Final report to USDA's Pest Management Alternatives Program (PMAP), December 2006

Project title: Pepper production and pest management optimized by plant spacing, pesticide application technology, and new pesticides

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Specific Aims:

Peppers are a valuable vegetable crop in Ohio and the Great Lakes region. Production of bell pepper, sweet banana pepper, and jalapeño pepper crops in this region is constrained by a key pest, the European corn borer, and a key disease, bacterial spot, as well as a new aggressive strain of a fungal pathogen causing anthracnose. Due to low tolerance of insect or disease damage by buyers, pepper growers need to prevent damage, typically by spraying pesticides. Profitability in pepper production has been threatened by the Food Quality Protection Act (FQPA) because implementation of FQPA has resulted in restrictions in use of acephate, the preferred insecticide for control of European corn borer. Anthracnose has become a serious problem, and the only fungicide available for its control, maneb, is only partially effective and is likely to be restricted under FQPA in the future. Because there are relatively few effective chemical options available for pepper pest management, it is critical to apply them in a system with maximum efficacy. The goal of this project was to develop methods for improved management of European corn borer and anthracnose. We used a systems approach that included horticultural, chemical, and engineering components. This work is benefiting pepper growers in the Great Lakes region by providing research-based information to improve fruit quality, reduce losses to insects and diseases, and optimize pepper yields.

Results and Benefits:

This project included six categories of field trials as well as extension activities. In this final report, each of those components is described briefly. Full details of each component will be posted on the internet by 12/31/2006, at: http://bugs.osu.edu/welty/veg-research.html

Part 1: Plant population trials

The objective was to determine whether wider plant spacing and lower total plant population affect insect and disease incidence, efficacy of insecticide and fungicide control programs, and yield of peppers. A trial was conducted in 2004 at three commercial farms on which each grower's standard spray program was used. The sites were a 28-ha field of bell peppers in Greene County where three plant densities were evaluated, a 24-ha bell pepper field in Henry County where two densities were evaluated, and a 6-ha field of jalapeño peppers in Wood County where two densities were evaluated. Yield of undamaged fruit was not significantly affected by plant population densities of 29,650 versus 24,220 plants/ha in bell peppers at the Henry County site. However, at the Greene County site, bell peppers planted at the medium stand density (31,310 plants/ha) had greater undamaged yield than the high density plots (33,550 plants/ha) or low density plots (19,570 plants/ha), while sustaining the least amount of sunscald damage. At the Greene County site, sunscald damage was most prevalent at the lowest plant stand density. At the Wood County site, yield of undamaged fruit of jalapeño peppers was greater at 28,420 plants/ha than with 22,240 plants/ha. These field trials showed that there was no pest management benefit by planting at lower or higher plant populations than the standard population, and sunscald was a significant problem at low plant populations.

Part 2: Spray application technology trials

Trials were designed to evaluate coverage and efficacy of pesticides applied to peppers by several application systems, to determine the most effective spray application method for disease and insect management. Trials were conducted at a research station in northern Ohio with bell peppers 'Socrates X3R' planted in twin rows. The biological effects of the sprays were evaluated at harvest by yield measurement, and external and internal inspection of fruit. Spray deposition pattern and quantity on leaves and fruits were evaluated by laboratory analysis of field-applied dye mixtures. Nine treatments evaluated in 2004 were combinations of sprayer and nozzle type, rate of pesticides, and application speed: a conventional boom sprayer with two nozzle types and two travel speeds, an air-assist boom sprayer with two travel speeds, and an electrostatic air-assist sprayer were compared with untreated control plots. All sprayers applied a half-rate of insecticides and fungicides, and one treatment included the full-rate of pesticides applied using 30 gallons per acre. A smaller trial in 2005 evaluated an air-assist boom sprayer and a conventional boom sprayer with two nozzle types. Pesticides were applied at half of their recommended rates in 2005.

In 2004, three treatments resulted in the highest yield of undamaged fruit: the conventional boom sprayer with air induction nozzles operated at high speed and low speed, and the boom sprayer with twin flat-fan nozzles at low speed. The electrostatic sprayer resulted in lower undamaged yield than in the conventional boom sprayer treatments. The air-assist sprayer resulted in intermediate values for undamaged yield. In 2005, undamaged yield, caterpillar damage, sunscald, and anthracnose damage in pepper fruit were not significantly affected by spray application technology. Yield in all plots was lower than normal in 2005 due to infection by Phytophthora that affected many plants before harvest, and this led to early termination of the trial after only two harvests. Relatively wet and cool climatic conditions in 2004 and dry, hot weather in 2005 slowed the growth of bell pepper plants compared to most years.

Analysis of dye deposits showed that in 2004 the spray deposition on leaves at the bottom of the plant canopy was greatest after application by the twin flat-fan nozzles, which showed good spray penetration power. There were no differences in deposits for applications made at 4 and 8 mph. There were few differences between treatments in the amount of spray found on leaves taken from upper and middle canopy areas. Air-assisted delivery provided no advantage in the amount of spray retained on the foliage, however, air-assisted delivery did result in more spray being deposited on the fruit, higher foliar spray coverage, and higher dried droplet density on foliage lower in the canopy and on the underside leaf surfaces.

Part 3: Interaction of plant population and spray technology trial

Although greater pepper fruit yields usually result from higher plant stand densities, increasing plant populations might diminish the amounts of spray deposit reaching the surface of fruits and leaves at middle or low plant elevations. The objective was to characterize interactions between pepper plant spacing and efficacy of pesticide application technology, to determine whether certain application technology was better suited for denser plantings.

A trial in 2005 on 'Socrates X3R' bell peppers used treatments that were factorial combinations of two row arrangements, three plant population densities, and three levels of application technology. Row arrangements were twin and single rows. Plant population densities were low, medium, and high. Application technology included two nozzle types on a conventional boom sprayer, and an untreated control. Yield in all plots was lower than normal in 2005 due to Phytophthora blight, which led to early termination of the trial after only two harvests. Yield of bell peppers was higher in single-row than in twin-row plots, but peppers in twin rows had less damage by caterpillars than those in single rows. Bell peppers planted at low density produced lower yield of undamaged fruit than plants at the middle and high densities. The twin flat-fan nozzle treatment resulted in greater undamaged yield than the air induction nozzle treatment. Plants treated by the air induction nozzle had greater undamaged yield and less caterpillar damage than the untreated control. The incidence of Phytophthora blight was higher in twin row than in single row plots, but there was no significant difference in the percentage of infected plants among plant stand density levels.

A similar trial on 'Sweet Spot X3R' banana peppers used treatments that were factorial combinations of three plant population densities and three types of pesticide application technology; plant population densities were low, medium, and high, all in single rows. Application technology included two nozzle types on a conventional boom sprayer, and an untreated control. Undamaged yield of banana peppers was greater at high density and medium density than at low plant stand density. Caterpillar damage or presence was more abundant at medium than at high plant stand densities. No significant differences in yield, insect, or disease damage were found across the application technology levels evaluated.

Part 4: Fungicide efficacy trials

The objective was to determine the efficacy of fungicide alternatives to maneb for control of anthracnose on immature pepper fruit.

A field trial was conducted in 2004 with 'Socrates X3R' bell peppers. Plants were inoculated at the late flowering/early fruit set stage with spores of the anthracnose pathogen. Treatments were applied on a 7-10 day schedule beginning 19 Jul and ending 9 Aug for a total of four applications. Disease pressure was severe. Amistar (Quadris) alternated with Manex or Bravo Weather Stik, Manex plus Kocide, the high (12 oz) and medium (10 oz) rates of Tanos tank mixed and alternated with Manex, and Cabrio alternated with Manex significantly reduced anthracnose incidence and intensity compared to the untreated control. TD2470-01, Topsin-M, or Tilt alternated with Amistar, and the low rate of Tanos (8 oz) tank mixed and alternated with Manex and Kocide did not reduce anthracnose incidence, although all reduced anthracnose intensity relative to the untreated control. Tilt applied alone did not reduce disease incidence or intensity. Plants treated with Amistar alternated with Manex produced the highest marketable yield, although all treatments except Tilt and TD2470-01 or Topsin-M alternated with Amistar resulted in higher marketable yield than the control. All treatments except Tilt resulted in larger fruit than the control.

A field trial was conducted in 2005 to evaluate products for the control of bacterial leaf spot and anthracnose of 'Paladin' bell peppers. Plants were inoculated with the bacterial leaf spot pathogen. Bacterial leaf spot pressure was severe, and all treatments significantly reduced disease progress compared to the untreated control. However, foliar disease severity was significantly lower than the control for only four treatments: Tanos + Manex + Kocide alternated with Manex + Kocide; Tanos + Manex + DPX-GFJ52 alternated with Manex + DPX-GFJ52; and DPX-JE874 SE or DPX-JE874 EC + Manex + Kocide alternated with Manex + Kocide. Bacterial spot on fruit was also lowest for these treatments, although the 8 and 10 oz rates of Tanos combined with Manex + Kocide and alternated with Manex + Kocide, and Manex + Kocide applied alone or as cover sprays to the Ridomil Gold EC treatment also reduced bacterial spot incidence on fruit compared to the control. Anthracnose appeared naturally in the plots, affecting 35% of untreated fruit. All treatments except Tanos + Manex + Kocide alternated with Manex + Kocide significantly reduced anthracnose on pepper fruit compared to the untreated control. Application of treatments containing the DPX-JE874 SE and EC formulations resulted in the highest marketable yield.

Part 5: Insecticide efficacy trials

The objective was to determine the efficacy of alternatives to acephate for control of European corn borer in bell peppers. A trial conducted in 2004 evaluated ten insecticides applied at 7-day intervals from early August until mid-September. Orthene (acephate) provided the best protection of bell pepper fruits from borer injury as shown by highest harvestable yield and lower percentage of fruit damaged. Mustang Max (zeta-cypermethrin) was not significantly different than Orthene in either variable for any harvest. Avaunt (indoxacarb) and Intrepid (methoxyfenozide) were not significantly different than Orthene for some but not all variables and harvests. Assail (acetamiprid), Calypso (thiacloprid), Dimilin (diflubenzuron), SpinTor (spinosad), Rimon (novaluron), and Proclaim (emamectin benzoate) did not offer a significantly better protection from borer damage than the untreated control based on yield and infestation variables.

A trial conducted in 2005 included eleven treatments that used two applications of acephate at the time of peak egg hatch, combined with five other insecticides (Calypso, Dimilin, Rimon, Assail, and Mustang Max) before peak egg hatch, and combined with five other insecticides (Mustang Max, Avaunt, Intrepid, Proclaim, SpinTor) after peak egg hatch. There were no significant differences among treatments in yield, number of worm-damaged fruit, percentage of undamaged fruit, and undamaged yield in either of two harvests. The treatments that looked most promising were Assail before peak egg hatch, and Intrepid after peak egg hatch. The trial was terminated early due to Phytophthora infection, which might have obscured treatment effects that would have been present in later harvests.

Part 6: Insecticide spray interval trials

The objective was to determine the appropriate spray interval for effective insecticidal control of European corn borer on bell peppers versus jalapeño and banana peppers. Spray intervals evaluated were 5, 7, 10, and 14 days. In general, jalapeño pepper fruit sustained little insect damage. Banana peppers had moderate fruit damage from European corn borer, but high incidence of blossom end rot. Bell peppers showed the greatest fruit damage by European corn borer. In 2004, pest pressure was high, and control of borer on bell peppers was significantly better when insecticide was applied on a 5- or 7-day schedule than on a 10- or 14-day schedule. On banana peppers, control was as good with a 14-day interval as with shorter intervals. On jalapeños, there was no damage by borer even in the untreated control treatment. In 2005, trends were similar but pest pressure was lower and differences were not significant. Although a short spray interval (7 day) is needed to control borer in bell peppers, a longer spray schedule (14 day) provided good protection on banana and jalapeño peppers.

Part 7: Extension of project results

The objective was to convey the results of these field studies to pepper growers to assist in their adoption of new pest management and production tactics.

Oral presentations to growers were made at a field tour at one of the cooperating farm sites in June 2004, at a field tour at the research farm in August 2005, at the Ohio Fruit and Vegetable Growers Congress in January 2005, and at the Great Lakes Expo in Michigan in December 2006. A poster was presented to the scientific community at the National IPM Symposium in St Louis in April 2006, at the annual conference of the American Society for Horticultural Science in New Orleans in July 2006, and the Ohio Agricultural Research and Development Center's annual conference at Wooster in April 2006.

Information about efficacy of insecticides and fungicides is being incorporated in to the Ohio Vegetable Production Guide. A fact sheet on European corn borer on peppers has been produced and will be ready for distribution to growers in January 2007.

Publications completed:

Lewis Ivey, M.L., Mera, J. R. and Miller, S.A. 2005. Evaluation of fungicides for the control of anthracnose on immature bell pepper fruit, 2004. Fungicide and Nematicide Tests 60:V095 (online).

Miller, S.A., Lewis Ivey, M.L. and Mera, J. R. 2006. Evaluation of products for the control of bacterial leaf spot and anthracnose of bell peppers, 2005. Fungicide and Nematicide Tests 61:V074 (online).

Miller, S.A., Vitanza, S., Bennett, M., Derksen, R. and Welty, C. 2006. Spacing studies in peppers. Presented December 5, 2006 at the Great Lakes Fruit, Vegetable and Farm Market Expo, December 5-7, 2006, Grand Rapids, MI. http://www.glexpo.com/abstracts/2006abstracts/Pepper2006.pdf

Vitanza, S., Welty, C., Derksen, R.C., Bennett, M., Miller, S. 2006. Effect of plant stand density and pesticide application technology on insect pests and diseases of bell peppers [Abstract]. In: Proceedings of the 5th National IPM Symposium, April 4-6, 2006, St. Louis, MO. Poster 078.

Vitanza, S., Welty, C., Bennett, M., Miller, S., Derksen, R.C. 2006. Effect of Plant Stand Density and Pesticide Application Technology on Insect Pests and Diseases of Bell Peppers [Abstract]. In: Proceedings of the annual conference of the American Society for Horticultural Science, 30 July 2006, New Orleans, LA. Poster 27.

Welty, C. and S. Vitanza. 2005. Insecticide efficacy evaluation of European corn borer control in bell pepper, 2004. Arthropod Management Tests, volume 30, report E52.

Publications in progress:

Derksen, R. C., S. Vitanza, C. Welty, S. Miller, M. Bennett, H. Zhu (in preparation). Field Evaluation of Application Variables and Plant Spacing for Bell Pepper Pest Management. To be submitted to an engineering journal.

Vitanza, S., Derksen, R.C., Bennett, M., Miller, S., Welty, C. (in review). Influence of pesticide application technology and plant stand density on pests and productivity in peppers. To be submitted to HortTechnology.

Vitanza, S. and Welty, C. (submitted). European corn borer control in bell peppers with foliar insecticides, 2005. Arthropod Management Tests, volume 31, report E__ (not yet assigned).

Vitanza, S. and Welty, C. (in preparation). European corn borer control in bell and non-bell peppers peppers with foliar insecticides on different timing schedules.