Results of the 2004 Demonstration of

Spatially Variable Plant Grant Regulator (PGR) and Defoliant Treatments on Cotton

Introduction

In 1999 a team from the LSU AgCenter, along with other groups, began developing and validating spatially variable (SVP) technology based on remote sensing. This technology was showcased in demonstrations on Louisiana cotton producers' farms in 2004, and this publication describes the results.

Remotely sensed imaging offers great potential as a method on which to base variable rate applications (SVP) of plant growth regulators (PGR) and defoliants. Normalized Difference Vegetative Index or NDVI is most often used as a method of remotely sensing plant vigor. NDVI is calculated as a ratio of light intensity in the near infrared wavelength to the light intensity in the red wavelength. This ratio provides a relative measure of plant biomass. NDVI values are thus used as the basis for changes in rate structures of PGRs and defoliants. Little research has been conducted on variable rate applications of PGRs or defoliants, presumably because of the intuitive relationship between NDVI and rate structure needs for PGRs and defoliants. Most research in this area indicates that PGR and defoliant rates can be varied without affecting lint yield or quality significantly.

There are, however, limitations to NDVI images, such as equal distribution of class data within the image and difficulty obtaining cloud free images. Equal distribution of class data within an NDVI means that comparisons cannot be made from field to field or on a single field over time. This technology uses visible light sources, so imaging is not possible on partly cloudy to cloudy days. During the average Louisiana day in June, there will be only 1.5 to 2 hours (usually 10 a.m. to noon) when aerial imagery can be obtained. Outside this time frame, either the sun is too low on the horizon (shadowing) or the sky too cloudy.

Our initial evaluations of variable rate PGRs based on NDVI indicate a good relationship between PGR rate needs and NDVI values, but no significant reductions in total quantity of PGR use were observed. The lack of PGR use usually occurred because grower/consultants tended to select a variable rate structure where the average use rate was similar to the rate that would have been used had a broadcast application been applied. Thus, when given the opportunity to make a variable rate application, the producer/consultant opted to apply a higher rate on areas with a high NDIV and a lower rate on areas with a low NDVI compared to the broadcast application rate.

Research with variable rate applications of defoliants based on NDVI indicates defoliant savings ranged from 0 percent to 40 percent of the cost of defoliant without significant impact on lint yield or quality. The savings were directly related to the amount of in-field variability. The 40 percent reduction in defoliant cost occurred only when in-field variability was extremely high (30 percent to 95 percent open bolls with considerable natural defoliation occurring) and multiple defoliant applications were made. Savings of 20 percent to 30 percent (about $4 an acre) lower defoliant costs have been common for most variable rate defoliation research.

Demonstrations Locations

Demonstrations were conducted on cotton production farms in Louisiana. Farms and farm locations are listed in Table 1. At each site the producer, his aerial applicator and agricultural consultant were involved throughout the process to improve technology transfer.

Table 1. 2004 Locations of Spatially Variable Demonstrations.

Producer	Parish
Boyd Holley	Morehouse
Barry Barham	Morehouse
Bougere Farms	Concordia
Jack Dailey	Franklin
Franklin Plantation	Tensas
Fritz Island Planting	Concordia
G&P Planting	Concordia
Hardwick Planting Co.	Tensas
Horseshoe Plantation	Concordia
Leak Farms	Tensas
Riverview Farms	Concordia
White Farms	Concordia
Wilkerson Farms	Tensas

Remotely sensed NDVI images were supplied to the producers/consultants at their request for a variable rate application of either a plant growth regulator or defoliant. The producer, or a representative, was then supplied with the information necessary to understand an NDVI image and options for a variable rate application. The producer/representative then developed a rate structure for the variable rate application.

At some locations, a comparison blanket application was made. At these locations the producer/representative was asked to supply a rate for a blanket treatment. This rate was selected based on the rate the producer/representative would have used if SVP were not available.

Image Acquisition and Prescription Generation

Field images and prescriptions for these demonstrations were from one of two sources. Demonstrations in Concordia used images and prescriptions from InTime (Cleveland, Miss., http://www.gointime.com/InTime/default.jsp) exclusively. Images and prescriptions in all other parishes were generated by the LSU AgCenter. Imagery for these demonstrations was obtained using an aircraft-mounted Duncan Tech MS4100 (http://www.imageteck.net/overviewms4100.htm). Images were geo-referenced with ERDAS Imagine (http://gis.leica-geosystems.com/). Prescriptions were generated in ArcView (http://www.esri.com). Cost of this equipment and software was approximately $9,000 for the Duncan Tech camera, $5,000 for ERDAS Imagine and $3,000 for ArcView. Cameras and software available today are much cheaper, with a total estimated cost of $6,000 for camera and software.

Application Equipment

All treatments were applied with an Ayers Thrush equipped to make variable rate applications by air. Equipment used to make variable rate applications were the Trimble *Ag*GPS® TrimFlight™ 3 System for variable rate control and the AutoCal Automatic Flow-Controller (Houma Avionics) to make physical changes in output (Figure 2). The AutoCal Flow-Controller was equipped with an additional electronic servo that changed pitch on the pump fan for additional rate changes (Figure 1). Output changes require 1 to 1.25 seconds with this system. Total cost of this system was about $22,000.

Figure 1. Electric Variable Pitch Pump

Figure 2. Flow Rate Controller

A hydraulically driven system also is available. This system replaces the variable pitch change prop on the pump with a hydraulically driven pump that changes pump volume. Speed of activity of the hydraulic unit appears to be slightly quicker than the electric, but this speed difference between the hydraulic and electric systems appears to be less than 0.25 second. Reported costs for a hydraulic system are $45,000 to $50,000.

Current application technology is such that variable rates are achieved by varying the volume output from the spray equipment. Pump capacity thus limits the variable rate applications because of a maximum output rate and speed of rate change. The ability to make variable rate applications is further reduced by the nozzles' output range. Most nozzles are only capable of outputs with 50 percent to 60 percent of the maximum.

Plant Growth Regulators

Plant growth regulators selected by producers were all variants of 4.2 percent mepiquat chloride. These products were sold under the trade names of Mepex, Mepiquat and Mepiquat Chloride. A price of $35 per gallon of 4.2 percent mepiquat chloride was used to calculate PGR costs.

Defoliants

Defoliant treatments applied varied by producers. DEF (25.6 oz. per acre) + SuperBoll (25.6 oz. per acre) was applied during the first and second applications to the blanket treatment in fields 8, 10 and 14. Dropp SC (1.5 oz. per acre) + SuperBoll (6.4 oz. per acre) was applied during the first application to the blanket treatment of field 11. Dropp SC (1.5 oz. per acre) + SuperBoll (21.3 oz. per acre) was applied during the second application to the blanket treatment of field 11. DEF (12.8 oz. per acre) + SuperBoll (25.6 oz. per acre) was applied as the first and second treatment to the blanket plots in field 12. Product prices used to calculate defoliant cost were DEF = $45/gal., Dropp SC = $375/gal. and SuperBoll = $36/gal.

Results and Discussion

Plant Growth Regulator

Applying PGR and defoliants as an SVP treatment reduced the total cost of the materials, with one exception. Savings from SVP applications of a PGR ranged from $0.52 to $2.41 per acre, with an average savings of $1.56 per acre (Table 2). The total savings from SVP applications of a PGR was a function of the percentage of the field not treated (range 16 percent to 59.8 percent) and the total quantity of PGR applied. Generally, as the percentage of the field not treated and the rate of PGR increased, the total savings from SVP application increased. For the field with a $2.41 per acre savings, 53.4 percent of the field was not treated in the SVP area, with an average PGR rate of 16 oz. per acre in the blanket treatment area. For the field with a $0.52 per acre savings, 23 percent of the field was not treated, with an average PGR rate of 8 oz. per acre in the blanket area.

Table 2. Comparison of Plant Growth Regulator Treatments.

Field	Application Date	Average Blanket Rate Oz/A	Average Variable Rate Oz/A	Savings from Reduced PGR Costs[1]
Field 1	14 June	11.4	5.6	$1.59
	30 June	7.3	3.1	$1.15
Field 2	14 June	8.0	6.1	$0.52
	29 June	8.0	5.3	$0.74
Field 4	24 June	12.0	9.1	$0.79
Field 5	28 June	18.3	9.7	$2.35
	16 July	17.2	9.9	$2.00
Field 6	29 June	16.0	7.2	$2.41
	16 July	12.3	6.9	$1.48
Field 7	24 June	10.9	8.0	$0.79
Average	—	12.8	7.1	$1.56

[1] Price calculated based on a PGR cost of $35 per gallon.

Lint yields of spatially variable treatments were evaluated at four locations (Table 3). At the four locations, paired strips of untreated and blanket application were included within the field. Lint yields were determined from using picker-mounted yield monitors. Lint yields are expressed as a percentage of the untreated area. Plots with a positive value yielded higher than the untreated, and plots with a negative value yielded lower.

Plot yields for the variable treatment ranged from -18.5 percent to 15.6 percent, with an average of -3.1 percent of the untreated area (Table 3). Plot yields for areas treated with the blanket PGR application ranged from -10.5 percent to 47.5 percent, with an average of 6.4 percent, of the untreated yields.

Table 3. Lint Yields by PGR Treatment Expressed as a Percentage of the Untreated.

Field	Variable	Blanket	Untreated
Field 1	1.6%	10.3%	0.0%
Field 2	12.6%	4.1%	0.0%
Field 5	13.5%	32.2%	0.0%
Field 6	-22.7%	-11.8%	0.0%
Average	1.3%	8.7%	0.0%

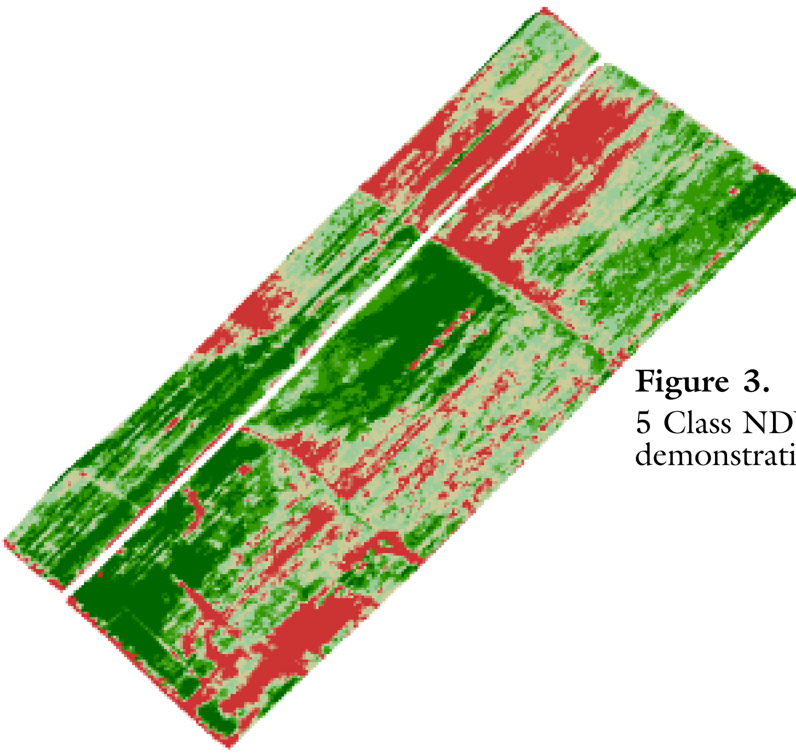

Figure 3.
5 Class NDVI Image from demonstration site in 2004.

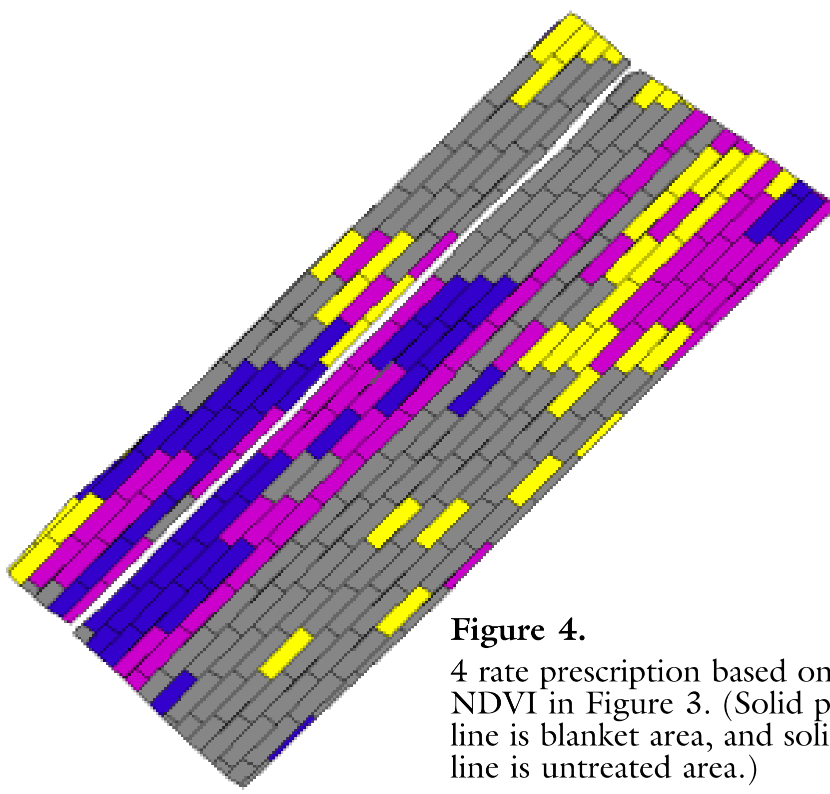

Figure 4.
4 rate prescription based on NDVI in Figure 3. (Solid purple line is blanket area, and solid gray line is untreated area.)

Defoliant

The total savings from SVP defoliant applications ranged from -$0.66 per acre to $9.47 per acre, with an average savings of $4.74 for two defoliant applications (Table 4). A single instance of increased cost for SVP defoliant did occur when a producer's representative elected to use a medium rate for the blanket application. The other two producers elected to use the high defoliant rate in the blanket application area. The highest SVP defoliant savings, $9.47 per acre, occurred as a result of the producer electing to leave 31.3 percent of Field 6 untreated during the first application. No significant influences in lint grade were observed as a result of SVP defoliant application.

Table 4. Comparison of Defoliant Treatment Costs.

	1st Application		2nd Application		
Field	Blanket	SVP	Blanket	SVP	Savings
Field 8	$16.20	$13.67	$16.20	$13.67	$5.06
Field 10	$16.20	$13.61	$16.20	$13.61	$5.18
Field 11	$5.97	$6.21	$10.41	$10.83	($0.66)
Field 12	$11.70	$9.36	$11.70	$9.36	$4.68
Field 14	$16.20	$9.56	$16.20	$13.37	$9.47
Average	$13.25	$10.48	$14.14	$12.17	$4.74

Additional Findings

Part of the demonstration process was to uncover potential difficulties associated with SVP application. Initial implementation of SVP at the aerial applicator level will require some knowledge of GIS and GIS software. Errors in prescriptions occur and will need to be detected by the applicator. Applicator will need an understanding of how to remedy these problems, else considerable time and frustration will occur with the initial implementation of SVP.

Available time for aerial photography was extremely limited in June and early July. This limitation has been previously recognized as a large bottleneck in the process of this technology. A member of the team conducting these evaluations, however, has developed a method that will increase the potential of obtaining aerial images on cloudy days. This technology will be evaluated during the 2005 demonstration.

An additional finding of this evaluation was a lack of awareness of aerial application properties. This lack of awareness has an impact of results observed in the field. First, pesticide overage is required for all applications (even ground applications). As a general rule, 105 percent to 125 percent of the total required quantity will be needed for an application, more if ends are trimmed. For example, a 100-acre field with a requested PGR rate of 1 oz. per acre will require 105 to 125 oz. of PGR. As much as 135 oz. of PGR may be required if the field is trimmed. Application equipment is not precise. Most pilots will turn the spray on before entering the field and will not turn off until they are sure they are out of the field. This requires extra chemical. Trimming adds additional chemical needs because the areas are sprayed twice. If, in the case of the 100-acre field and 1 oz. PGR per acre, 100 oz. were delivered to the airport, expect the amount of PGR to be applied to the field to range from 0.75 to 0.95 oz. per acre.

The second aerial application finding was that the ground speed of an aircraft is extremely variable. Ground speed in this evaluation ranged from 115 to 185 mph during application. This variability is caused by head winds, tail winds, diving into a field, pulling up from a field, etc. This aircraft was equipped with a flow rate controller that automatically changed the flow rate based on the ground speed of the aircraft. Thus, the aircraft had the same quantity output, on a per acre basis, regardless of the ground speed. Unfortunately, many of the agricultural aircraft in Louisiana are not equipped with automatic flow rate controllers. These controllers are relatively inexpensive ($5,000 to $6,000 per aircraft).

Conclusions

SVP application of PGR and defoliants resulted in considerable savings from reduced chemical usage. Current costs of this technology are: Image acquisition and prescription generation from InTime (Cleveland, Miss.) are $1.50/acre/image for three images and $2 per acre for a single image plus $0.25 per acre for prescription generation (please contact an InTime representative for additional details and pricing structure). Application cost for SVP application by Griffin

Ag Inc. in Helena, Ark., is $1 per acre above normal application cost (see Delta Farm Press, Friday, April 22, 2005, "Aerial VR applications prove worth"). Thus, SVP from commercially available sources costs between $2.75 and $3.25 an acre for acquisition of the remotely sensed image (NDVI), prescription generation and SVP application.

During these demonstrations the average savings from SVP of PGR was $1.56 per acre while the average savings from the SVP defoliant was $4.74 per acre. Applying the estimated cost of $2.75 per acre for imaging, prescription and application, the average net return to the grower was (-$1.19 per acre) for the PGR and $1.72 per acre for the SVP defoliant application. Initially the thought was that yield increases associated with SVP of PGR might offset the added costs. The data obtained from these demonstrations does not seem to support this idea; however, 2004 was a very unusual year. These data also do not consider the public perception benefit that agriculture receives as a result of this technology.

It should be noted that we measured the chemical costs and yield to asses SVP for the PGR evaluations and lint grade for the defoliation. Other effects of PGR applications such as earliness, incidence of boll rot and harvest efficiency were not measured. There are no data to support SVP as providing these benefits compared with blanket applications. Similarly, potential benefits such as improved overall defoliation or regrowth inhibition may be positive effects for SVP. Defoliation levels, however, were not quantified following SVP and there are no data that indicate SVP defoliation treatments increase overall defoliation or inhibit regrowth at economically meaningful levels.

While it is intuitive that SVP may provide some benefits not measured for PGR and defoliation application, these are areas of research that should be considered to begin building a data set and further examining the practice.

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