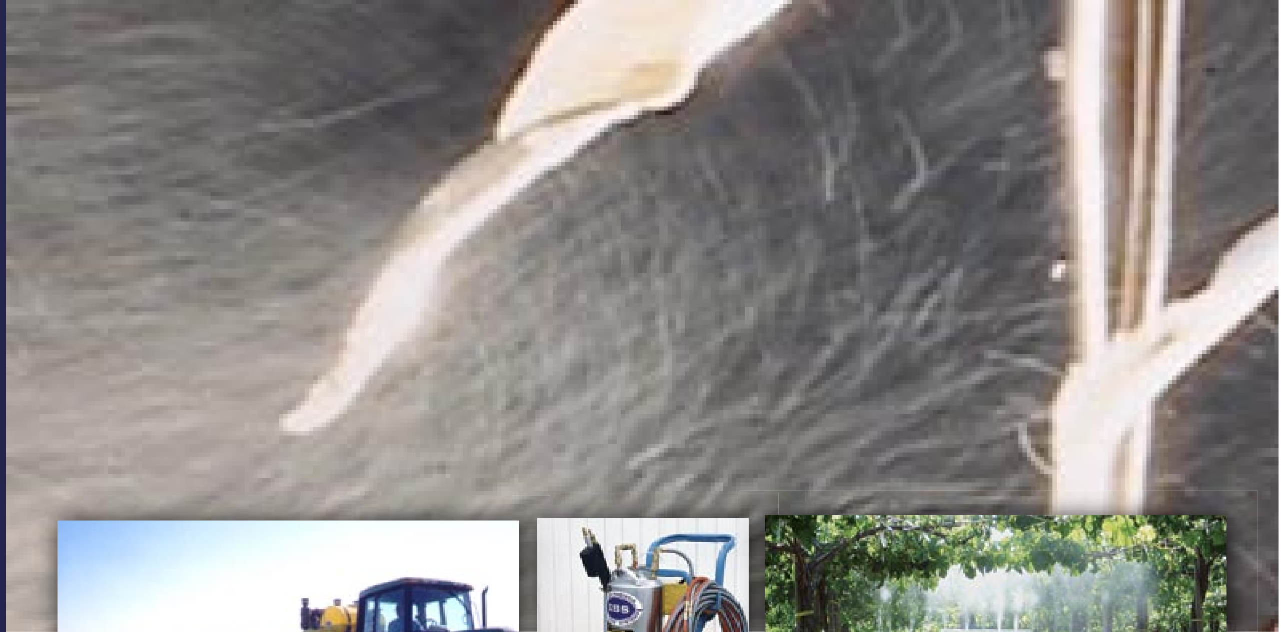


What Growers Should Know About Air-Assisted Electrostatic Spraying

Data submitted by leading univerisites demonstrate that air-assisted electrostatic sprayers:

- Significantly increase insect and disease control.
- Reduce the amount of agrichemical applied.
- Cut the application water used by half.
- Reduce waste and off-target drift by over 50%.

ESS

What is Air-Assisted Electrostatic Spraying?

Air-assisted electrostatic sprayers manufactured by ESS produce spray droplets which are 900 times smaller than those produced by conventional sprayers. These tiny droplets are carried deep into the plant canopy in a high-speed air-stream. The result is more than twice the deposition efficiency of both hydraulic and non-electrostatic air-assisted sprayers.

Electrical charging causes a natural force of attraction between the spray droplets and the plant, similar to the attraction between items of clothing created by the tumbling of a clothes dryer. The charge on the droplets is small, but the force pulling the spray towards the plant is up to 75 times greater than the force of gravity. Droplets literally reverse direction and move upwards, against gravity, when passing a leaf surface (Figure 1). This remarkable phenomenon by which the spray coats the undersides of the leaves and the backsides of the stems is known as electrostatic "wraparound."

Spray coverage is the uniformity of spray droplets on plant surfaces. Figure 3 demonstrates leaf coverage using air-assisted electrostatic sprayers with that of hydraulic sprayers. Electrostatic sprayers achieve greater spray coverage by combining air turbulence with tiny, evenly sized spray droplets. Dense under leaf coverage (Figure 2) results from electrostatic wraparound. The benefits are clear: insect and disease control are better because the chance of contact is greater (see "A New Way to Look at Under Leaf Spray Coverage" on page 6). Chemical burn is reduced because chemicals do not accumulate in large single deposits.

Low-volume spraying requires 10 to 25 times less water carrier than standard spraying. This is possible because of the uniform droplet size and improved coverage characteristics achieved by the electrostatic sprayer.

ESS air-assisted electrostatic sprayers allow you to cover an average of 30 or more acres per 150 gallon tank of chemical. Compare this to the 500 gallon tank on most hydraulic

Figure 1. Electrostatically charged spray droplets reverse direction and defy gravity to coat stems and the undersides of leaves. Photo: The University of Georgia

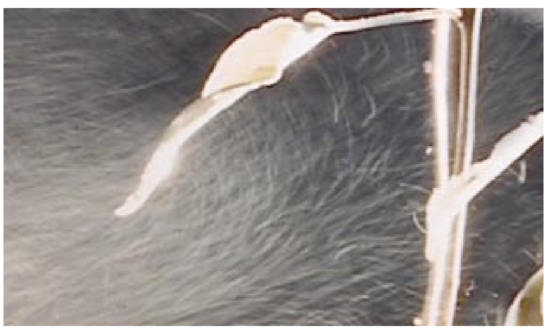


Figure 2. This magnification of a leaf underside showed that the whole leaf had 15,000 spray droplets on it (as counted by a computer).

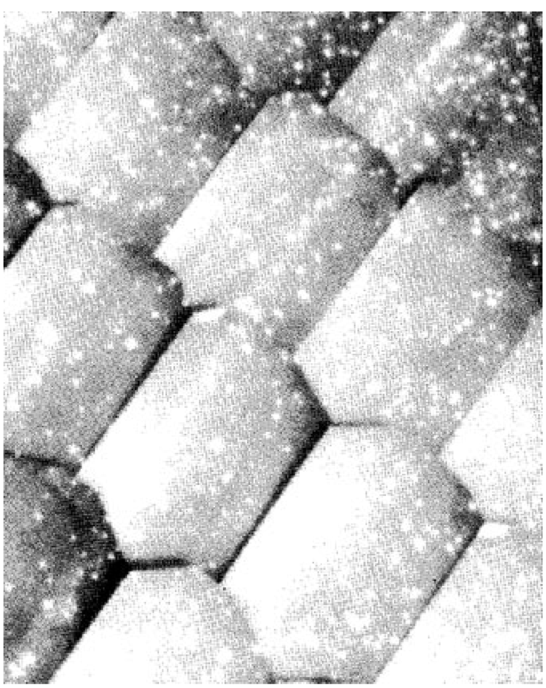
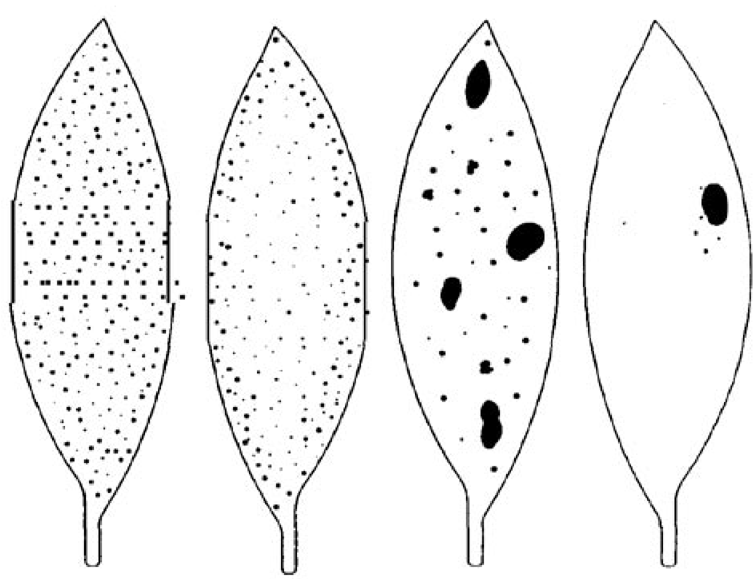


Figure 3. Illustrations based on microscope evaluations of spray deposits on plant leaves. The coverage with the air-assisted electrostatic sprayer is a fine powder coat which is well distributed on both sides of the leaf (see photo below). Hydraulic sprayer droplets (right) vary widely in size and often "puddle" on the leaf.



Front Back Front Back

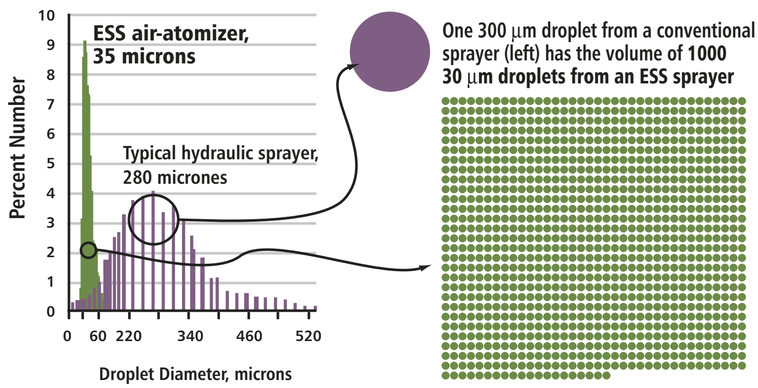
ESS Air-Assisted Charged Spray Deposit   Hydaulic Spray Deposit

How the ESS Nozzle Works

The heart of the air-assisted electrostatic sprayer is the patented "air-atomizing induction-charging" nozzle, which was invented and refined at the University of Georgia.

Air and liquid enter the rear of the nozzle separately. The air moves through the nozzle at a high speed and intersects the liquid at the nozzle tip (Figure 4), causing the formation of spray droplets that are 30 to 60 microns in diameter (Figure 5). The air pressure required is 15 to 60 psi, and the liquid pressure is below 30 psi. In comparison, a hydraulic sprayer would require nearly 3,000 psi to achieve equivalent atomization.

Figure 5. Droplet size is important in sprayer performance. Droplets between 25 and 60 microns enhance spray coverage and are best for insect and disease control. The volume of one 300 micron diameter drop equals 1000 droplets of 30 microns. Ohio State University



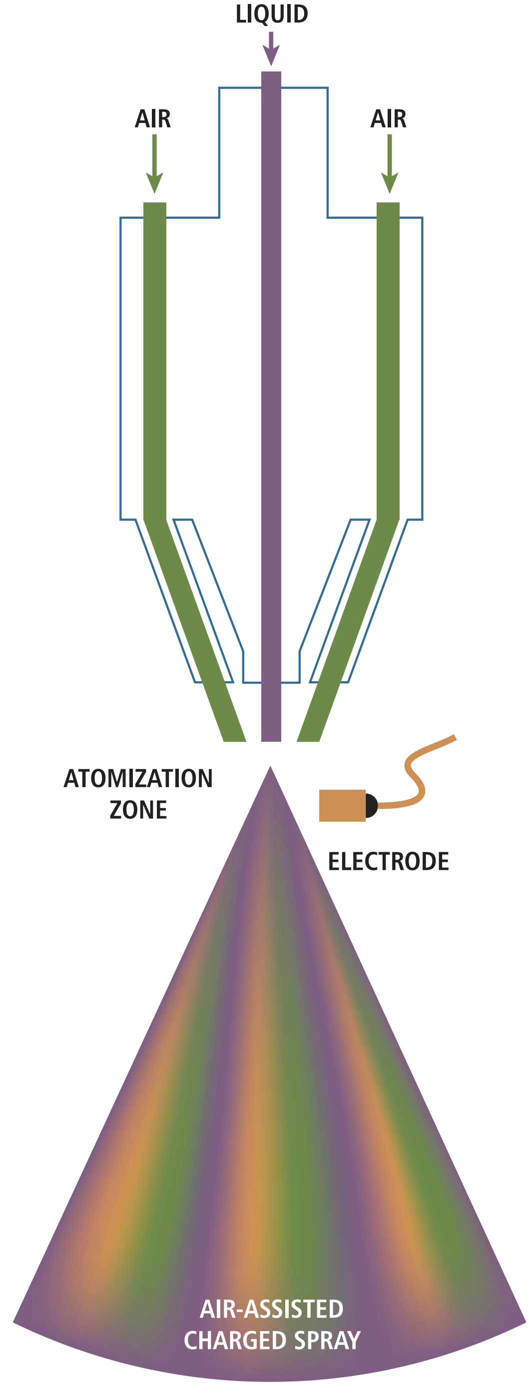
As the spray is atomized, the droplets pass an electrode (Figure 4) that induces a negative charge on each one. The force of the turbulent air stream then propels the charged droplets deep into the plant cover. Positive electrical charges on the plant surface cause a natural attraction between the plants and the droplets. Following the natural lines of force, some of the droplets wrap around the plant's leaves and stems to coat their undersides (Figure 1). Once the droplets contact the leaves, they lose their electrical charges.

ESS air-assisted nozzles are self-cleaning. When the liquid pressure is shut off, the remaining spray is automatically siphoned out. Air continuously moving through the nozzle and a larger liquid passage help prevent clogs and reduce maintenance.

The spray nozzle tip of the electrostatic sprayer does not wear like that of a hydraulic sprayer, even when using wettable powders. Hydraulic spray tips wear because abrasive liquid passes through the opening under high pressure, but the electrostatic sprayer uses very low pressure. The atomization process is "frictionless" because it takes place in mid-air, in the atomization zone, which is just outside the nozzle tip.

- **Canopy penetration**
- **Wraparound effect**
- **Under-leaf and stem coverage**
- **Reduced leaf burn**
- **Fewer refill trips**
- **Self-cleaning nozzles**

Figure 4. ESS Nozzle



Research on Air-Assisted Electrostatic Sprayers

Studies at university experiment stations are designed to analyze one of four important areas:

1. spray deposition and coverage,
2. insect and disease control,
3. environmental and worker safety, or
4. crop safety.

1. Spray Deposition and Coverage on Plants

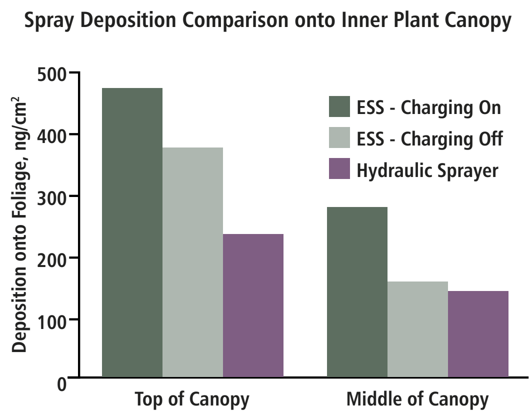
Deposition testing demonstrates sprayer efficiency by measuring the amount of spray deposited on the plant. Deposition tests look at spray on specific areas of the plant such as leaf undersides or areas inside the plant canopy where insects and disease problems are found. Low spray deposition indicates off-target movement by run-off or drifting.

Crop: Broccoli. Study: Broccoli plants form hard-to-penetrate, deep, dense canopies with many leaf layers.

Results: Figure 6 shows the results of a large-scale test with fluorescent tracer powder added to the spray tank. After spraying, researchers measured the amount of tracer deposited on each individual leaf. Results showed that the air-assisted electrostatic system deposited 72% more active ingredient than the conventional sprayer and 49% more than the uncharged air-assisted sprayer.

To control most insect and disease problems, it is important to cover interior plant regions. Deposition measurements made on the inner parts of the broccoli plants showed that the electrostatic sprayer deposited two times more spray than either the conventional hydraulic sprayer or the uncharged air-assisted sprayer. Georgia Agricultural Experiment Stations

Figure 6. This graph shows the quantity of active ingredient deposited onto broccoli plants. A two-fold improvement in spray deposition was achieved on the inner-canopy leaves using the air assisted electrostatic sprayer. University of Georgia.

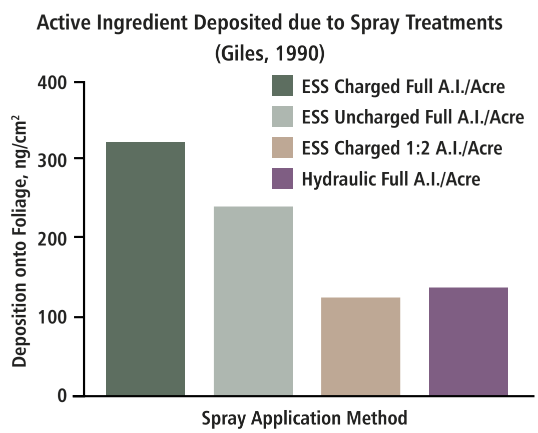


Crop: Strawberries. Study: Strawberries are difficult to spray effectively due to the shape of the plant and the density of the canopy. The larger outside leaves shield the inner canopy, and the lower leaves lie against the mulch.

Results: Field trials (Figure 7) show that an electrostatically charged sprayer deposited 2.4 times more spray per leaf than a conventional high-pressure strawberry spray rig. Further trials using the air-assisted electrostatic sprayer *with the charging unit turned off* revealed the benefit of the air-assist feature alone: the spray deposition was 1.7 times higher than the hydraulic sprayer.

In a third study, researchers used the same sprayer with the charging unit turned on *but at only ½ the normal rate of chemical*. It achieved deposition equal to that of a conventional sprayer operated at the full rate. Using application rates of seven gallons per acre allowed researchers to spray for a much longer period of time between refills. In some cases, they were able to complete nearly twice the usual acreage in one day. University of California

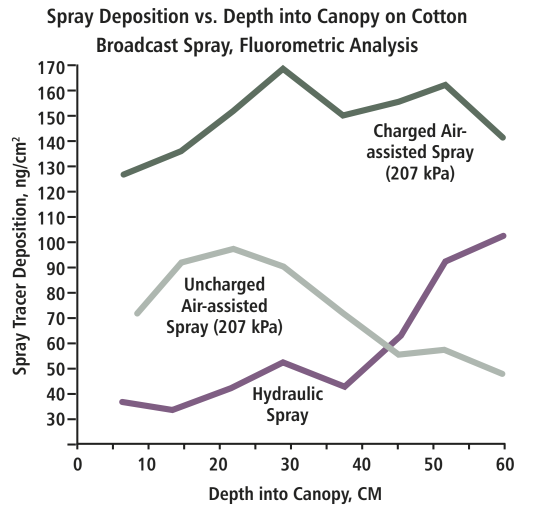
Figure 7. Spray deposited onto strawberry foliage. Trials performed by the University of California and the California Strawberry Advisory Board. University of California, Davis.



Crop: Cotton. Study: Because cotton is a tall crop, it is good for testing canopy spray penetration and coverage throughout the plant.

Results: Electrostatic sprayers of the past were less effective because they didn't utilize air assistance. Without the air carrier, charged spray can only coat the top of the crop. Turbulent air-assistance greatly enhances crop penetration while helping to reduce chemical drift. Figure 8 shows the results of a typical test on ten-week cotton. The air-assisted electrostatically charged sprayer deposited significantly more spray in the canopy top, center and bottom than the hydraulic sprayer. Georgia Experiment Stations

Figure 8. Good canopy penetration and excellent spray deposition uniformity from the top of the canopy to the bottom results from using the air-assisted electrostatic sprayer. University of Georgia, USDA.



A common problem with air-assisted sprayers is that the spray can be blown all the way through the other side of the plant canopy or down to the ground, resulting in poor deposition. Research on cotton funded by the U.S. Department of Agriculture demonstrates that when air-assisted sprays are electrostatically charged, this problem is greatly reduced. As Figure 9 shows, when air speed increases, the deposits of uncharged air-assisted sprayers tend to decrease because the spray is being blown through the crop. When the spray is electrostatically charged, the droplets are drawn to the plant, and spray deposition is increased by as much as three-fold.

Crop: Chrysanthemums. **Study: Compare the residule effects of pesticide applied using air-assisted electrostatic vs. hydraulic handgun sprayers.**

Results: Pounce™ was applied once. Pesticide levels on plants were then measured throughout a two-week period (Figure 10). With the charged spray, the initial deposition was 3.5 times greater and the pesticide remained on the plant longer. This increased residual effect helps break the life cycle of insects such as whitefly. At Day 5, the plants treated with charged spray had 4.4 times more pesticide remaining. At Day 10, the remaining pesticide from the charged spray was 4.6 times greater. The average half-life of the pesticide was 10.5 days with the air-assisted electrostatic spray but only eight days with the hydraulic spray. University of California

Where Does the Spray Go?

In a test comparing a conventional hydraulic hand sprayer with an air-assisted electrostatic system, the hydraulic sprayer deposited only 16% of spray on the plants while the ESS unit deposited 60% on the plants. This is a remarkable four-fold difference in efficiency. Figure 11 (next page) shows where the rest of the spray went.

With the electrostatic sprayer:	With the hydaulic sprayer:
60% went on the plants.	16% went on the plants.
9% went onto the bench.	27% went onto the bench.
1% went to the aisle.	4% went to the aisle.
3% went under the bench.	2% went under the bench.
27% was undetermined.	**51% was undetermined**.

Sprayer performance was significantly improved using air-assisted electrostatics. A report from the University of California clearly states, "If the chemical rate were reduced by three-fold when using the electrostatic unit, the amount [deposited] onto plants would still be greater than the conventional at full rate. But, the amount of chemical moving off-target would be one-tenth that of the conventional application."

Figure 9. As air pressure (and air velocity) increased the electrostatically charged spray deposition increased. Both uncharged sprayer deposits went down. This is due to an air boundary-layer at the leaf surface much like a car in a wind tunnel. The boundary layer is effectively overcome by charged spray. University of Georgia, USDA.

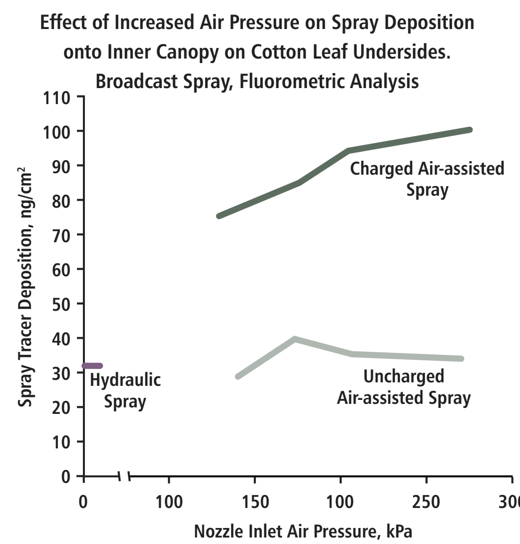


Figure 10. Deposition of Permethrin onto mature chrysanthemums was initially 3.5 times higher using the air-assisted electrostatically charged sprayer compared to a conventional sprayer. The average residual life was over 20% greater. University of California, Davis.

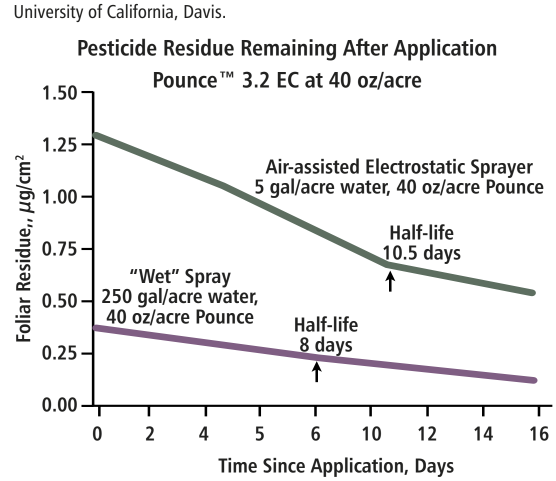
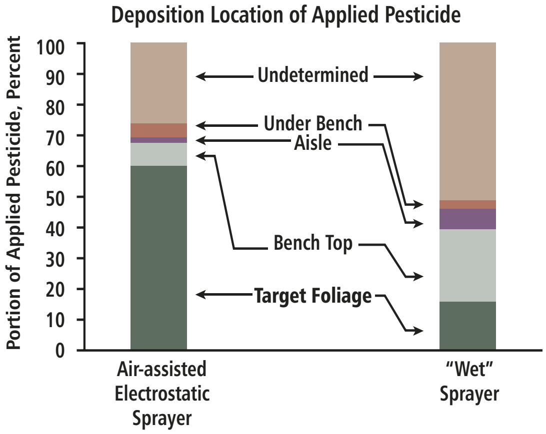


Figure 11. Spray deposition to various locations in the greenhouse comparing air-assisted electrostatic sprayers to conventional high-volumn hydraulic sprayers. University of California, Davis.



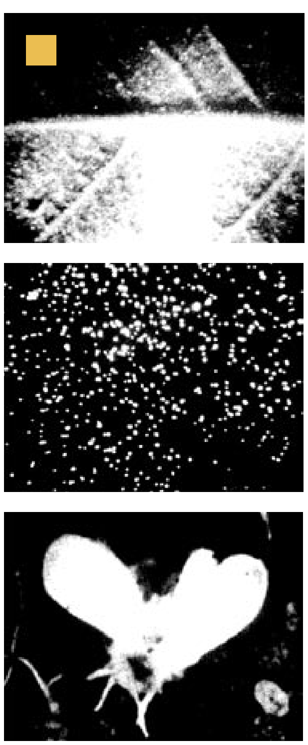
A New Way to Look at Under-Leaf Spray Coverage

Inspired by a system at Cornell University, the University of Georgia and ESS developed an extraordinary spray deposition analysis technique called **"image-intensified computer vision"** in which a computer is used to view and count spray droplets on leaves.

Using different sprayers, researchers spray a fluorescent powder onto plants. They then remove the leaves and view them using a special camera attached to a computer. Magnification of up to 600X allows even minute droplets and insects to be seen.

The top image in Figure 12 shows a computer view of the underside of a 4 mm^2 leaf section. The middle image is the same leaf section viewed using a light intensifier and an optic filter that eliminates the leaf background. The white dots are spray droplets. The computer system counts the spray droplets, revealing that there are over 200 in this 4 mm^2 area. This is the same size area that would be occupied by a single adult whitefly, such as a Banded-Winged whitefly (bottom). Comparing these images (all made at the same magnification), it is easy to see that the air-assisted electrostatically charged spray distribution is adequate to cover the insect with many droplets.

Figure 12. Magnified view of a 4 mm^2 leaf section (yellow square shows actual size). The middle image is the same section as viewed with a light intensifier and filter that hides the background so even the smallest fluorescent spray particles (the white spots) can be seen. The bottom image shows an adult Banded-Winged whitefly and nymphs on a cotton leaf underside. Each of these images is of the same size area and is enlarged to the same magnification so it is plain that the air-assisted electrostatic sprayer will cover insects with hundreds of droplets.



2. Insect and Disease Control

Field Crops

The previous reports showed improved spray deposition with air assisted electrostatic sprays. The bottom line for the grower, however, is control of insects and diseases.

Crop: Celery. Study: A large-scale three-year test program on a commercial farm in Florida. Predominant insects were leaf miners and cabbage loopers. Insecticides used during the test were Lorsban, Ambush and SOK. Predominant diseases were early blight *Cercospora Apii*, *Rhizoctonia* and *Alternaria*. The fungicides used were Bravo 500, Manzate and copper. Researchers made efficacy comparisons between conventional equipment dispensing at full rate of chemical in 55 gallons of water per acre and the air-assisted electrostatic sprayer dispensing ½ to ¾ rate insecticide and fungicide in only 5 gallons of water per acre.

Results: During the course of the program, no difference in infestation was noted between the reduced-rate air-assisted electrostatically treated plots and the full-rate conventionally treated plots. At harvest, the yields were 32% greater in the air-assisted electrostatically treated plots, yielding 965 crates per acre versus 652 crates in the conventionally sprayed plots.

Crop: Cabbage. Study: Researchers conducted commercial field trials using low-toxicity chemicals in side-by-side comparisons of a grower's normal field sprayer and the air-assisted electrostatic sprayer for control of Lepidoptera and onion thrips. Cornell University

Results: They discovered that *Bacillus thuringiensis* reduced the Lepidoptera populations an average of 86% with the electrostatic system but only 47% with a conventional system. When applying synthetic pyrethoid chemicals (SP) to onion thrips, the results were a 62% reduction with the electrostatic system, compared to only a 31% reduction with the conventional sprayer.

With the strong trend toward using lower-toxicity, more environmentally safe pesticides, it is important to note that several recent evaluations have shown that the action of these safer materials is significantly enhanced by the air-assisted electrostatic system. Studies included the insect growth regulator Dimilin, the viral insecticide Elcar, and the microbial insecticide Javelin (*Bacillus thuringiensis*). The air-assisted electrostatic system gave good results with these materials in all spray trials targeting beet armyworm and corn earworm (Figure 29).

Greenhouse Crops

Growers of specialty crops, such as greenhouse ornamentals and vegetables, are faced with an ever-decreasing number of available pesticide formulations. Crop appearance is vitally important, so several universities, with funding from ornamental grower groups, have evaluated the electrostatic sprayer as a way to improve the action of the more environmentally safe materials that remain available.

Plant: Poinsettias. Study: Researchers at Ohio State University, which has a program to help growers implement new spray technology, studied the use of Talstar (bifenthrin) in an air-assisted electrostatic sprayer to control whitefly nymphs.

Results: Nearly 100% control was achieved in this single-application test, in spite of a mistake which led to **only 1/6** and **1/12 chemical rates** being used.

Plant: Impatiens. Study: Researchers applied AVID 0.15 EC at 12 ml/l onto impatiens infested with two-spotted spider mites and aphids. They then rated the infestations on a 0-4 scale, with 0 indicating no mites or aphids per terminal shoot and 4 indicating over 50. During the applications, plants were placed in positions 1.5 m, 4 m and 6 m from the spray nozzle. Ohio State University

Results: Spider mite control was 100%, even at the most distant plants. Aphid control was also good, rating 1 or less, and was very uniform across the wide spray swath.

Other Results: In another set of evaluations, researchers collected data on the effectiveness of AVID and Talstar when applied with several different spraying systems. As Figures 13, 14 and 15 show, the air-assisted electrostatic sprayer consistently yielded the highest level of insect control, even at minimum label rates. University of Georgia Agricultural Station

In all greenhouse applications, the electrostatic sprays were done in ½ to ¼ the time of the hydraulic spray applications.

Environmentally safe insect growth regulators such as Enstar (Sandoz), and Margosan-0 (Grace-Sierra), are now in widespread use. Favorable results with each material were achieved using air-assisted electrostatic sprayers. For example, when researchers applied Margosan-0 at 2/3 rate to poinsettias within 4 m of the nozzle the charged spray achieved control that was nearly double that achieved by the uncharged treatments. Ohio State

Electrostatic spray application of ENSTAR insect growth regulator has been shown to be an effective tool for controlling sweet potato whitefly both when used at higher rates alone, and when used at lower rates in a rotation with an adulticide. Figure 16 shows results of spray applications of ENSTAR used in conjunction with THIODAN 50WP adulticide. The plants were mature poinsettias infested with all life cycle stages of sweet potato whitefly. By monitoring the cast skins (empty pupal cases) left after the adult whiteflies emerged, researchers were able to demonstrate that ENSTAR was significantly more effective in reducing adult emergence when applied with the air-assisted electrostatic sprayer than when applied with a conventional high-volume sprayer.

Figure 13. Live aphids remaining after treatment with AVID on chrysanthemums using various greenhouse sprayers. Univ. of Ga.

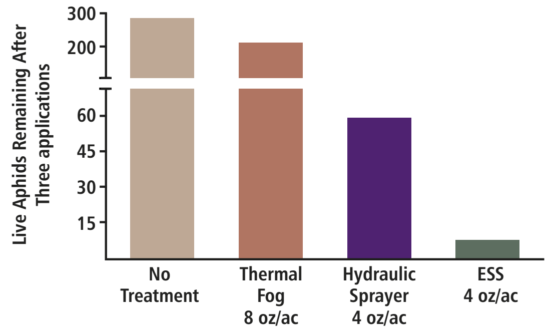


Figure 14. Live whitefly remaining 24 hours after treatment with Talstar on poinsettias using various greenhouse sprayers. University of Georgia.

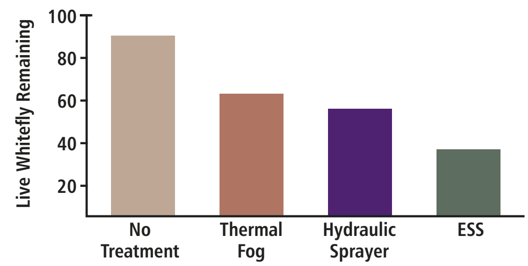


Figure 15. Live thrip remaining after experimental treatment with AVID using various greenhouse sprayers. University of Georgia.

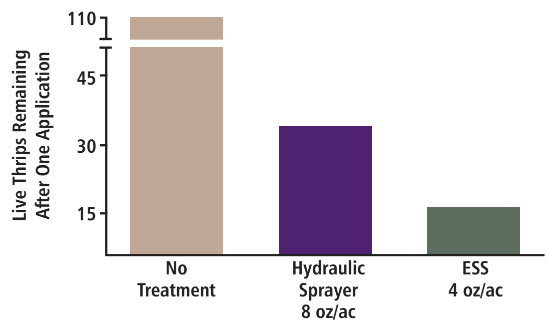
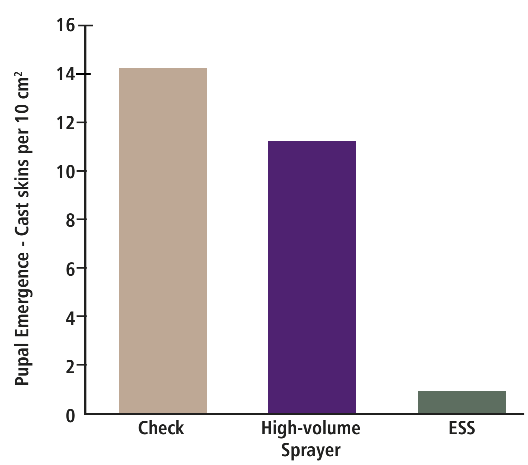


Figure 16. Whitefly cast skin count 21 Days after three applications of Enstar at 8 oz. rate plus adulticide. Univ. of Georgia.



3. Worker Safety

A significant test revealed that workers applying charged spray experience very low levels of chemical exposure and no more than they would experience when applying uncharged spray.

The test consisted of handgun spray trials comparing deposition with and without the charging on. The test results indicated that 3.3 times more chemical reached the plants with the charged spray. However, charging **did not increase deposits onto the sprayer operator** or the greenhouse structure. In contrast, much of the chemical from the uncharged spray could not be accounted for. University of Georgia

4. Environmentally Safe Pesticides

In commercial agriculture, pesticides are vital for profitability, low food prices and for maintaining an adequate food supply. Without pesticides, crop losses could be as high as 50% for field crops and up to 100% for fruit crops and greenhouse ornamentals. A study by the Office of Technology Assessment determined that without pesticides, U.S. food prices as a whole would increase 50% and the cost of vegetables would increase by as much as 95%.

The public, governments and producers themselves are becoming increasingly alarmed about the hazards associated with pesticides in the environment. Much of the environmental impact results from overuse and off-target movement of toxic pesticides from inefficient spray application.

Growers must balance their need to use pesticides with their responsibility to minimize the possible adverse effects of those chemicals. Fortunately, a growing number of environmentally safe pesticide compounds are available for use in place of hazardous chemicals. However, these alternative materials are generally less effective than conventional pesticides **unless they are placed directly at the site of insect or disease activity**. They are also often very expensive. It is estimated that the high-volume hydraulic sprayers used by most growers deliver less than 1% of chemical to the sites where insects and disease organisms thrive.

With the air-assisted electrostatic sprayer, growers have a powerful new weapon in their pest-control arsenal. These sprayers not only improve coverage, they also significantly improve the action of less-toxic, more environmentally safe chemicals. In addition, air-assisted electrostatic application has been proven to reduce worker exposure to chemical drift.

In order to achieve desirable pest control levels and economic thresholds with environmentally "soft" pesticides, present application methods need to be improved, particularly regarding distribution of spray to under-leaf surfaces. Air-atomizing electrostatic sprayers are overcoming the deficiencies of conventional sprayers. Air delivery reduces drifting and increases spray penetration and turbulence within the plant canopy. Electrostatic charging increases spray deposit level, reduces waste and greatly improves spray distribution for better insect and disease control.

Equipment Payback

Case studies have been done to determine the actual payback time on air-assisted electrostatic systems. This type of data varies widely due to farm size, crop types and the factors used to calculate payback. In general, the payback is extremely quick: **averaging about eight months** for both greenhouse growers and row-crop vegetable producers. Growers cite both tangible and intangible benefits in questionnaires. The benefits to which solid economic values can be attached and that are cited most often in case studies are:

1. Net **chemical savings of more than 50%** and the ability to use less-expensive chemicals.
2. **Labor savings of 30% to 50%** from reduced spraying time.

Greenhouse growers tend to move through the greenhouse about 50% faster. Row-crop growers spend about 30% longer in the field between tank fills, which translates to more acres per day and less days in the field.

Other benefits most often cited are:

1. Good results when using less toxic chemicals.
2. Improved crop quality and overall appearance.
3. Simplicity of operation and low maintenance.
4. Longer intervals between sprays.
5. Less waste, no run-off and no chemical residue visible on plants.
6. Better insect and disease control.

With so many documented advantages and payback in less than one year, the air-assisted electrostatic sprayer has become an essential piece of equipment for growers who want to succeed in today's marketplace. For more specific information on ESS' line of row crop, greenhouse or grape sprayers, please call us today:

1-800-213-0518
www.maxcharge.com

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