Project Plan Prospectus
305 Crop Production
NP305 (60%)/NP304 (40%)
May-July, 2003

Old CRIS Project Number
6202-220000-018-00D

Research Management Unit
6202-22 - Areawide Pest Management Research

Location
College Station, Texas

Title
Aerial Application Technology for Crop Production and Protection

Investigators

Wesley C. Hoffmann, Lead Scientist	100%
John K. Westbrook, Research Leader	10%
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Scientific Staff Years
4.1

Planned Duration
60 months

Signatures

Research Leader	Date Approved
Center Director	Date Approved
Area Director	Date Approved
National Program Team Leader	Date Approved

Key Words

Aerial application, drift, precision application, nozzles, pesticides, crop protection, crop production, formulations, adjuvants

Objectives

Objective 1: Develop and evaluate nozzles and other application technologies and spray formulations that reduce driftable fines and improve efficacy of insecticides, herbicides, fungicides or plant/insect growth modifiers on cotton, corn, soybeans, and other major field crops

Objective 2: Develop and evaluate systems for aerial delivery of new crop and pest management materials

Objective 3: Develop and integrate technologies for precision application of crop production and protection materials

Objective 4: Determine effects of meteorological conditions on efficacy and off-target movement of sprays

Need for Research

- *Description of the Problem to be Solved* - Aerial application of crop protection and production materials is an integral component of the highly productive American agricultural system. Agricultural aircraft can apply materials very rapidly over large areas when timing is critical for protecting and enhancing the productivity of a crop. Further, aerial application can effectively treat areas that are inaccessible to other application systems due to wet fields or extensive crop growth. Applicators must work with the latest technological knowledge to deliver their products to optimize product efficacy and minimize off-target movement. Aerial delivery of precise and variable amounts of crop protection and production materials has the potential for significant cost savings to farmers by reducing of the amount of pesticides used on farms. Pesticide labels are changing due to evolving regulatory and modeling data; therefore, applicators must balance application parameters, environmental conditions, and product label requirements during each treatment.

  During ARS planning workshops for crop production and protection, the user community for NP305 and NP304 identified application technology as a program area that needed significant effort. This project addresses these needs and serves as the primary research resource for the aerial application industry encompassing 4,000 fixed- and rotary-wing applicators. These applicators operate small, independent businesses with no other organized research support. As new chemistries and biological controls are introduced into agricultural systems, these materials or agents must be applied in specific ways to maximize benefits and minimize deleterious effects. Applicators must understand how to effectively use these materials that are crucial to the success and implementation of current and future pest management strategies. The goals of this project are to develop and implement new and improved aerial application technologies for safe, efficient and sustainable crop production and protection.

- *Relevance to ARS National Program Action Plans*
  Crop Production - This project contributes primarily to Component 2 (Agroengineering, Agrochemical, and Related Technologies), Part B (Application Technology for Agrochemicals and Bioproducts) of NP305. This project specifically addresses three of the four expected outcomes from Part B. *Crop Protection and Quarantine* - The project also directly supports Component 6 (Integrated Pest Management Systems and Areawide Suppression Programs), Parts D (Implementation of IPM Systems) and E (Transition and Technology Transfer to Users) of NP304. To a lesser extent, the project contributes to Component 5 (Pest Control Technologies), Part E (Chemical Control) of NP304.

- *Potential Benefits Expected from Attaining Objectives* - Accomplishing the stated objectives will benefit aerial applicators, American farmers, agrochemical companies, scientists, and the public as a whole by making the most judicious use of current application methods, equipment, and crop production and protection materials. The development of new equipment, products, and technology will minimize off-target movement of these applied materials. These developments will serve to lessen the tension between applicators and the public caused by the movement of urban populations into traditional farming areas. New crop and pest management technologies developed by this project will significantly reduce, and possibly eliminate, the use of some of the most toxic pesticides used in American crop production systems.

- *Anticipated Products of the Research* - Expected products of this research include new and modified spray nozzles, validation and refinement of spray atomization and deposition models, improved spray delivery procedures, and optimization of new crop production and protection materials. These products and associated technology for their effective use will be delivered to customers through scientific meetings and publications, discussions with aerial applicators, cooperative agreements with industrial partners, field days, implementation of areawide pest management programs, and articles in popular and trade publications. This project is also dedicated to serving as an accessible, objective, and unbiased information resource for pilots and others involved in the agrochemical industry.

- *Customers of the Research and Their Involvement* - Aerial applicators, farmers, crop consultants, and the agrochemical industry will utilize the research results and technologies that are developed and delivered by this project. Input from customers will be obtained from technical and general conferences, research planning meetings, field days, and discussions between ARS personnel and our customers. This input will be used to plan and conduct research projects that are relevant and of high priority to the dynamic American agricultural system. Other ARS locations involved in application research, industry groups, and University personnel will be regularly consulted via research planning and technical committee meetings to coordinate research activities.

Scientific Background

This project contributes to and benefits from coordination with the Unit's three other CRIS projects: 6202-22000-006-00D (Biology, Ecology, and Management of the Boll Weevil), 6202-22000-007-00D (Development of Areawide Management for Corn Earworm, Corn Rootworm & Other Field Crop Pests), and 6202-32000-022-00D (Development of Neuropeptide Mimics for Control of Veterinary Arthropod Pests). Research results relating to enhanced application of crop protection materials are transferred to each of these projects. Engineering and entomological expertise within this project is utilized to supplement other CRIS research projects at Stoneville, MS and Wooster, OH. The project is also enhanced by CRADA's as appropriate. A renewal Memorandum of Understanding with SATLOC Inc. (Phoenix, AZ) is being negotiated to further develop the company's current Global Positioning System (GPS) for agricultural aircraft. The project has a Memorandum of Understanding with Florida Food Products (Eustis, Florida) to evaluate aerial application of new insecticide materials. Project staff members contribute information and technology on aerial spray systems and droplet size spectra to the Department of Defense, Department of State, the Drug Enforcement Agency, and the Central Intelligence Agency. A project scientist serves on the Texas Engineers Task Force on Homeland Security. Project scientists are involved in the development of training and educational modules for the National Agricultural Aviation Association's Professional Aerial Applicator Support System (PAASS) program.

Approach and Research Procedures

Objective 1: Develop and evaluate nozzles and other application technologies and spray formulations that reduce driftable fines and improve efficacy of insecticides, herbicides, fungicides or plant/insect growth modifiers on cotton, corn, soybeans, and other major field crops

- *Experimental Approaches and Procedures* - Current and new spray imaging and measurement equipment will be used to determine locations where small, driftable droplets are atomized by prevalent spray nozzles such as those from CP Products and Spraying Systems. Spray nozzles will be modified or invented to overcome the shortfalls of current spray nozzles. Atomization models for flat fan nozzles not covered by existing models will be developed. Information from nozzle evaluations will be used to simulate spray deposition on cotton, corn, soybean, and other major field crops in a spray table relative to various aerial application parameters. Effects of the depositions will be determined directly from the plants (plant growth regulators, herbicides, nutrients) or indirectly by treating plants infested with insect pests, such as aphids, cotton fleahoppers, and stinkbugs, or infected with pathogens. Promising results from laboratory studies will be verified under field conditions. The field studies will focus on targeting insect pests in corn and cotton as identified by the Unit's other CRIS projects. Since the physical characteristics of a spray (e.g., viscosity) can significantly change the atomization properties of the spray, the performance of commercial and experimental adjuvants for reducing the driftable component of a droplet spectrum will be assessed in wind tunnel and field studies. The influence of control technologies (e.g., left- and right-boom shutoffs) and spray parameters (e.g., height of release, airspeed, droplet size, swath offset) on reductions of downwind drift deposits will be documented in field studies. Electrostatic technologies that coalesce fine droplets with larger, less drift-prone droplets will be assessed for effectiveness at conventional spray rates of 3 to 5 gallons per acre. Spray nozzles and formulations that have potential for reduced production of driftable fines will be measured for atomization properties in wind tunnel studies. Chemicals recommended or labeled for use on different crops/pests will be evaluated including new chemicals as they are introduced into the market.
- *Contingencies* – If modifications to spray nozzles do not significantly reduce driftable fines and improve efficacy of pesticide applications, efforts will be redirected to determine the effect of changing the physical location of nozzles on agricultural aircraft. Relocation of the nozzles may prevent the small droplets from becoming entrained in the turbulent air created by the aircraft's wheels and the trailing edge of the wing. Spray table facilities will be used to investigate new chemistries that may not be registered for field applications.

Objective 2: Develop and evaluate systems for aerial delivery of new crop and pest management materials

- *Experimental Approaches and Procedures* - Among the most exciting new approaches in pest management is the use of specific attractants/stimulants mixed with an insecticide for controlling targeted pests or preventing adult reproduction of these pests. Adult controls have been developed for corn rootworm and are being developed for several species of noctuids and other pests. These new pest control methods are very sensitive to application parameters such as droplet size, droplet density, and spray rate. Methodologies for applying baits, feeding stimulants, or experimental products will be developed to deliver these products precisely to the locations of infested or infected plant parts. The components (attractants, stimulants, and insecticides) will be formulated and evaluated through aerial application to optimize efficacy. New application equipment such as electrostatic spray systems, aerial strip-spraying of attracticides, and other novel technologies will be developed and/or evaluated to improve efficacy of pest control products as they are integrated into management systems. Spray applications will be evaluated in commercial production fields. Biological effects of new pest management materials will be determined by field counts of the target pest, and by assessment of crop damage when compared to untreated or conventionally treated areas. Materials that are effective in test plots will also be evaluated in large-scale field trials. Effective adult control technologies will be integrated into current farming and pest control systems.
- *Contingencies* – If attempts to develop more effective crop production and protection materials are unsuccessful, efforts will be refocused to develop spray technologies that improve efficacy or reduce effective rates of the most commonly used materials in corn and cotton. If field studies prove to be too variable, aerial application parameters will be simulated in the spray table facilities to treat plants for bioassay and/or cage studies using crop pests.

Objective 3: Develop and integrate technologies for precision application of crop production and protection materials

- *Experimental Approaches and Procedures* – Initial efforts will be directed towards the development of equipment and controls for an automated on-off spray system. The purpose of the on-off system is the prevention of off-field or buffer zone spraying based on GPS coordinates of the field and buffer zone boundaries. The systems will factor in the position, speed and heading of aircraft in relation to these boundaries. Concurrent with the on-off system design, development of equipment and controls for variable-rate application will be initiated, which may include the use of direct injection nozzles. Once completed, the variable rate system will be coupled with the on-off system. These spray systems will be automated with pilot controls for start-up, shutdown, and override. The new spray system will be adapted and integrated onto an Air Tractor 402B aircraft. Operation of the variable-rate application will require the coupling of GPS and Geographic Information Systems (GIS) information in order to define field edges as well as required application dosages by field location. GIS data will be integrated with the GPS system on modern agricultural aircraft to control spray equipment so that spray is delivered only to targeted spray areas. Field data or satellite imagery will be used to determine areas within fields that need to be treated, and the technology will automatically activate equipment to spray only these areas with variable amounts of pesticide as indicated by the GIS data. Insect pests, weeds, and diseases that are amenable to precision application in corn, cotton, soybeans, and other major field crops will be identified. The effect of precision applications for these specific targets will be determined under simulated laboratory conditions or in field trials. Sensors will be interfaced with aircraft GPS/GIS systems to monitor variables important to precision application of

pesticides. Variable-rate aerial applications will be implemented based on GIS/GPS-defined zones that require higher- and/or lower-than-normal rates.
- *Contingencies* – If the precision of currently available GPS/GIS technology proves insufficient for accurate and reliable application of on-off systems on relatively high-speed aircraft, research efforts will be focused on developing spray control software and equipment that attains the desired precision. This system will be designed solely for on-off controls at field margins, which can be predefined before the aircraft begins spraying.

Objective 4: Determine effects of meteorological conditions on efficacy and off-target movement of sprays
- *Experimental Approaches and Procedures* - Meteorological measurements will be analyzed to develop a probability assessment of the incidence of atmospheric inversions as related to time of day, wind velocity, and other meteorological parameters at several crop production areas in Texas. The influence of crop canopies on environmental trespass of aerially sprayed materials will be determined in field studies. The impact of temperature inversions on spray deposition and drift measurements will be defined. Interactions between crop canopy, wind direction, and wind speed on atmospheric turbulence above and within crop canopies will be evaluated to determine the significance of turbulence on spray deposition, airborne spray composition, and pesticide efficacy. Biological assessments and mass accountability will be coupled with deposition and drift measurements to elucidate the impact of spray applications under a variety of atmospheric conditions. As the effects of meteorological conditions on spray deposition and off-target movement are identified, simulations of the on- and off-target deposition will be made on a spray table to evaluate the effects on target and non-target organisms following procedures similar to those in Objective 1. Based on real-time air temperature measurements, equipment will be developed and installed in the cockpit to measure the temperature lapse rate, as an indication of atmospheric stability. This equipment will alert an applicator if they are treating a field under stable atmospheric conditions.
- *Contingencies* – If temperature inversions are to fleeting for reliable and repeatable field studies, field studies focusing on deposition and drift will be limited to stable meteorological conditions. The data will be used to further validate AgDrift, which is a computer model used by researchers and regulators to predict downwind spray deposition. Studies will also be conducted over a range of droplet sizes and wind speeds to predict their impact on spray deposition and drift.

Collaborations
ARS: Steve Thomson and Lowrey Smith (Application and Production Technology Research Unit, Stoneville, MS); Eugene Milus (U.S. Wheat and Barley Scab Initiative, East Lansing, MI); Richard Derksen (Application Technology Research Unit, Wooster, OH)

Non-ARS: Milton Teske (Continuum Dynamics, Ewing, NJ); Leland Snow (Air Tractor, Olney, TX); Greg Guyette, (SATLOC, Inc., Scottsdale, AZ); Jerry Brown and Robert Schroder (Florida Food Products, Eustis, FL); Daniel Fromme (Texas Agricultural Extension Service, Wharton, TX); Dale Faust (National Agricultural Aviation Association Research and Technology Committee, Casselton, ND); Darrell Frey (Lakeland Dusters Aviation, Corcoran, CA); Carlos Blanco (Dow AgroSciences, Beaumont, TX).