB strains including the multivoltine Z and E strains were also tested. Field-collected larvae were reared for one or two generations in the laboratory, and susceptibility of neonate progeny was determined. Susceptibility was determined with feeding bioassays where increasing concentrations of the toxin were applied to the surface of artificial diet. Mortality and larval weight gain were determined after 7 days. Significant differences in LCso and ECso (based on weight reduction relative to controls) values were observed, but the magnitude of the differences was small (<fourfold). Intense exposure to B.t. is not known to have occurred in these populations, indicating that the observed susceptibility differences are due to natural variation among populations and unrelated to prior selection with B.t. The baseline susceptibility as reported here should provide a means to designate diagnostic concentrations that can be used in monitoring programs to determine the resistance status of field populations.

**Management of 1,3-Dichloropropene for Efficacy And Environmental Safety.** B. S. Sipes, D. P. Schmitt, R C. Schneider, and R. E. Green, Department of Plant Pathology and Department of Agronomy and Soil Science, University of Hawaii, Honolulu, 96822

A series of experiments determined the effect of application methods on the environmental fate of 1,3-dichloropropene (1,3-D) in pineapple. The goal was to reduce atmospheric emissions of 1,3-D while retaining control *Rotylenchulus reniformis*. In experiment 1, 1,3-D applied with a fumigun at 224 1 a.i./ha was as effective as rates of 337 or 393 1 a. i./ha. Greater soil gas concentrations of 1,3-D occurred in the center of the planting bed with a single-chisel application compared to a dual-chisel application. Soil residue concentrations of 1,3-D were similar along the plant line in single- and dual-chisel applications. In experiment 2, 1,3-D (224 l a.i./ha) applied with a single chisel 45-cm deep, centered in the planting bed, and immediately sealed with a 1.1 m wide x 1.0 mil thick plastic cover, reduced peak ambient air concentrations by 29 percent and interbed soil gas concentrations by 75 percent compared to the same rate applied 40-cm deep with two chisels. Both application methods reduced pretreatment nematode populations by 97 percent. In experiment 3, no differences were found in efficacy or air emissions of 1,3-D when the fumigant was applied with a single chisel in the center of the bed and immediately covered with a 2-m or l.l-m wide plastic film. An environmentally safe and effective application of 1,3-D can be achieved by applying the fumigant 45-cm deep with a single chisel run in the center of the bed, and immediately sealing the soil with a plastic film.

**Greenhouse IPM Implementation in Northern New England**. Margaret Skinner, Michael Brownbridge & Bruce L. Parker, Univ. of Vermont, Entomology Research Laboratory, P.O. Box 53400, Burlington, VT 05405-3400; James F. Dill, Univ. Of Maine, Entomology Dept., Orono, ME 04473; Alan T. Eaton, Univ. Of New Hampshire, Entomology Dept., Durham, NH 03824; and, Julie Iskow and Jane Kolodinsky, Univ. Of Vermont, Com. De. & Applied Econ., Burlington, VT 05401.

The horticulture industry is the fastest growing agricultural sector in grower cash receipts and the heaviest user of chemical pesticides based on active ingredient per acre in the U.S. Crop production under glass provides important economic opportunities in the Northeast, a region where crop diversification is essential to its agricultural future. IPM can reduce the use of "hard" chemical pesticides but its adoption is slow. A tri-state, multi-disciplinary effort to promote its use in greenhouse ornamentals in Maine, New Hampshire and Vermont has been initiated. These States joined forces because their greenhouse operations share several common characteristics-- they are generally

small, seasonal and diversified. IPM development and implementation must be addressed systematically, drawing on the expertise of extension specialists, researchers and growers. A survey of pesticide usage, IPM practices and economic factors related to IPM will be conducted. Results from this survey will be used by the tri-state network to develop a long-term approach for encouraging IPM implementation in these three States.

**Crucifer Integrated Pest Management.** Kenneth A. Sorensen, Dept. of Entomology, Harry S. Duncan, Dept. of Plant Pathology and Douglas C. Sanders, Dept. of Horticulture Science, Box 7626, N. C. State University, Raleigh, North Carolina 27695-7626

Insects and diseases cost crucifer growers millions of dollars in North Carolina through direct losses, the cost of control and the application of unnecessary sprays. Growers, field scouts and extension agents often cannot recognize or identify causal agents and pests in a timely manner. Some 100 slides of insects, diseases and disorders were selected and reproduced. Enlarged color prints were made from selected examples and mounted on poster display together with objectives, statements of content, results, future efforts and acknowledgments. Notebooks with identifications, departmental insect notes, plant pathology leaflets and horticulture leaflets and selected crucifer production bulletins, vegetable insect manual and biological insect control bulletin were prepared. These notebooks could be used alone in training sessions or used in conjunction with the poster-display. We also conducted a distance learning workshop on Crucifer IPM that used our UNC network of 16 remote sites.

This Crucifer IPM poster display has been shown at National ESA meeting in Las Vegas, at county extension reviews, at annual Extension Conference, at the NC Crop Protection School and at various meetings throughout the State. Thus thousands of growers and practioners will be exposed to Crucifer pest identification, damage recognition and management tactics and strategies.

With these educational resources, growers, field scouts and county extension agents will be better able to recognize and provide IPM information in an efficient and effective manner. Hence grower losses will be reduced, pest control improved, insecticide resistance slowed, and the environment spared needless contaminants and our vegetable industry remain viable and become more competitive in a global environment. Also this educational program will foster improved public relations and professionalism among the University, the Cooperative Extension Service, the county Extension Office, growers, private consultants and the consuming public.

**Developing an Integrated Program for Managing Aphids And Aphid-transmitted Virus Diseases of Vegetable Crops in the San Joaquin Valley**. James J. Stapleton and Charles G. Summers, Statewide IPM Project and Dept. of Entomology - UCD, Kearney Agric. Center, Univ. of California, Parlier, CA 93648

A serious epidemic of aphid-transmitted virus diseases has developed in the warmer valleys of California. Without multiple virus resistance in the many specialty vegetable varieties grown in the San Joaquin Valley (SJV), crop losses are increasing each year to viruses including CMV, WMV, ZYMV, TEV, ToRSV, among many others. Numerous insecticides, pheromones, and cultural methods have been tested to control the many species of aphids capable of transmitting the viruses, but none has given satisfactory results. Silver reflectorized mulches have been the best management tool for susceptible crops, and have given up to 25-fold increases in yield over nontreated control plots. However, growers in the SJV have not traditionally used mulches, and the infrastructure needed to put a widespread plasticulture system into practice must be developed. We are working with suppliers, growers, and crop advisors to facilitate the transition. Among the key growers spearheading implementation may be those involved with a

"biologically-intensive farming systems" project coordinated by UC Cooperative Extension in the central SJV. Efforts are underway to integrate other strategies with the mulch treatments to improve the economic benefit to users.

**Urban IPM Training Using the Master Gardener Program**. Robert Stauffer, Master Gardener, Robert Morris, Horticulture Specialist and Wayne Johnson, State IPM Coordinator, Nevada Cooperative Extension, 2345 Red Rock Street, Suite 100, Las Vegas, NV 89102-3156

The Las Vegas valley is a rapidly growing area of the country with increasing environmental pressures created by an urban community without an agricultural base. A survey conducted in nursery/garden centers demonstrated that the general public's first choice for pest control were pesticides and that they had little concept of IPM. When questioned about pesticide safety and disposal, none of the respondents could answer the most basic questions. This can be particularly dangerous since the Las Vegas valley is an open hydrological system that ultimately drains into the Colorado River. Recently, the Clark County Sanitation District detected high levels of diazinon in waste water. The first year of a four-year educational program is underway to teach the general public on alternatives to pesticides (IPM) for commonly found urban pests in southern Nevada. The educational program is conducted through extension's volunteer Master Gardener program in cooperation with local nursery/garden centers. An educational curriculum (training manual) is being developed by extension specialists to teach existing Master Gardeners urban IPM techniques, pesticide safety, and proper pesticide disposal techniques. Alternative pest control measures are emphasized as first choice alternatives to the selection of traditional pesticides. Master Gardeners are identifying and prioritizing major pest problems of southern Nevada that could be controlled through IPM. Twelve home horticulture fact sheets are being developed or revised (emphasizing IPM techniques as first-choice alternatives, pesticide safety and pesticide disposal) to address local pest control needs. These fact sheets will become an addendum, tailored to southern Nevada pest problems, to the training manual.

**IPM on the World Wide Web: the National IPM Network - Center for IPM (CIPM) Server.** Ron Stinner, Dept. of Entomology, North Carolina State University, Raleigh, NC 27607 [http:// ipmwww.nc-su.edu/cipm/VirtualCenter. html]

The transfer of information from the researcher to the end-user is vital in facilitating the adoption of any new technology. World Wide Web (WWW) sites on the Internet have rapidly become an important information tool for a wide variety of topics. This increased popularity results from a number of factors: the software to access the information on WWW sites is essentially free to non-commercial users, the software's interface makes the transfer of text and graphic information 'user-friendly' and simple, and access to the Internet through commercial providers is becoming easier and less expensive. Commercial interests are taking advantage of the WWW for a number of purposes but are motivated by economics; WWW is an inexpensive and effective way of reaching a widely distributed body of consumers. In addition, WWW sites are easily developed and rapidly modified. The increased popularity of the WWW presents an opportunity to provide information on Integrated Pest Management techniques to a wide audience of end users at a minimal cost.

The National Integrated Pest Management Network (NIPMN) has established a system of regional servers containing IPM information and resources. These sites also provide real-time weather data, market reports, and pest alerts; the most recent pesticide label information; and numerous other types of IPM-related data. In addition, they will incorporate interactive resources such as keys to pest species and expert systems for identification and decision support.

Demonstrations of the resources available on these servers will be provided and future resources and potential uses discussed. An assessment of the

economic advantages provided through electronic publication of extension materials will be presented.

**Establishment of a Multiregional, Computer-Based Crop Disease Forecasting System**. Joyce F. Strand, Computer Systems Manager, Statewide IPM Project, University Of California, Davis, CA 95616-8621, Paul H. Gosselin, Assistant Director, California Department of Pesticide Regulation, 1020 N St., Sacramento, CA 95814, Robert K. Curtis, Manager, IPM Programs, Campbell Soup Co., 6200 Franklin Blvd., Sacramento, CA 95824

Management of diseases in many California fruit and vegetable crops relies heavily on the use of fungicides as the most effective means of protecting the crop from quality and yield losses. In many crops, fields are sprayed on a regular schedule, often weekly throughout the growing season. An effective means of reducing fungicide use is to improve spray timing by basing it on evaluation of risk of infection rather than on a calendar spray schedule. In recent years, scientists have made progress in developing models that describe the relationships between environmental variables and disease development. To ensure widespread applicability, the descriptive models must be validated across the variety of microclimates where they will be applied. However, such validation requires a large scale effort in weather monitoring, field data collection, and analysis. Taking advantage of advances in environmental monitoring technology, a project funded by US-EPA, California Department of Pesticide Regulation, University of California, and the California agricultural industry proposes to provide an infrastructure to provide appropriate weather data, facilitate the research and validation of models of diseases, and demonstrate their utility. Based on proposals from industry and scientist participants, regional weather networks, monitoring air temperature, relative humidity, leaf wetness, and precipitation will be purchased and
installed, and data will be gathered centrally, quality controlled, stored, and made available to users. The environmental data, along with field scouting reports, will be used in model development, validation, and correction. When ready for implementation, the new technologies will be transferred to growers and pest management consultants responsible for making treatment decisions. Disease indices computed centrally using validated models will be disseminated by computer, fax-on-demand, and voice-synthesized telephone messaging systems, and their use will be monitored as part of the evaluation of adoption of the new technology.

**The Impacts of Policy And Institutional Reform on the Agricultural Sector in Sub-Saharan Africa: The Effect of Market Forces on Integrated Pest Management Adoption**. Philip Szmedra, Agricultural Economist, USDA/ERS, and Walter Knausenberger, Environmental Advisor, US AID/Bureau for Africa. USDA, 1301 New York Ave. N.W., Washington, DC 20005

Some important impacts of structural adjustment programs on the agricultural sectors of many Sub-Saharan African (SSA) nations have been the removal of government involvement in input subsidization schemes, the introduction of markets where previously State control had existed, and the promotion of non-traditional export crops to help diversify agriculture. Each of these policies has significant import for the availability and use of chemical pesticides which in turn affects the long term environmental and societal well being in the region. The removal of subsidies and the introduction of input markets has caused pesticide prices to increase. This, along with diminished sources of subsidized agricultural credit, has left many farmers without effective access to modern pest control alternatives. Further, nontraditional export crop promotion has generally focused on horticultural and floricultural crops for the European market. Therefore, forces are in place to both stimulate the demand for effective pest management methods while at the same time limiting access to modern chemical pesticides while encouraging the continued use of pesticide materials that have been banned from agricultural use in the developed world. The research and extension of Integrated Pest Management (IPM) practices would do much to address the pest management needs of the

smallholder and cash crop producer, as well as the plantation production systems in the region. This paper provides a synopsis of a portion of the work undertaken since 1994 by US AID/Bureau for Africa in Operation with the EPAT Project of Winrock International in assessing the environmental implications of agricultural trade and policy reform programs in SSA. Specifically, the paper gives an overview of the current state of pesticide use and pest management in the SSA region, explores the economic factors involved in assessing pesticide use and judging possible future trends in use in SSA, identifies impediments to IPM dissemination and recommends strategies that would help to promote IPM methods.

**IPM on the World Wide Web: the National IPM Network - Northeast Regional Server**. Cheryl TenEyck, NYS Integrated Pest Management Program, Cornell University, Geneva Campus, New York
[http://www.nysaes.cornell.edu:80/ipmnet/]

The transfer of information from the researcher to the end-user is vital in facilitating the adoption of any new technology. World Wide Web (WWW sites on the Internet have rapidly become an important information tool for a wide variety of topics. This increased popularity results from a number of factors: the software to access the information on WWW sites is essentially free to non-commercial users, the software's interface makes the transfer of text and graphic information 'user-friendly' and simple, and access to the Internet through commercial providers is becoming easier and less expensive. Commercial interests are taking advantage of the WWW for a number of purposes but are motivated by economics; WWW is an inexpensive and effective way of reaching a widely distributed body of consumers. In addition, WWW sites are easily developed and rapidly modified. The increased popularity of the WWW presents an opportunity to provide information on Integrated Pest Management techniques to a wide audience of end users at a minimal cost.

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Demonstrations of the resources available on these servers will be provided and future resources and potential uses discussed. An assessment of the economic advantages provided through electronic publication of extension materials will be presented.

**Multiple Pest Interactions Involving Root-knot Nematodes and Annual or Perennial Weeds**. Stephen H. Thomas and Jill Schroeder, Department of Entomology, Plant Pathology and Weed Science, and Leigh W. Murray, Department of Experimental Statistics, New Mexico State University, Las Cruces, NM 88003-8003

The ultimate success of IPM efforts depends largely upon our understanding of the interactions among multiple types of pests and agricultural commodities. The goal of current research efforts in New Mexico is to characterize the interaction between selected weed species, including *Cyperus esculentus* and C. *rotundus* (yellow and purple nutsedge, respectively), the plant-parasitic nematode *Meloidogyne incognita* (southern root-knot nematode), and chile pepper (*Capsicum annuum*). The pest species were chosen because of their concomitant world-wide distribution and severity of effects on crop plants. Our specific objectives are to determine the influence of root-knot nematodes on weed growth, development, and competitive interaction with peppers and to determine the influence of yellow nutsedge, purple nutsedge and selected annual weeds on nematode population development, life cycle, virulence, and winter survival. Field research in which peppers and weeds were interplanted during 1993 and 1994 demonstrated that the presence of perennial weeds increased root-knot nematode reproduction on

peppers and decreased pepper root weight, possibly due to weed/chile competition. Annual weeds (*Amaranthus palmeri* = Palmer amaranth; *Anoda cristata* = spurred anoda; *Physalis wrightii* = Wright groundcherry) generally supported greater root-knot nematode reproduction than perennial weeds (yellow and purple nutsedge), but had less effect on nematode reproduction on chile or pepper root weight. Purple nutsedge roots, rhizomes and tubers persisted from the end of the season until field preparation the following year, and maintained root-knot nematode eggs at relatively constant levels. In greenhouse experiments during 1995, tuber production by yellow nutsedge plants increased as root-knot nematode populations increased. These results indicate that the combined presence of nutsedges and root-knot nematodes may enhance survival of both groups of pests. Additional research is underway in which nematode-infested and uninfested treatments are being studied to identify the interactions between peppers, annual and perennial weeds and root-knot nematodes under approximate field conditions.

**Naturalyte Insect Control and IPM.** G.D. Thompson, P.W. Borth, S.H. Hutchins and L.G. Peterson, DowElanco, Indianapolis, IN 46268

Naturalyte Insect Control is the name for DowElanco's new proprietary biologically based insect control products. Naturalytes are defined as naturally produced metabolites from living organisms that selectively control pests. To qualify within DowElanco's naturalyte class, the metabolites must have a high level of efficacy that is equivalent or superior to commercial standards and at the same time possess human and environmental compatibility that is equivalent to that provided by most biological products. Naturalyte Insect Control products are exciting IPM tools due to the fact that they provide (1) a high level of efficacy that permits waiting until pests reach economic thresholds before treating; (2) selectivity against pests only-leaving beneficial insects for residual control; and (3) a unique mode of action which allows product class rotation to avoid resistance development or the need for higher rates and more frequent applications. Field results are graphed to demonstrate these attributes.

**The Commercialization and Implementation of Pheromone-based IPM in Pome Fruits.** Don Thomson, Pacific Biocontrol Corp., 400 E. Evergreen Blvd., #205, Vancouver, WA 98660

Mating disruption technology is increasingly being used for the control of codling moth in pome fruit production areas around the world. Some of the countries where codling moth mating technology is used commercially include the United States, Canada, Argentina, Australia, Italy and South Africa. In 1991, Isomate C Plus (Pacific Biocontrol Corp., Vancouver, Washington) became the first commercial formulation of codling moth pheromone to be registered in the United States. The total pome fruit acreage treated with Isomate C Plus has increased from approximately 1,200 hectares in 1991 to approximately 7,300 hectares in 1995.

The successful commercialization of mating disruption technology will depend in large part on the development and implementation of a pheromone- based IPM systems approach. The objective of a pheromone-based IPM program is to effectively manage key and secondary pests in an economically, ecologically and environmentally acceptable manner. In a pheromone-based IPM system, mating disruption is the major tactic used to control the key pest(s). The subsequent reduction or elimination of insecticides for control of the key pest(s) will promote crop or orchard environments that will support higher populations of natural enemies and thus enhance the biological control of both key and secondary pests. The development of monitoring and sampling techniques in conjunction with economic thresholds is essential in order to accurately assess the biological relationships between key and secondary insects and their natural enemies and to implement supplementary controls if required. Pheromone-based IPM should be presented to growers as a long term approach and commitment to pest management. Growers should be encouraged to define yearly objectives and then

identify the strategies and tactics needed to achieve those objectives.

**Insect Management by North Carolina Potato Growers in 1994**. Stephen J. Toth, Jr., Department of Entomology, North Carolina State University, Box 7613, Raleigh, NC 27695 and Kenneth A. Sorensen, Department of Entomology, North Carolina State University, Box 7626, Raleigh, NC 27695

A mail survey of potato growers in 14 counties in North Carolina was conducted by the Cooperative Extension Service in the winter of 1995 to determine the use of pesticides and nonchemical pest management practices by growers on the 1994 crop. Pest management data from this and other grower surveys are provided to the NAPIAP. In 1994, potato growers treated 72 percent of the acreage with Asana XL, while Furadan and Thimet were used on 26 and 24 percent of the acreage, respectively, for Colorado potato beetle management. Other insecticides used to manage Colorado potato beetles included Monitor, M-Trak, Ambush, Vydate, Pounce and Guthion. Seventy percent of the potato growers surveyed felt that Colorado potato beetles in their potato crop had developed resistance to insecticides in 1994. Sevin and Furadan were considered ineffective against Colorado potato beetles by ovcr 40 percent of growers. Between 10 and 25 percent of growers reported beetle resistance to Guthion, Thiodan, Asana XL, Monitor, Ambush, Thimet and Vydate. For European corn borers, Monitor, Furadan and Asana XL were used by potato growers on 27, 24, and 17 percent of the acreage, respectively, in 1994. Growers also used Ambush and Guthion for the management of this pest. Potato growers treated about 40 percent of their acreage with Thimet to manage wire worms. Seventy-six percent of the growers reported that they, a family member and/or an employee scouted their potato fields for weeds, insects or plant diseases in 1994. Nearly 39 percent claimed that a professional scout or consultant performed this service. One grower's potato crop was scouted by a county extension agent. Approximately 86 percent of potato growers indicated that they rotated the fields on which they planted potatoes as a means of pest management. Corn and soybeans were the predominant crops rotated with potatoes. Seventy-four percent of potato growers applied different insecticides to reduce Colorado potato beetle resistance. A Colorado potato beetle resistance monitoring kit developed at North Carolina State University was used by 28 percent of growers in 1994.

**Evaluating The Effectiveness of Pest Management Training to Vineyard Farm Workers**. Lucia G. Varela, Area IPM Advisor, University of California Cooperative Extension & Statewide IPM Project, 2604 Ventura Ave., Santa Rosa, CA 95403-2894; and Rose Krebill-Prather, Sociologist, University of California Statewide IPM Project, Kearney Agricultural Center, 9240 South Riverbend Ave., Parlier, CA 93648

Early detection of pest problems allows for selection among preventive and control measures. Trained farmworkers can provide the grower with the prompt pest detection needed for an effective IPM program. Through a series of hands-on workshops, I taught 235 vineyard foremen how to identify the most important insect and mite pests in their area, how to diagnose the major grape diseases, how to identify the most important natural enemies found in vineyards, and how to monitor throughout the season. We used hand lenses and the knowledge acquired to practice techniques for identification and monitoring of insects in the field. We provided students with hand lenses and Spanish-language posters, fact sheets, and handouts so that they could train their crews.

We developed two post-training evaluation instruments, one for the foremen and the other for the employers. I conducted face-to-face interviews in Spanish with 100 vineyard workers. Employers were mailed the questionnaire.

Overall, the learning reported by workers was modest. Workers appeared to be most confident about information on disease identification, moderately confident about insect pest and mite

identification and least confident about information on beneficial insects. Employer respondents were more positive. About three quarters reported that their workers' knowledge had improved "moderately" to "greatly" with regard to identification of diseases and insect pests. There was a positive correlation between how much the workers reported to have learned in the class and how much responsibility they have on the job. There was no correlation between the number of years of formal education the foremen had and the level of learning. The fact that literacy was not a significant factor in level of learning argues that hands-on training is an effective way of teaching farm workers. Three- fourths of the workers reported that their managers encouraged them to look for disease and insects more after attending the workshop. A majority of employers (88 percent) reported a change in their expectations of how workers perform their jobs. Two- thirds reported a "moderate" to "great" change in pest monitoring skill among workers.

**Development And Implementation of a Grape Weather Network Computer-based Bulletin Board System For Grower Use in Making Pest Management Decisions**. Timothy H. Weigle, New York State IPM Program, 412 E. Main St., Fredonia, NY 14063; C. Petzoldt, C. TenEyck, and J. Gibbons, New York State IPM Program, NYSAES, Geneva, NY 14456

In response to the reduction in the cost of weather monitoring equipment and the proven effectiveness of post- infection disease management programs, 20 Lake Erie Region grape growers purchased 10 weather units in 1994. These units, combined with the 4 weather stations currently being operated by the Grape IPM program provide weather information from Lake Ontario to Harborcreek, PA. Weather-driven disease management programs for black rot and powdery mildew developed at the New York State Agricultural Experiment Station, Geneva, NY, have been used successfully for timing of fungicides in Grape IPM implementation projects in New York since the 1990 growing season. Eliminating a single prebloom fungicide application of mancozeb + Nova would reduce fungicide use on the 33,000 acres by approximately 107,000 pounds, a potential savings of approximately $860,000 or $26/acre. The increase in weather instruments during 1994 and the increase in the number of growers interested in weather information created the need for a central location to collect, manipulate and disseminate weather data. A computer bulletin board system was developed and implemented for use by growers, industry personnel and extension specialists, faculty and staff in the Lake Erie Region to access information on disease infection periods. pest scouting results, insect identification, pest management protocols and local electronic mail. Wildcat! BBS, a text based BBS software, was used during the 1995 growing season. A new software package is being tested for use in 1996 which will provide a graphical interface similar to the World Wide Web. The BBS prototype used in grapes during 1995 will be replicated in four to five locations across New York State in 1996 in conjunction with a USDA Agricultural Telecommunications grant.

**Areawide Management of Codling Moth with Pheromone Mating Disruption: the Randall Island Project.** Stephen C. Welter and John E. Dunley, University of California, 201 Wellman Hall, University of California, Berkeley, CA 94720

Pheromone mating disruption was initiated on a regional scale in California pear orchards in 1993 to improve the level of success for mating disruption for codling moth and to address increasing problems with resistance in codling moth to azinphosmethyl. Low levels of resistance to azinphosmethyl were first discovered in California in 1989 that were correlated with increased application rates and frequencies as well as increasing problems with control. Mating disruption also was implemented on a large scale in an effort to manage a genetic problem at the appropriate population level. In addition, implementation at a larger regional scale targeted reducing problems among orchards, improving biological control of secondary pests, and achieving a general areawide suppression. A uniform management program was designed and

accepted by growers for a three year period that relied primarily on the use of a synthetic pheromone dispenser (Isomate, Biocontrol, Inc.) for control of codling moth.

The Randall Island Project consists of 760 contiguous acres owned by 5 growers in the Sacramento Delta of California. The project is bordered by the Sacramento River and non-host crops on 2 additional borders. Along the final border that intersected a small portion of adjacent pear acreage, a buffer of pheromone dispensers plus insecticides were used to limit immigration of codling moth.

Overall, the project averaged less than 1 percent infestation for all harvests in all three years. In the first year, azinphosmethyl was used twice against the first generation and eliminated for the second or third generations, resulting in a 50 percent reduction. In subsequent years, azinphosmethyl use was limited to areas considered at risk. As such, azinphosmethyl use was reduced by 85 percent in Year 2 and 75 percent in Year 3 from the traditional number of 4 applications per year. In 1994, approximately 60 percent of the acreage was not treated with azinphosmethyl, whereas 30 percent was not treated in 1995. Despite the 75 to 85 percent reductions in azinphosmethyl, codling moth infestation averaged 0.41 and 0.76 percent in 1994 and 1995 respectively. However, there were untreated sites in both years than exceeded the 2 percent threshold for infestation. In contrast, all sites that received one application of azinphosmethyl timed to increasing codling moth flights achieved less than 1 percent infestation.

**Methodological and Institutional Barriers to Farm Practices Assessment**. Steven Wolf, University of Wisconsin, Institute for Environmental Studies, P.O. Box 1732, Wilmington, VT 05363. Peter Nowak, University of Wisconsin, Department of Rural Sociology, 1450 Linden Drive, Madison, WI 53706. Robert McCallister, University of Wisconsin Institute for Environmental Studies, 1450 Linden Drive, Rm. 350, Madison, WI 53706

Managing for change and measuring change within agricultural production systems, including IPM, requires rigorous assessment of both the context in which behaviors are examined and the behaviors themselves. We argue that such rigor has been lacking as applied to public sector IPM initiatives. In our assessment, IPM adoption research has been largely ad hoc, politically motivated, and characterized by application of outmoded theories and tools. As a result, base-line data on IPM implementation and our ability to conduct comparative analysis across commodities, production regions, and time are weak. This paper identifies conceptual and empirical constraints to understanding patterns of change in production systems in U.S. agriculture. We go on to suggest a series of theoretical, methodological and institutional innovations that support a more systematic and cost effective approach to tracking how individuals and farming systems respond to changes in agroecological parameters, markets, technology, policy, and public and private sector extension.

Specifically, we argue for integration of primary and secondary data sets through development and application of spatially explicit sampling and inventorying techniques. Similar to the conceptual approach employed in the multi-institutional Area Studies Program, we advocate using GIS technology to support integration of agroecological and socioeconomic data. Such an approach supports evaluation of behavioral change of individuals as well as farming system adaptation within the context of hypothesized IPM "drivers" such as modified pest regimes, resource management conflicts (e.g., odor problem), articulation of consumer preferences (e.g., pesticide-free), technological and economic change, public investment (e.g., SP-53), and development of a competitive crop consulting industry.

**Pest Management Practices of Crop Consultants in the Midwestern United States.** R. J. Wright and T. A. DeVries, University of Nebraska, South Central Research & Extension Center, Clay Center NE 68933-0066 and S. T. Kamble, Dept. of

Entomology, University of Nebraska, Lincoln NE 68583-4816

A mail survey of crop consultants in 12 north central States was conducted to assess pest management practices on corn, soybeans, alfalfa, wheat and grain sorghum during 1993. Selected information from the survey will be presented, primarily emphasizing insect management. The most crop consultants were identified in Kansas and Nebraska, with fewer crop consultants per State in the eastern part of the region. Kansas and Nebraska had the greatest reported acreage of crops scouted. The greatest scouted acreage was of corn, followed by soybeans, wheat, alfalfa and sorghum. The most common scouting interval reported was l/week; 68 percent reported making visits once a week or more frequently. Consulting fees per acre varied with crops; averaged over all States, the highest fees were charged for alfalfa ($4.80). with less charged for corn ($4.31). sorghum ($4.26). soybeans ($4.07), and the least charged for wheat ($3.74). There was a great range within crops, across the region, (e.g. corn varied from $3.21 to 6.13 per acre). This variation is probably related to the frequency of visits and the range of services offered (from comprehensive integrated crop management to less comprehensive agronomic only [no IPM] services) in different States. Planting time application of insecticides was the most commonly used corn rootworm control practice. Post-emergence applications of insecticides directed at larval rootworms (cultivation time applications, chemigation) were used primarily in the western part of the region. Foliar sprays for adult corn rootworn control were also most common in the western part of the region but some use occurred further east also. Use of crop rotation varied greatly across the region (23.8 to 83.7 percent rotated). Additionally, across all States there was an association between frequency of rotation in corn and insecticide use against corn rootworms; i.e., States with higher frequencies of rotated corn tended to treat a lower percentage of corn acreage for corn rootworm control.

**Production And Pest Management Software For Potato Growers**. Jeff Wyman, Walt Stevenson, Larry Binning, Tim Connell, Keith Kelling, Dave Curwen, University of Wisconsin, Madison, WI 53706

The Wisconsin potato crop is managed intensively through multiple inputs of pesticide, fertilizer, and irrigation. Beginning in 1979, a multidisciplinary team at the University of Wisconsin developed an effective IPM program to address key management decisions associated with this crop. Results of this research, funded by grower, State and Federal sources, provided the essential ingredients for development of a computer software program, WISDOM, now used for managing the potato crop on 70,000 acres in a multi-state area. The software helps growers determine the need for and timing of critical crop inputs. By reducing unneeded pesticide and irrigation applications, the software improves overall production efficiency and reduces adverse environmental impact.

**Farm Size and Use of IPM**. Jet Yee and Walter Ferguson, Agricultural Economists, United States Department of Agriculture, Economic Research Service, Room 532, 1301 New York Ave., NW, Washington, DC 20005-4788

This poster uses data from the 1992 Chemical and Farm Finance Survey to analyze the effects of farm size on the use of sustainable pest and nutrient management practices. The surveyed farmers grew corn, oats, soybeans, and wheat in Minnesota, and rice, cotton, and soybeans in Louisiana. Farms were sized using three criteria: crop sales, harvested acreage, and net cash farm income. Sustainable pest and nutrient management practices included scouting, crop rotation, beneficial insects, insect/disease test, pest management strategy, alternative pesticide, manure application, soil test, and nitrogen test. In general, big farms were more likely to use pest and nutrient management practices than small farms in Minnesota. In Louisiana, small farms were more likely to use nutrient management practices. There was no discernible pattern between farm size and use of pest management practices.

Comparison of results to previous studies and policy implications will also be presented.

**Enhancing the TOMCAST System Through Expansion and Research.** Curtis Young, IPM Extension Specialist, Jim Jasinsk, IPM Extension Specialist, Mac Riedel, Dept of Plant Pathology, Celeste Welty, Dept. of Entomology, Mark Bennett and Bob Precheur, Dept. of Horticulture and Crop Science, Ohio State University Extension, SW District Office, 303 Corporate Center Drive, Suite 208, Vandalia, OH 45377

TOMCAST is a disease forecasting program used in thirteen processing and fresh market tomato field sites throughout southern Michigan, Indiana, and Ohio. The development of warm, wet weather fungal diseases such as early blight, *Septoria* leaf spot, and anthracnose are monitored at each site using environmental dataloggers such as Campbell Scientific CR10 or Omnidata Datapods units. Clearly defined durations of leaf wetness and temperature result in the accumulation of Disease Severity Values (DSV). When specific DSV thresholds are exceeded, growers are recommended to initiate spray treatments to protect the crop from fungal disease. Bacterial and viral pathogens are not affected or predicted by this system. In 1995, late blight prediction was incorporated into the TOMCAST system by adding precipitation gauges to existing CR10 units and acquiring late blight software (BLITECAST module of WISDOM). There are currently ten CR10 units providing late blight prediction information within the tri-state TOMCAST network, in addition to disease prediction for early blight, *Septoria* leaf spot, and anthracnose. Seasonal variation in disease pressure can be tracked using this monitoring system. In 1995, 9 of 13 TOMCAST sites averaged 30 DSV units above 1994 levels. There were also three first year sites in 1995 and one site that accumulated fewer DSV than in 1994. Late blight was not detected in Ohio, but according to BLITECAST conditions were conducive at all locations for its development at various times throughout the State. Late blight warnings were also issued for the sites in both Indiana and Michigan; only Michigan reported having the disease. Efforts to increase the use of TOMCAST throughout the Midwest is dependent upon the proximity of a field to the nearest CR10 unit. In 1995, a cooperative research agreement with Sky bit, Inc., a company that generates weather information using National Weather Service data, remote sensed data, and computer modeling is being looked at as an option to replace CR10's. Preliminary work suggests promise for this "hardwareless" approach to disease management, but requires further research to verify reliability and accuracy.