Final Report for Northeast SARE Grant FNE10-689
Development of a Low Cost Vertical Patternator

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1. Goal

The use of an agricultural airblast sprayer with improperly positioned and/or defective nozzles results in spray drift, poor pest control and inaccurate application. When these conditions exist, the farmer, in order to maintain proper pest control, must use more pesticides. Any spray drift from the target results in lower deposition and consequently reduces insect and disease control. With properly positioned and maintained nozzles, the pesticides that are used are applied efficiently and effectively.

Newer pesticides in use today are much higher in cost and often carry a much greater risk of the target organism developing resistance to the pesticide. Pesticides must be deposited on the plant at the proper rates for control of pest and disease problems. It has been estimated that in trees sprayed with an airblast sprayer, 55% of the spray hits the target, 20% ends up on the ground and 25% remains airborne as spray drift.

The use of a spray patternator reveals exactly where the spray is deposited. The rotating fan in an airblast sprayer forces air upwards on one side and down on the other. Nozzles must be oriented differently on each side for effective application. The use of a spray patternator allows the nozzles to be adjusted properly to compensate for sprayer design and differences in nozzle type. A patternator reduces waste created when pesticide sprays are not hitting the target. This in turn reduces environmental risks and prevents agricultural pollution from pesticide drift. The use of a patternator can reduce costs, increase productivity from reduced pesticide use, better application and increase the efficacy of the pesticide with improved spray deposition. The purchase or construction of a patternator can vary from very expensive to moderately expensive depending on the design.

The goal of this project is to design an inexpensive, more efficient vertical patternator that is easily constructed by any farmer and has $100 or less in newly purchased material costs. The patternators developed in this project will be constructed entirely of newly purchased parts to reflect the true cost of construction. Various patternators will be built and tested for their ability to quantify the spray pattern of an airblast sprayer.

2. Farm Profile

I am a part-time farmer currently farming 5 acres with my brother. The land is rented from our mother. The total size of the present farm is only 7.8 acres, although it has been cultivated by our family for seven generations. There is no house on the premises, only a 40' by 60' tobacco barn. My brother and I first planted wine grapes on the farm in 1974. Today a total of 3.5 acres is planted in wine grapes and includes the French hybrids: seyval, vidal and chambourcin and pinot noir, a vinifera. The vidal was planted in 1976, chambourcin in 1980, seyval in 1984 and 1986 and pinot noir in 2007, 2008 and2009.

Vines are grown with unilateral or bilateral cordon training on the bottom wire. A standard three wire system with wires at 36, 54, and 72 inches is used for the trellis. The vines are trained using vertical shoot positioning. Vineyard spacing is 9 foot wide rows with 6 feet between the vines in the row. An area of approximately one half acre is used for the growing and production of grafted vines and other varieties. Since 1989 I have also grown one half acre of saffron on the farm. Previously I was the only commercial grower of saffron in the United States. The saffron was harvested, dried, packaged and sold directly to retail outlets under the label of Greider's Lancaster County Saffron. Since 2004 the saffron harvest has been dramatically reduced to the point we no longer have a sufficient quantity for sales.

The farm is composed entirely of Duffield silt loam with a 0 to 3% slope on the top of a small hill. The location provides excellent air drainage with no frost pockets. The surrounding area is almost entirely in farmland and is located in an agricultural security area. There have been no changes in the operation since the initiation of the SARE project.

3. Participants

The technical advisor for this project is Mark Chien of Pennsylvania State University . Since 1999, Mark has been the wine grape agent for Penn State Cooperative Extension. Currently he is serving all of Pennsylvania.

4. Project activities

The goal of this project was to develop two different versions of a vertical spray patternator along with a lower priced modified Cornell patternator. A modified Cornell patternator was built to allow comparisons between the various designs. Another objective was to develop a patternator that has $100 or less in newly purchased material costs.

During 2006, Dr. Andrews Landers of Cornell University and Dr. Emilio Gil, developed two different designs of vertical spray patternators. Dr. Landers's design is known as the Cornell patternator and Dr. Gil's is called the UPC patternator. The cost of materials for the Cornell design was $489.28 in 2006, while the material cost for the UPC design was $820.33. The Cornell design has been utilized by growers in New York State, Maine and Canada. Information on the Cornell and UPC patternators may be found at http://web.entomology.cornell.edu/landers/pestapp/documents/Patternator.pdf and http://web.entomology.cornell.edu/landers/pestapp/documents/CornellPatternator_000.pdf.

The first part of this project was to develop a much lower cost and easier to construct Cornell type patternator. The Cornell patternator utilizes window screen to collect the spray generated by an airblast sprayer and the SARE modified Cornell design also utilizes the same material. Only the final design will be described, but numerous modifications were tried and rejected in order to lower the cost and improve reliability. All patternators built for this project are based on multiple panels with a standard size of 3 feet wide by 1 foot tall. A standard size panel allows for test results of the various designs to be compared statistically. The panel size was selected because it captured a majority of the spray and was not too large to be cumbersome.

All materials for the patternators were purchased at large national home improvement stores and farm supply stores.

A. modified Cornell patternator

Parts and instructions are for building an 8 foot tall vertical patternator for vineyard use. If a taller patternator is needed the design can be extended. The Cornell patternator is based on using window screen to catch the spray from an air-blast sprayer. It is divided into numerous sections that allow the user to quantify the amount of spray in each section. This design divides the patternator into seven sections of one foot by three feet.

Materials
-window screen frame sections (7 feet/section) 8 sections $3.79 per section $30.32
-plastic corners for frames 7 packets $1.29 per packet (4 corners/packet) $9.03
-spline (.160 inches) for frames, need about 50 feet   ($3.49 for 25 feet) $6.98
-fiberglass window screen roll 36” x 25' $12.57
-screen tool for applying spline $4.49
-5/8” J channel for vinyl siding (12.5 feet/section) 3 sections $6.17 per section $18.51
-screw hooks 1.75 inches long   14 hooks $5.37
-deck screws   ($2.99/lb.)   8-2” - #6, 4-2.5”- #8 $0.24
-machine screws 14-3/4”#8-32, 6-1 ¼”#8-32, nuts 26#8-32, washers 26#8, lock washers 20#8 $8.92
-3/16” aluminum pop rivets, grip 1/4” $5.19
-2”x4”x8' wood stud $2.25 each   2 required $ 4.50
-1”x3”x8' wood furring strip $1.48
-2 steel T posts 6' each $4.45/post $8.90
-2 wood blocks – cut from a 2” x 4”,   3.5” x 3.5” $1.80
-large plastic syringe (60 ml) from farm supply store-for animal injections $1.79
-silicon caulk $4.97
-rubber bands $2.49
-string
-baler twine or some rope
-reused plastic containers or cans, 7 identical containers required
-1' long rod or stick

Total $127.55

Instructions for constructing a modified Cornell patternator

-Construct seven identical window screens of 1' by 3' using instructions from hardware store.
-Cut J channel into 40.5” long sections and remove lip from low side, leaving it about 3/4” high along the front side. A tin snips works well to cut the J channel.
-All J channels must be closed on both ends. Fold in 3/4” of the J channel to form an end and secure with a pop rivet, screw or nut and bolt. A 3/16” pop rivet works well. Seal the ends with silicone caulk. Drill a 1/2” hole at the same end of all the J channels. Make up seven identical J channels.
-At the end of the J channel with the 1/2” hole, about 1/4” from the end, cut about an 1/8” wide slot on both sides of the J channel. The slots should end about 1/2” from the bottom. A container with a string will be suspended from the slots to catch the water running from the J channel.
-Place a screen section in the J channel and secure the bottom of the screen to the J channel with two 3/4” #8-32 machine screws, washers and nuts. The screen should be positioned very close to the end of the J channel opposite the hole. The J channel should extend about 2.25 inches from the screen on the other end with the 1/2” hole.

-Drill a 3/16” hole through the vertical side of six of the screen frames. The hole will be on the same side as the 1/2” hole in the J channel and about 4.5” from the top of the frame.
-Construct a frame with the 2x4's and furring strip. The 2x4's should be around 20 inches apart on center with the 4” side to the front and back. Secure the proper length of the furring strip to the top and center of the 2x4's with 2” deck screws.
-Prepare two square blocks from 2x4's. Cut about a 1/2” deep and 1/2” wide channel in the middle along one long side of the block. Attach the blocks with 2.5” deck screws to each 2x4 support about 2.5 feet from the bottom. The slot should be perpendicular to the length of the 2x4 and against the 2x4.
-Drill two 3/16” holes through the top frame of each screen section. The holes should be about 20” apart so the screen section will be centered on the 2x4 frame.
-Place the first screen section, without a hole in the side of the frame, at the top of the wood frame. -With a screen section that is three feet wide, there should be a 3/4” drop from one end to the other end of the screen section. Mark the 2x4's for placement of the screw hooks. If the 2x4's are 20” apart on center, the drop will be 7/16” on the center of the 2x4's.
-Hang the first screen frame on the hooks and repeat the procedure for each screen.
-Place 1 ¼” machine screws through the holes in the side frames of the screen sections. About a 1/4” of the machine screws should extend beyond the nuts and washers on each side of the frame.
-Place the two T posts in the ground about 1.5 feet deep and 20 inches apart. The patternator will held to the posts with ropes or twine placed through the slots in the wood blocks.
-Hang a container from the end of each J channel. Polyethylene terephthalate (01, PET or PETE) containers work well.
-Secure the containers to the machine screws on the screen frames with the rubber bands.
-Secure the bottom container with a rubber band to a rod or stick placed in the ground.
-Plug the tip of the plastic syringe body with silicone caulk.
-After collecting spray, the contents of the containers can be measured with the large syringe or the depth can be measured with a ruler.

The next part of this project was to develop a vertical patternator that cost less than $100 and was more efficient than a Cornell patternator at capturing the spray from an airblast sprayer.

B. SARE patternator

Parts and instructions are to build an 8 foot tall vertical patternator for vineyard use. If a taller patternator is needed the design can be extended. The SARE patternator is based on using painted plywood panels to catch the spray from an air-blast sprayer. It is divided into numerous sections that allow the user to quantify the amount of spray in each section. This design divides the patternator into seven sections of three feet by one foot.

Materials
-1 sheet 8' x 4' Lauan plywood $9.97
-2”x4”x8' wood stud $2.25 each 2 required $4.50
-1”x3”x8' wood furring strip 2 required $2.96
-5/8” J channel for vinyl siding (12.5 feet/section) 3 sections $6.17 per section $18.51
-deck screws ($2.99/lb.) 14-1” - #6, 8-2” - #6, 4-2.5” - #8 $0.36
-machine screws 14-1”-#8-32, nuts 14-#8-32, washers 14-#8, lock washers 14-#8 $5.46
-wood screws 28-1/2” - 6X, 14-1” - 6X $3.92
-primer 1 quart $9.98
-high gloss enamel paint 1 quart $11.38
-paint brush $1.48

-3/16” aluminum pop rivets, grip 1/4” $4.97
-2 steel T posts   6' each $4.45/post $8.90
-2 wood blocks – cut from a 2 x 4   3.5” x 3.5” $1.80
-large plastic syringe (60 ml) $1.79
-silicon caulk $4.97
-rubber bands $2.49
-string
-baler twine or some rope
-reused plastic containers or cans, 7 identical containers required
-1' long rod or stick

Total $93.44

Instructions for constructing a SARE patternator

-Cut seven identical Lauan plywood panels of 1' by 3'.
-Cut 14 pieces of wood from a furring strip. The dimensions are 11.5” long and 11/16” x 11/16”.
-Place the strips of wood along each 1' side of the plywood panels and flush with the top. Attach each strip with two 1/2” 6x wood screws.
-Paint the plywood panels with primer and high gloss enamel.
-Cut J channel into 40.5” long sections and remove lip from low side, leaving it about 3/4” high along the front side. A tin snips works well to cut the J channel.
-All the J channels must be closed on both ends. Fold in 3/4” of the J channel to form an end and secure with a pop rivet, screw or nut and bolt. A 3/16” pop rivet works well. Seal the ends with silicone caulk. Drill a 1/2” hole at the same end of all the J channels. Make up seven identical J channels.
-At the end of the J channel with the 1/2” hole, about 1/4” from the end, cut about an 1/8” wide slot on both sides of the J channel. The slots should end about 1/2” from the bottom. A container with a string will be suspended from the slots to catch the water running from the J channel.
-Place the plywood panel in the J channel and secure the bottom of the panel to the J channel with two 1” - #8 machine screws and nuts. The panel should be positioned very close to the end of the J channel opposite the hole. The J channel should extend about 2.25 inches from the panel on the other end with the 1/2” hole.
-Construct a frame with the 2x4's and furring strip. The 2x4's should be around 20 inches apart on center with the 4” side to the front and back. Secure the proper length of the furring strip to the top and center of the 2x4's with 2” deck screws.
-Prepare two square blocks from 2x4's. Cut about a 1/2” deep and 1/2” wide channel in the middle along one long side of the block. Attach the blocks with 2.5” deck screws to each 2x4 support about 2.5 feet from the bottom and the slot should be perpendicular to the length of the 2x4 and against the 2x4.
-Drill two 7/64” holes through the top of each plywood panel. The holes should be about 20” apart so the panel will be centered on the 2x4 frame.
-Place the first panel at the top of the wood frame. With a panel that is three feet wide, there should be a 3/4” drop from one end to the other end of the panel. Mark the 2x4's for placement of the panel. If the 2x4's are 20” apart on center, the drop will be 7/16” on the center of the 2x4's.
-Secure the panel to the frame with 1” deck screws and repeat the procedure for each panel.
-Hang a container from the end of each J channel. Polyethylene terephthalate (01 PET or PETE) containers work well.
-Place a 1” wood screw or small screw hook on the wood strip on the front and back of six panels , so about half of the screw protrudes from the panel. The top panel will not need these two screws. The

screws will be placed on the side of the panel with the container, about 1” from the bottom of the container.
-Secure the container to the screws with a rubber band.
-Place the two T posts in the ground about 1.5 feet deep and 20 inches apart. The patternator will held to the posts with ropes or twine placed through the slots in the wood blocks.
-Plug the tip of the plastic syringe body with silicone caulk.
-After collecting spray, the contents of the containers can be measured with the large syringe or the depth can be measured with a ruler.

C. SARE patternator with screens

This patternator was built to combine features from the previous two patternator designs. Parts and instructions are to build an 8 foot tall vertical patternator for vineyard use. If a taller patternator is needed the design can be extended. The SARE patternator with screens is based on using painted plywood panels covered with screens to catch the spray from an air-blast sprayer. It is divided into numerous sections that allow the user to quantify the amount of spray in each section. This design divides the patternator into seven sections of three feet by one foot.

Materials
-1 sheet 8' x 4' Lauan plywood $9.97
-fiberglass window screen roll 36” x 25' $12.57
-2”x4”x8' wood stud $2.25 each 2 required $4.50
-1”x3”x8' wood furring strip 2 required $2.96
-5/8” J channel for vinyl siding (12.5 feet/section) 3 sections $6.17 per section $18.51
-deck screws ($2.99/lb.) 14-1” - #6, 8-2” - #6, 4-2.5” - #8 $0.36
-machine screws 14-1”-#8-32, nuts 14-#8-32, washers 14-#8, lock washers 14-#8 $5.46
-wood screws 28-1/2” - 6X, 14-1” - 6X $3.92
-primer 1 quart $9.98
-high gloss enamel paint 1 quart $11.38
-paint brush $1.48
-3/16” aluminum pop rivets, grip 1/4” $4.97
-2 steel T posts 6' each $4.45/post $8.90
-2 wood blocks – cut from a 2 x 4 3.5” x 3.5” $1.80
-large plastic syringe (60 ml) $1.79
-silicon caulk $4.97
-hot melt glue $6.46
-staples T-50 ¼” $2.67
-rubber bands $2.49
-string
-baler twine or some rope
-reused plastic containers or cans, 7 identical containers required
-1' long rod or stick

Total $115.14

Instructions for constructing a SARE patternator with screens

-Cut seven identical Lauan plywood panels of 1' by 3'.

-Cut 14 pieces of wood from a furring strip. The dimensions are 11.5” long and 11/16” x 11/16”.
-Place the strips of wood along each 1' side of the plywood panels and flush with the top. Attach each strip with two 1/2” 6x wood screws.
-Paint the plywood panels with primer and high gloss enamel.
-Cut the fiberglass screen into 7 sections of 4' by 11.5”
-When the paint has dried, secure one end of a fiberglass screen section to the front and outside sides of the wood strip on a panel. The screen is secured with hot melt glue and staples. Stretch the screen taunt and attach on the opposite wood strip in the same manner.
-Cut J channel into 40.5 inch long sections and remove lip from low side, leaving it about 3/4” high along the front side. A tin snips works well to cut the J channel.
-All the J channels must be closed on both ends. Fold in 3/4” of the J channel to form an end and secure with a pop rivet, screw or nut and bolt. A 3/16” pop rivet works well. Seal the ends with silicone caulk. Drill a 1/2” hole at the same end of all the J channels. Make up seven identical J channels.
-At the end of the J channel with the 1/2” hole, about 1/4” from the end, cut about an 1/8” wide slot on both sides of the J channel. The slots should end about 1/2” from the bottom. A container with a string will be suspended from the slots to catch the water running from the J channel.
-Place the plywood panel in the J channel and secure the bottom of the panel to the J channel with two 1” - #8 machine screws and nuts. The panel should be positioned very close to the end of the J channel opposite the hole. The J channel should extend about 2.25 inches from the panel on the other end with the 1/2” hole.
-Construct a frame with the 2x4's and furring strip. The 2x4's should be around 20 inches apart on center with the 4” side to the front and back. Secure the proper length of the furring strip to the top and center of the 2x4's with 2” deck screws.
-Prepare two square blocks from 2x4's. Cut about a 1/2” deep and 1/2” wide channel in the middle along one long side of the block. Attach the blocks with 2.5” deck screws to each 2x4 support about 2.5 feet from the bottom and the slot should be perpendicular to the length of the 2x4 and against the 2x4.
-Drill two 7/64” holes through the top of each plywood panel. The holes should be about 20” apart so the panel will be centered on the 2x4 frame.
-Place the first panel at the top of the wood frame. With a panel that is three feet wide, there should be a 3/4” drop from one end to the other end of the panel. Mark the 2x4's for placement of the panel. If the 2x4's are 20” apart on center, the drop will be 7/16” on the center of the 2x4's.
-Secure the panel to the frame with 1” deck screws and repeat the procedure for each panel.
-Hang a container from the end of each J channel. Polyethylene terephthalate (01 PET or PETE) containers work well.
-Place a 1” wood screw or small screw hook on the wood strip on the front and back of six panels , so about half of the screw protrudes from the panel. The top panel will not need these two screws. The screws will be placed on the side of the panel with the container, about 1” from the bottom of the container.
-Secure the container to the screws with a rubber band.
-Place the two T posts in the ground about 1.5 feet deep and 20 inches apart. The patternator will held to the posts with ropes or twine placed through the slots in the wood blocks.
-Plug the tip of the plastic syringe body with silicone caulk.
-After collecting spray, the contents of the containers can be measured with the large syringe or the depth can be measured with a ruler.

5. Results

The three patternators were tested to determine if there was any significant difference between the various designs. Our vineyard sprayer used for the testing is a three point hitch Berthoud MGP 360 with torex nozzles purchased in 1975. The tractor utilized to operate the sprayer is an Oliver Super 55. The tractor PTO was set to 440 RPM using an ES 332 laser tachometer for all tests. At this RPM the sprayer pressure was set at 70 PSI. Water with no additives was used in the sprayer for all tests. The sprayer nozzles were open for one minute during all tests. Testing was also done with two sets of sprayer discs. One set were Berthoud Saphirex 10 discs that came with the sprayer. The disc orifice diameter was checked with a digital caliper accurate to 0.0005 inches. The Berthoud Saphirex 10 discs had an orifice diameter of 0.033 inches. A new set of Teejet D1.5 hardened stainless steel discs was also used. The orifice diameter of these discs is listed as 0.036 inches. Measurement with a digital caliper found the orifice diameter to be 0.032 inches.

The Berthoud 360 MPG sprayer has a total of 10 nozzles with five on each side. When spraying in our vineyard, once the vines have reached the top wire at 6 feet, only three nozzles per side are opened. The top and bottom nozzles are not utilized. For all testing of the patternators, the same setup was used. Only the nozzles on the right side of the sprayer were utilized during testing.

The total output of each nozzle with the Berthoud Saphirex 10 discs was measured. A plastic one gallon jug was placed over each nozzle and securely fastened. With the PTO running at 440 RPM, the spray was collected for one minute at 70 PSI. The total output with Teejet D1.5 hardened stainless discs was also determined. Knowing the total output of the sprayer with each set of discs will allow the determination of the percentage of total spray captured by each patternator. Three replicates for each set of discs was run and the amount of water collected was measured in milliliters. The mean of three replicates for the Berthoud Saphirex 10 discs was 1921 milliliters. The mean of three replicates with the Teejet D1.5 discs was 1771 milliliters.

Statistical analysis was performed on the data utilizing the website http://faculty.vassar.edu/lowry/VassarStats.html. A one-way analysis of variance (ANOVA) for independent samples with a Tukey's HSD test was selected.

Table 1. Total output of three Berthoud Saphirex 10 discs for one minute

mean of three replicates

Treatment	Mean	
top disc	633 ml	no statistical significance was found
middle disc	633 ml	
bottom disc	655 ml	

Table 2. Total output of three Teejet D1.5 discs for one minute

mean of three replicates

Treatment	Mean		
top disc	571 ml	a	treatments with different letters
middle disc	593 ml	a b	are significantly different
bottom disc	606 ml	b	

1% level of significance

The new Teejet discs had a significant difference between the top and bottom nozzles.

The amount of water captured by each of the three patternators was tested. The mid-line of the sprayer was positioned 4.5 feet from the patternator surface. When spraying in our 9 foot wide rows, the mid line of the sprayer is 4.5 feet from the trellis on either side. The height of the sprayer remained constant through all testing. For each test the tractor was positioned with the sprayer nozzles in line with the leading edge of the patternator. This position maximized the collection of sprayer effluent. Tractor PTO was set at 440 RPM for all tests with an ES 332 laser tachometer. Sprayer nozzles were opened for one minute during each test. All patternators received a one minute trial run before any measurements were made. This trial run was made to insure all surfaces had been exposed to the spray and any water adhesion due to surface tension had occurred. With no trial run, the initial test would have slightly lower amounts of water collected in the containers. Three replicates were run for each test.

Patternator tests with Berthoud Saphirex 10 discs

Statistical analysis was performed between the same panel on the three different patternators. Panel #1 is positioned to collect spray from one to two feet off the ground. Panel #2 is positioned to collect spray from two to three feet off the ground and so forth. The top panel is #7 which collects spray from seven to eight feet off the ground.

Table 3. Panel #7 Berthoud discs

Treatment	Mean		
Cornell	0 ml	a	treatments with different letters
SARE	30 ml	b	are significantly different
SARE with screens	5 ml	a	

5% level of significance

Table 4. Panel #6 Berthoud discs

Treatment	Mean		
Cornell	17 ml	a	treatments with different letters
SARE	111 ml	b	are significantly different
SARE with screens	95 ml	b	

1% level of significance for Cornell compared to SARE
5% level of significance for Cornell compared to SARE WITH SCREENS

Table 5. Panel #5 Berthoud discs

Treatment	Mean		
Cornell	24 ml	a	treatments with different letters
SARE	198 ml	b	are significantly different
SARE with screens	185 ml	b	

1% level of significance

Table 6. Panel #4 Berthoud discs

Treatment Mean

Treatment	Mean		
Cornell	68 ml	a	treatments with different letters
SARE	320 ml	b	are significantly different
SARE with screens	292 ml	b	

1% level of significance

Table 7. Panel #3 Berthoud discs

Treatment	Mean		
Cornell	59 ml	a	treatments with different letters
SARE	368 ml	b	are significantly different
SARE with screens	319 ml	c	

1% level of significance for Cornell compared to SARE and SARE WITH SCREENS
5% level of significance for SARE compared to SARE WITH SCREENS

Table 8. Panel #2 Berthoud discs

Treatment	Mean		
Cornell	64 ml	a	treatments with different letters
SARE	148 ml	b	are significantly different
SARE with screens	122 ml	b	

1% level of significance for Cornell compared to SARE
5% level of significance for Cornell compared to SARE WITH SCREENS

Table 9. Panel #1 Berthoud discs

Treatment	Mean		
Cornell	11 ml	ab	treatments with different letters
SARE	20 ml	b	are significantly different
SARE with screens	5 ml	a	

5% level of significance for SARE compared to SARE WITH SCREENS

The SARE patternator captured significantly more spray material than the Cornell patternator on all panels except the bottom panel (#1) that was positioned at 1 to 2 feet off the ground. The top panel (#7)was significant at the 5% level while the 2^{nd} through 6^{th} panels were significantly different at the 1% level.

The addition of screens to the SARE WITH SCREENS patternator did not provide any improvement and actually decreased its efficiency slightly. On the top (#7) and bottom (#1) panels there was no significant difference with the Cornell patternator. The 2^{nd} and 6^{th} panel were significant at the 5% level, while the panels in the middle (#3,4,5) were significant at the 1% level.

There were some significant differences between the SARE patternator and the SARE WITH SCREENS patternator. On the top panel (#7), significantly more spray material was captured at a 5% level of significance by the SARE patternator. The same result was found on panels #3 and #1.

Patternator tests with Teejet D1.5 discs

Statistical analysis was performed between the same panel on the three different patternators. Panel #1 is positioned to collect spray from one to two feet off the ground. Panel #2 is positioned to collect spray from two to three feet off the ground and so forth. The top panel is #7 which collects spray from seven to eight feet off the ground.

Table 10. Panel #7 Teejet discs

Treatment	Mean		
Cornell	0 ml	a	treatments with different letters
SARE	36 ml	b	are significantly different
SARE with screens	9 ml	a	

1% level of significance

Table 11. Panel #6 Teejet discs

Treatment	Mean		
Cornell	29 ml	a	treatments with different letters
SARE	131 ml	b	are significantly differnet
SARE with screens	104 ml	b	

1% level of significance

Table 12. Panel #5 Teejet discs

Treatment	Mean		
Cornell	39 ml	a	treatments with different letters
SARE	180 ml	b	are significantly different
SARE with screens	153 ml	b	

1% level of significance

Table 13. Panel #4 Teejet discs

Treatment	Mean		
Cornell	64 ml	a	treatments with different letters
SARE	311 ml	b	are significantly different
SARE with screens	269 ml	c	

1% level of significance for Cornell compared to SARE and SARE WITH SCREENS
5% level of significance for SARE compared to SARE WITH SCREENS

Table 14. Panel #3 Teejet discs

Treatment	Mean		
Cornell	89 ml	a	treatments with different letters
SARE	319 ml	b	are significantly different
SARE with screens	322 ml	b	

1% level of significance

Table 15. Panel #2 Teejet discs

Treatment	Mean		
Cornell	90 ml	a	treatments with different letters
SARE	113 ml	a	are significantly different
SARE with screens	174 ml	b	

1% level of significance

Table 16. Panel #1 Teejet discs

Treatment	Mean	
Cornell	14 ml	no statistical significance was found
SARE	26 ml	
SARE with screens	24 ml	

When the total output of the Teejet discs was tested, a significant difference at the 1% level was found between the top and bottom discs. The bottom disc had an increased output as compared to the top disc. This significant difference most likely modified the total amount of spray captured on the lower panels as compared with the Berthoud discs that no significant difference.

The SARE patternator captured significantly more spray material than the Cornell patternator on all panels except the bottom panel (#1) that was positioned at 1 to 2 feet off the ground and panel #2. The 3^{rd} through 7^{th} panels were significantly different at the 1% level.

The addition of screens to the SARE WITH SCREENS patternator did not provide any improvement over the SARE patternator. On the top (#7) and bottom (#1) panels there was no significant difference with the Cornell patternator. The 2^{nd} through 6^{th} panels were significantly different at the 1% level.

There were some significant differences between the SARE patternator and the SARE WITH SCREENS patternator. On the top panel (#7), significantly more spray material was captured by the SARE patternator at a 1% level of significance and on panel #4 at the 5% level. On panel #2, the SARE WITH SCREENS captured significantly more spray at the 1% level.

Total Spray Recovery

The mean of the total amount of spray captured by each of three patternators with the Berthoud and TeeJet discs was calculated. The mean of the three replicates for each patternator was compared to the mean of the the replicates for the total output of sprayer to give the percentage of recovery for the two types of discs.

Table 17. Total spray recovery-Berthoud discs

Treatment	Mean	% recovery
Cornell	243 ml	12.6
SARE	1195 ml	62.2
SARE with screens	1024 ml	53.3

Table 18. Total spray recovery-Teejet discs

Treatment	Mean	% recovery

Cornell	325 ml	18.4
SARE	1116 ml	63.0
SARE with screens	1054 ml	59.5

The percentage of the total spray captured by each of the three patternators reiterates the statistical significance found in Tukey's HSD tests for each of the panels. The SARE and SARE with screens patternators are much better than the Cornell model in capturing spray material. The SARE patternator with its high percentage recovery and low material cost would be the patternator of choice of the three models tested.

6. Conditions

No site conditions or conditions specific to our farm would have affected the results of this project. The output of a sprayer can be effected by the tractor pto rpm, pressure setting on the sprayer, type of nozzle, orifice size of disc and the make and model of the sprayer. Although these variables would differ from farm to farm, the percentage of spray captured in each panel should remain fairly constant.

7. Economics

No economic findings have found with this project. The project was not designed to test for any variation, positive or negative, in vineyard performance due to the use of patternators. Eventually the use of a patternator would improve sprayer performance and reduce the incidence of disease and insect problems. With a reduction in losses due to disease and pests, farm income would increase.

8. Assessment

Results from this project has shown the Cornell patternator design captures only 13 to 18% of the spray material. The large amount of uncollected spray material (82 to 87%) generated by the Cornell design could introduce errors in sprayer adjustment. The SARE patternator design developed in this project captured between 62 and 63% of the spray material, while the SARE WITH SCREENS patternator captured 53 to 60%. On average, the new patternator designs represent an almost four fold increase in spray material captured versus the Cornell patternator.

The spray distribution recorded by the patternators also varied. Each patternator design was divided into seven equally sized panels, each being one foot tall by three feet wide. Different designs of spray patternators resulted in differences in the recorded distribution of spray material from the same type of nozzle discs. With the Berthoud Saphirex discs the SARE patternator captured significantly more spray material than the Cornell patternator on all panels except the bottom panel (#1) that was positioned at 1 to 2 feet off the ground. The top panel (#7)was significant at the 5% level while the 2nd through 6th panels were significantly different at the 1% level. The same discs with the SARE WITH SCREENS patternator captured significantly more spray than the Cornell patternator on most of the panels. On the top (#7) and bottom (#1) panels there was no significant difference with the Cornell patternator. The 2nd and 6th panel were significant at the 5% level, while the panels in the middle (#3,4,5) were significant at the 1% level.

The TeeJet discs gave results similar to the Berthoud discs. The SARE patternator captured significantly more spray material than the Cornell patternator on all panels except the bottom panel (#1) that was positioned at 1 to 2 feet off the ground and panel #2. The 3rd through 7th panels were significantly different at the 1% level. The same discs with the SARE WITH SCREENS patternator also captured significantly more spray than the Cornell patternator on most of the panels. On the top (#7) and bottom (#1) panels there was no significant difference with the Cornell patternator. The 2nd through 6th panels were significantly different at the 1% level.

This difference in spray distribution would result in different nozzle orientations depending on the model of patternator used.

A question that could not be answered by the project was which design actually gives a more accurate representation of the true spray pattern generated by an airblast sprayer. A patternator that closely mimics the actual results when spraying crops would be the most beneficial. Additional research needs to determine which patternator gives results closest to actual spraying in a fruit crop. The patternator design with the most accurate representation of the actual spray material deposited will help farmers be more efficient and economical in their pesticide spraying.

9. Adoption

The results of this project have been extremely encouraging. The two patternators developed in this project, both outperformed the previously designed Cornell patternator. The SARE patternator captured between 3.4 and 4.9 times more spray material than the Cornell patternator and the SARE with screens captured between 3.2 and 4.2 times more spray. A majority of the spray, between 82 and 87%, was not captured by the Cornell patternator. Only 37 to 38% of the spray was not captured by the SARE patternator, while the SARE with screens patternator did not capture 41 to 47% of the spray.

Statistical analysis comparing the individual panels of each patternator showed the SARE developed patternators were far superior to the Cornell patternator. Combining the results from the two patternators and both spray discs, 75% of the panels captured amounts of spray that were significantly greater than the panels of the Cornell patternator. Statistical significance was determined with Tukey's HSD test.

The SARE patternator performed the best of the three patterntors tested. The materials cost totaled $93.44, below the targeted total cost of $100. Even the modified Cornell patternator had a much lower cost than the Cornell patternator developed in 2006. The Cornell patternator had a material cost of $489.28 in 2006, while the modified Cornell patternator developed in this project had a total cost of $122.55 in 2010.

The two SARE patternators outperformed the Cornell patternator to such an extent that additional work is warranted. Which patternator is more indicative of how the spray is actually being applied in the vineyard? On panel #3, which is the fruiting zone on our cordon pruned vines, the SARE patternator captured 6.2 times more spray than the Cornell model. Another project is being planned to attempt determining which patternator most closely mimics the actual results in a vineyard. A sprayer can only be properly adjusted when the true amount of spray material being deposited is known.

10. Outreach

The patternators developed in this project were displayed and used during a one hour field day presentation held at our farm on August 19, 2010. Handouts for the construction of the SARE and Cornell patternators were prepared. A sheet with basic results was also available. The meeting was listed on the Penn State grape extension email listing for upcoming viticulture events. The

Pennsylvania Department of Agriculture approved the meeting for 2 core pesticide credits and listed the meeting on the Bureau of Plant Industry's pesticide recertification course locater on the internet. The meeting was also approved for 2 core pesticide credits by the Maryland Department of Agriculture and listed on their recertification course website. University of Maryland's extension specialist in viticulture and small fruit also sent out an email through his mailing list detailing the meeting. Although the meeting was well publicized and would generate 2 core credits, it was attended by only four grape growers and a representative from Northeast SARE.

A half hour power point presentation on the SARE patternator project was given by Martin Keen at the Penn State Grape IPM Workshop on March 23, 2011 in Lancaster, PA. The meeting was sponsored by the Penn State Cooperative Extension and had 46 attendees in Lancaster. The meeting was also simultaneously transmitted by video to three other locations, Susquehanna, Erie and Washington Counties, in Pennsylvania. One core pesticide credit was available to attendees.

A website has been created to present the results of the project. The URL is http://www.patternator.com. The state viticulture extension agents in Pennsylvania, Maryland and New Jersey have been contacted about the website. They will place an announcement about the website in their online newsletters. An employee of USAID in Croatia, that had an interest in patternators, has also been contacted about the website.

12. Report Summary

The use of an agricultural airblast sprayer with improperly positioned or defective nozzles results in spray drift, poor pest control and inaccurate application. It has been estimated that only 55% of a pesticide spray may hit the target. The use of a vertical spray patternator reveals exactly where the spray is deposited and allows the farmer to adjust the sprayer to its maximum efficiency. A patternator can help increase the amount of spray that hits the target plant, thereby increasing efficiency and efficacy. Use of a patternator can reduce spray drift by up to 90% and reduce pesticide use up to 20%. The goal of this project was to design an inexpensive, efficient patternator that is easily constructed and performs better than a Cornell patternator and is substantially lower in cost.

The original Cornell patternator developed in 2006 had a material cost of $489. A modified Cornell patternator was developed for this project with a material cost of $128. Two additional patternators were designed, the SARE and SARE WITH SCREENS patternators. One of the goals of this project was to develop an efficient patternator with a total material cost of under $100. The SARE patternator has a cost of $93 for materials.

Each patternator was divided into seven panels of 1' by 3'. The amount of spray captured by each of the panels on the three patternators was measured with three replicates. Two different sets of spray discs were also used. The amount of spray captured by each panel was compared statistically. The use of Tukey's HSD test revealed most of the panels on the SARE and SARE with screens patternator captured significantly greater amounts of spray than the Cornell patternator. Statistical analysis showed the SARE developed patternators were far superior to the Cornell patternator. The total recovery of spray by the three patternators paralleled the statistical results. The SARE patternator captured between 62 and 63% of the total sprayer output, while the modified Cornell patternator only captured 13 to 18%. On average, the new patternator designs represent an almost four fold increase in spray material captured versus the Cornell patternator. The SARE patternator with its high percentage recovery and low material cost would be the patternator of choice of the three models tested.

The two SARE patternators outperformed the Cornell patternator to such an extent that additional work is warranted. Which patternator is more indicative of how the spray is actually being applied in the vineyard? A patternator that closely mimics the actual results when spraying crops would be the most beneficial. Additional research is needed to determine which patternator gives results closest to actual spraying in a fruit crop. The patternator design with the most accurate representation of the actual spray material deposited will help farmers be more efficient and economical in their pesticide spraying.