2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

DETERMINING OPTIMAL TIMING OF SITE-SPECIFIC APPLICATIONS OF COTTON HARVEST AID MATERIALS USING REMOTELY SENSED IMAGERY AND THE COTMAN PLANT MONITORING SYSTEM

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Abstract

Midsouth cotton producers routinely apply harvest aid chemicals to their crops in the fall to defoliate plants, promote boll opening and reduce regrowth. Blanket applications of these products across a field may be at rates too low for rank cotton and too high for senesced plants. This is especially true in variable fields with a mixture of soil types and textures and/or prominent irrigation patterns. Newly available application and spatial technologies may provide producers with the ability to make *just right* applications in these variable fields. GPS controlled sprayers are now commercially available that allow producers to make spatially variable chemical applications based on prescription maps generated using remotely sensed imagery of the crop. Cotton producers are interested in this new technology, but they have many questions related to system efficacy, profitability, reliability, and ease-of-use. We attempted to answer some of these questions in a 2003 field study where we compared variable rate technology and standard defoliation techniques.

The experiment was performed in a 155 acre field located on Wildy Farms in Northeast Arkansas near Manila. The three harvest aid treatments were (1) the grower's standard practice (two separate blanket applications of a combination of defoliant (Def 12 and 4oz/ac) and boll opener (Prep 8 and 40 oz/ac)), (2) two separate variable rate applications of the grower standard ((Def 9.53 and 3.18 oz/ac (total)) and boll opener (Prep 6.35 and 31.77 oz/ac)) and (3) a single variable rate application of defoliant/boll opener (GinStar 3.97 oz/ac, Prep 17.48 oz/ac and Finish 17.48oz/ac). Spray volumes for variable rate applications ranged from 10 to 20 gpa depending on crop biomass classification. Plots were 30 rows wide across a ½ mile field, and treatments were replicated 9 times. Prescriptions for variable rate application were generated by InTime Inc. (Cleveland, MS; http://www.gointime.com) using imagery obtained in mid-September and based on 7 crop biomass classifications created using their system. Prior to application, plants were monitored to compare crop information from remote sensing to actual plant measurements. Imagery obtained in early July was used to define 3 crop vigor zones based on InTime's crop biomass classification. Plants in these vigor zones were sampled from the time of squaring and first flowers through physiological cutout (mean nodes above white flower = 5) using the COTMAN crop monitoring system. Standard UA Cooperative Extension insect scouting procedures also were employed in each area. Square and boll retention, plant height, and sympodial production along with insect injury symptoms were recorded. Application of the first harvest aid treatment was on 30 Sept. Wet weather delayed the 2nd application until 13 Oct. At 7 and then 14 days after harvest aid applications, measurements including % open bolls, % defoliation, and regrowth observations were recorded. End-of-season plant mapping using COTMAP was performed in each management zone. A single hand harvest was conducted in each of the 12 sample areas per zone on 5 Nov. Ten ft of row were harvested, and lint/ac calculated at 33% of seedcotton. Yield for defoliation treatment plots was determined on 11 Nov using a 6-row picker equipped with a Trimble 170 with a Mid Tech 6100 Controller.

Biomass classifications from NDVI measures were validated with in-season plant monitoring using COTMAN (Fig 1,2,3). Imagery corresponded to plant monitoring observations in the field. Representative plant monitoring data from COTMAN sampling of the 3 vigor zones are presented in Tables 1 through 4. COTMAN growth curves for each zone show that plants associated with low biomass (low vigor) zones reached physiological cutout 9 days earlier than plants in high biomass zones (Fig. 4). Hand picked yield data along with crop maturity measures (date of physiological cutout, mean days to cutout) show

highest yields were associated with high biomass zones (Table 5). Results from final plant mapping indicate significant differences in plant structure among plants (Table 6). We observed no differences among plant vigor zones in insect infestations or insect induced square or boll shed rates through cutout, although spider mites were more abundant in non-irrigated pivot corners. Sheds that were observed late season were primarily small bolls and were not associated with arthropods. There were no differences in defoliation treatment evaluations; there was no yield penalty for variable rate applications. Economics and profitability of this approach and procedure presently are unknown. Simple cost comparisons of harvest aid compounds used in each application are shown in Table 7. Use of a variable rate spray approach in large, uneven and highly variable fields shows promise and will be explored in the upcoming season. The COTMAN system is an efficient crop monitoring tool to ground-truth remote imagery.

Table 1. Mean plant height observed in each biomass (plant vigor) zone determined using COTMAN sampling.[1]

Sample	Height (inches) per plant				
Date (DAP)[2]	High	Medium	Low	*Pr>F*	*LSD_{05}*
07/17 (76)	35.7	27.7	19.5	*0.003*	*5.64*
07/23 (82)	36.3	33.7	22.2	*0.008*	*1.97*
08/01 (91)	48.0	39.8	25.7	*0.002*	*7.59*
08/08 (98)	50.7	39.5	25.4	*0.001*	*2.30*
08/13 (103)	49.2	38.8	26.6	*0.001*	*2.47*

[1]Data are means of 3 to 12 sites in each designated zone on 10 plants per site using standard COTMAN procedures.
[2]Days after planting (DAP).

Table 2. Mean no. of sympodia observed per plant in each biomass zone determined using COTMAN sampling.[1]

Sample	No. sympodia per plant				
Date (DAP)[2]	High	Medium	Low	*Pr>F*	*LSD_{05}*
07/17 (76)	9.8	9.2	6.8	*0.05*	*2.48*
07/23 (82)	11.3	10.1	9.4	*0.34*	
08/01 (91)	12.9	12.1	10.0	*0.18*	
08/08 (98)	14.9	12.7	10.3	*0.001*	*0.75*
08/13 (103)	14.6	13.7	11.3	*0.001*	*0.69*

[1]Data are means of 3 to 12 sites in each designated zone on 10 plants per site using standard COTMAN procedures.
[2]Days after planting (DAP).

Table 3. Mean no. of 1st position bolls observed per plant in each biomass zone determined using COTMAN sampling. [1]

Sample	No. 1st position bolls per plant				
Date (DAP)[2]	High	Medium	Low	*Pr>F*	*LSD_{05}*
07/17 (76)[3]	1.7	0.9	2.2	*0.18*	
07/23 (82)	4.1	4.0	3.6	*0.51*	
08/01 (91)	5.9	6.0	5.0	*0.36*	
08/08 (98)	9.0	6.7	5.8	*0.001*	*0.89*
08/13 (103)	9.6	8.5	6.9	*0.001*	*0.91*

[1]Data are means of 3 to 12 sites in each designated zone on 10 plants per site using standard COTMAN procedures.
[2]Days after planting (DAP).
[3]Flowers were observed in all zones by 72 days after planting (DAP).

Table 4. Mean percent shed of 1st position fruiting forms observed per plant in each biomass zone determined using COTMAN sampling. [1]

Sample Date (DAP) [2]	Mean % shed per plant High	Medium	Low	*Pr>F*	*LSD_{05}*
07/17 (76)	2.7	0.4	0.6	*0.19*	
07/23 (82) [3]	6.4	6.5	14.3	*0.49*	
08/01 (91)	12.4	14.8	20.2	*0.67*	
08/08 (98)	27.9	20.7	25.6	*0.03*	*5.4*
08/13 (103)	30.1	22.6	32.3	*0.01*	*4.5*

[1]Data are means of 3 to 12 sites in each designated zone on 10 plants per site using standard COTMAN procedures.
[2]Days after planting (DAP).
[3]Flowers were observed in all zones by 72 days after planting (DAP).

Table 5. Mean number of days to physiological cutout, and mean no. of heat units (DD60s) accumulated from date of physiological cutout until application of defoliants and hand-harvested yield of each of 3 biomass zones.

Biomass Designation	Mean date of physiological cutout[1]	Mean no. days to cutout	DD60s from Cutout to defoliation[2]	Hand-Harvested Yield (lb/ac)[3]
Low	1 Aug	92	839	798 b
Medium	6 Aug	97	753	1090 a
High	10 Aug	101	688	1185 a

[1]Date at which plants in each zone reached mean NAWF = 5.
[2]First application of harvest aids was on Sept. 30 with hand harvest on Nov 5.
[3]Mean lint yield (lb/ac) was calculated based on 33% turnout of seedcotton harvested from 10 ft of row in each of 12 sample sites/zone (Pr>F = 0.001: LSD_{05}=167).

Table 6. Results from final end-of-season plant mapping following defoliation using COTMAP[1].

Category	Mean per plant from each biomass zones High	Medium	Low	Pr>F	*LSD_{05}*
1st Sympodial Node	6.9	7.1	6.8	*0.32*	
No. Monopodia	1.1	1.1	1.3	*0.27*	
Highest Sympodia with 2 nodes	11.8	11.0	8.5	*0.002*	*1.8*
Plant Height (inches)	48.3	39.1	28.1	*0.0001*	*3.4*
No. Effective Sympodia	12.9	10.8	8.0	*0.0001*	*0.9*
No. Sympodia	17.9	15.9	14.1	*0.0001*	*0.80*
No. Sympodia with 1st Position Bolls	5.6	5.0	4.0	*0.0001*	*0.6*
No. Sympodia with 2nd Position Bolls	2.5	1.8	1.1	*0.0001*	*0.4*
No. Sympodia with 1st & 2nd Bolls	1.4	1.5	1.0	*0.15*	
Total Bolls/Plant	13.1	11.6	8.8	*0.006*	*1.9*
% Total Bolls in 1st Position	55.0	57.0	58.9	*0.36*	
% Total Bolls in 2nd Position	29.9	28.6	23.3	*0.001*	*0.3*
% Total Bolls in Outer Position	8.2	5.7	3.1	*0.001*	*2.6*
% Total Bolls on Monopodia	5.9	8.8	13.3	*0.009*	*4.5*
% Total Bolls on Extra – Axillary	1.0	0.0	1.5	*0.4*	
% Boll Retention - 1st Position	39.2	41.1	35.8	*0.08*	
% Boll Retention - 2nd Position	27.5	30.2	24.5	*0.11*	
% Early Boll Retention	36.9	44.8	46.9	*0.03*	*7.5*
Total Nodes/Plant	23.8	22.0	19.9	*0.0001*	*0.8*
Internode Length (inches)	2.0	1.8	1.4	*0.0001*	*0.1*

[1] means of 10 plants per site with 12 sites per zone sampled

Table 7. Machine harvested mean lint yields observed following defoliation trial comparing variable rate approach and standard blanket application method.

Harvest Aid Treatments [1]	Product Cost ($/ac)[2]	Mean Lint Yield (lb/ac)[3]
2 Flat Rate Applications of Grower Standard (Def/Prep)[1]	$18.08	884 a
2 Variable Rate Applications of Grower Standard (Def/Prep)[1]	$14.38	932 a
1 Variable Rate Application (Ginstar/Prep/Finish)[1]	$20.30	888 a

[1] Harvest aid treatments were (1) the grower's standard practice (two separate blanket applications of a combination of defoliant (Def) and boll opener (Prep)), (2) two separate variable rate applications of the grower standard, and (3) a single variable rate application of defoliant/boll opener (GinStar, Prep and Finish). Spray volumes ranged from 10 to 20 gpa depending on crop biomass classification.

[2] Costs per acre based on actual grower costs for product. Application costs are not included.

[3] Mean lint yield (lb/ac) was calculated based on 33% turnout of seedcotton weight harvested by machine and measured with a Trimble yield monitor (Pr>F 0.22).

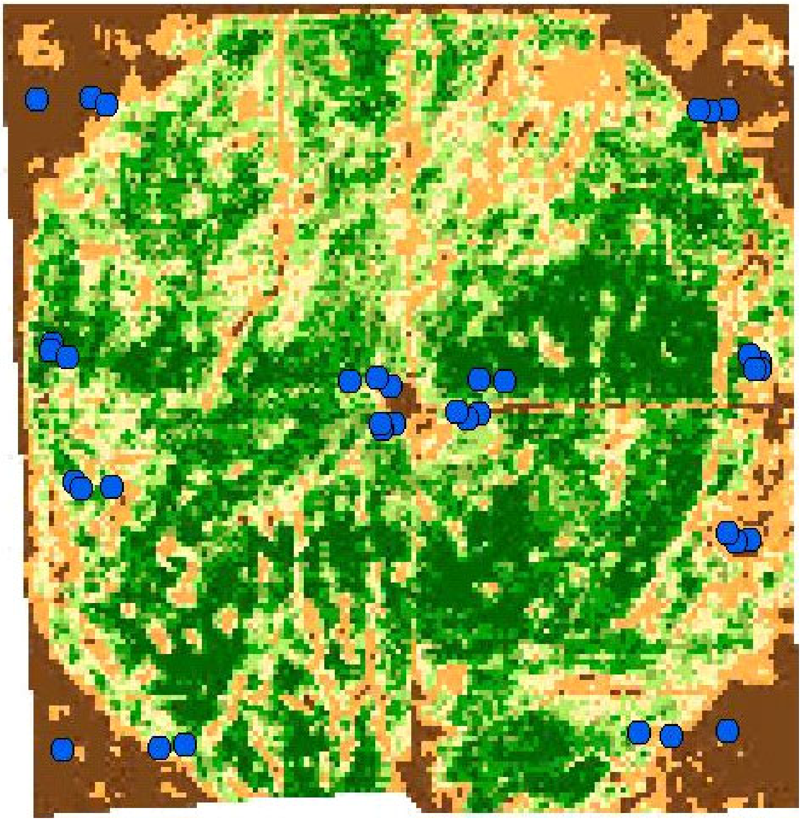

Figure 1. In each quadrant of the field, 3 sample points were selected for the high, medium, and low vigor zones. Sample points are shown above as blue dots in relation to 25 July imagery obtained from Intime Inc. Seven biomass zones shown in the imagery were re-categorized by our team into 3 zones to reduce sampling time.

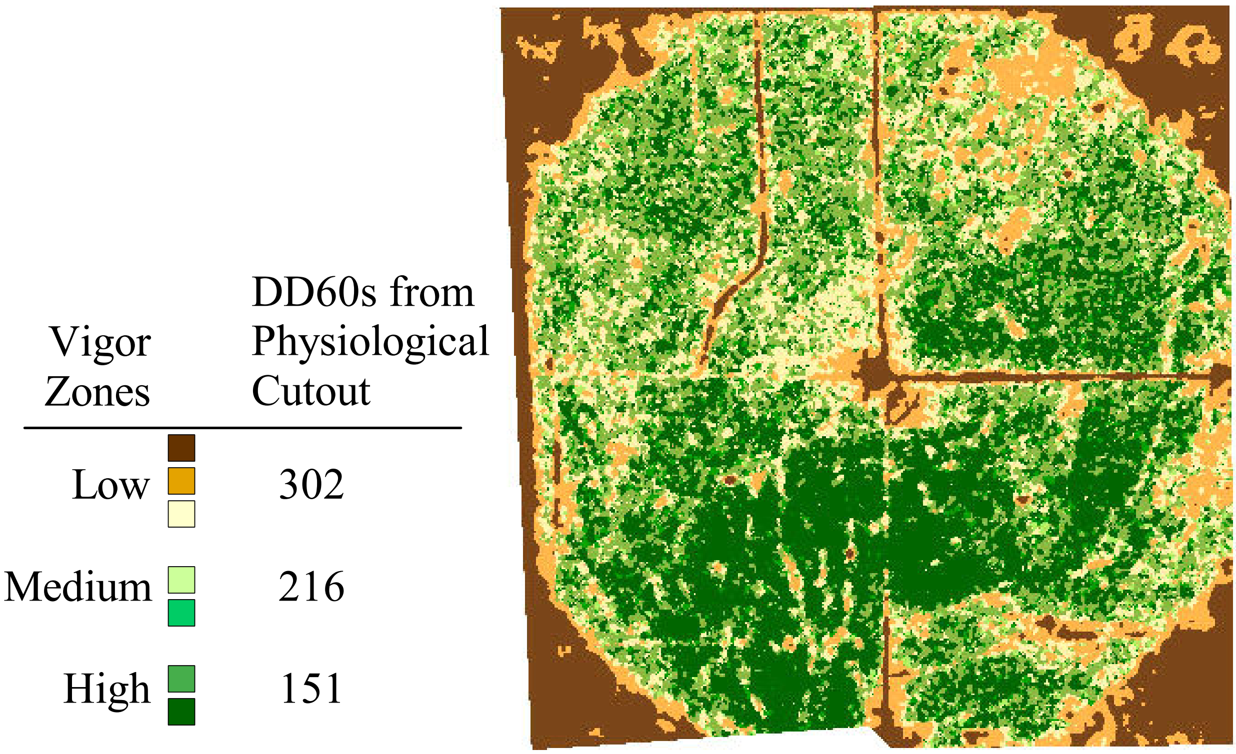

Figure 2. Imagery from 18 Aug (108 days after planting); physiological cutout for the low, medium and high biomass zones occurred on 1, 6 and 10 Aug, respectively.

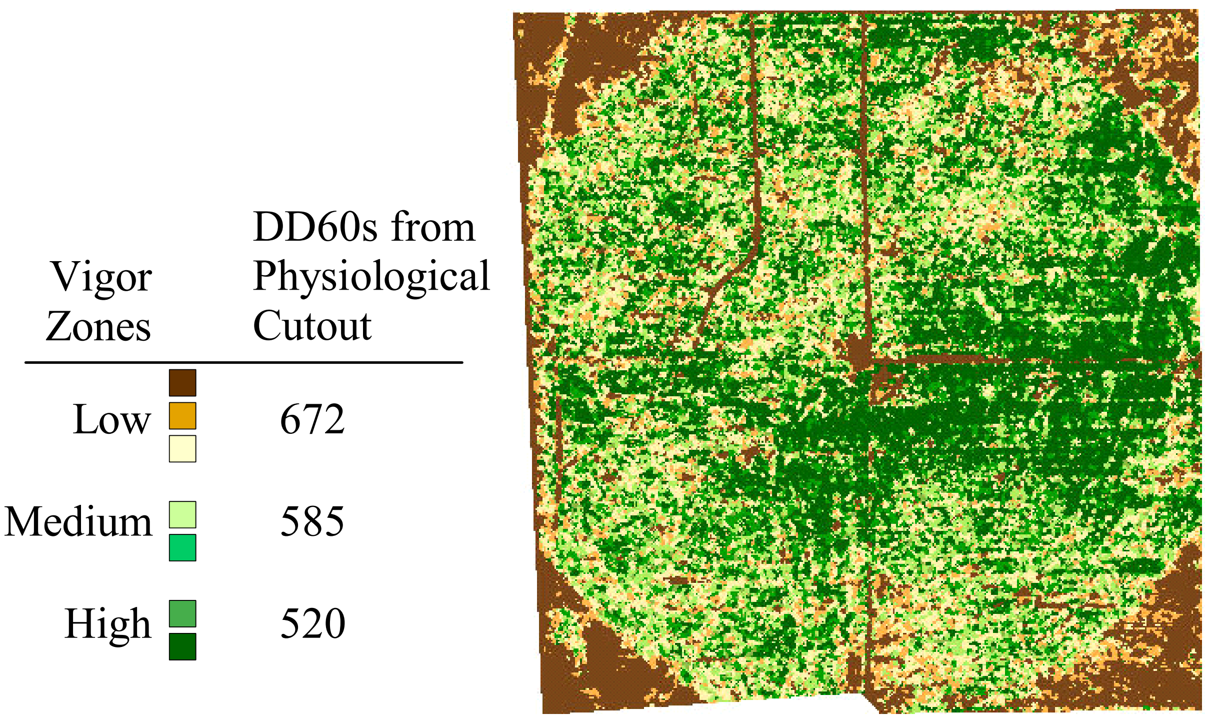

Figure 3. Imagery from 8 Sept (129 days after planting); physiological cutout for the low, medium and high biomass zones occurred on 1, 6 and 10 Aug, respectively.

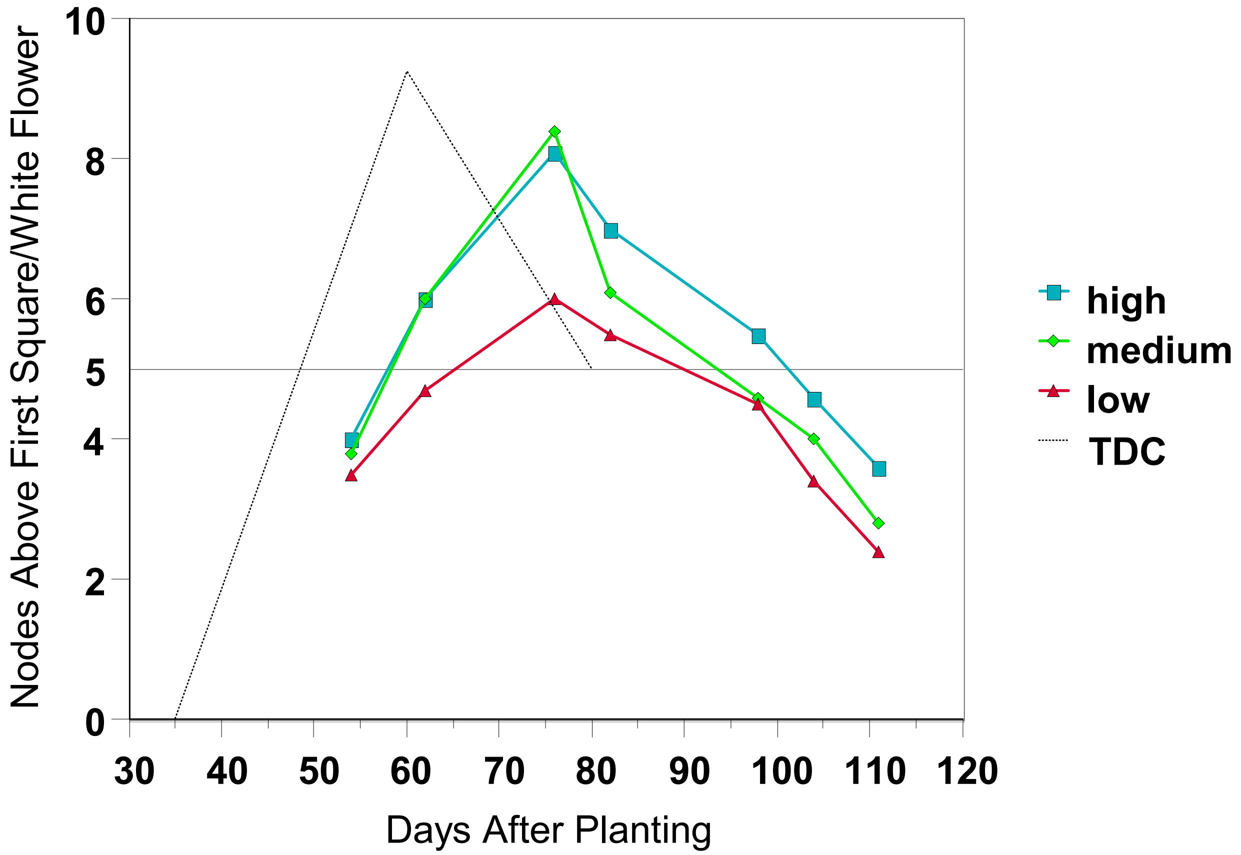

Figure 4. COTMAN target development curve (TDC) and crop growth curves of plants from 3 biomass zones.