DEVELOPMENT AND EVALUATION OF THE AVERAGE FIVE INTERNODE LENGTH TECHNIQUE TO DETERMINE TIME OF MEPIQUAT CHLORIDE APPLICATION

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Abstract

Mepiquat Chloride (MC) is the most common plant growth regulator used in commercial cotton production. MC allows producers to regulate vegetative growth to match current weather conditions. This study proposes the use of the Average Length Technique (of the uppermost five internodes), ALT5 as an indicator of potential plant height. The information can be used to determine the need for applications of MC. Objectives of this study are to (1) present assumptions made in the design and calibration of the technique and (2) to demonstrate the use of ALT5 to forecast final plant height at the cessation of vegetative growth (cutout). Data used to design ALT5 were collected during 1991 at Corpus Christi, Texas, using cultivar DPL-50. In 1995, a second experiment was conducted to validate the effectiveness of ALT5 to forecast final plant height. Experimental treatments were (1) untreated control, (2) MC applications made to maintain ALT5 below 1.6 inches and (3) MC applied to maintain ALT5 below 1.4 inches. Final plant height was measured at harvest in all the treatments. ALT5 is based on the following two assumptions: (1) individual internodes attain their maximum length in a period of 12 to 15 days from their initiation and (2) the time course of plant height development follows a sigmoidal growth pattern. A color-coded ruler or stick was developed to facilitate the measurement and estimation of ALT5. The ruler was calibrated to relate ALT5 measurements to potential plant height at the cessation of vegetative development. Initial evaluation and validation of this technique has proven satisfactory. The technique accurately predicted final plant height in an experiment conducted at Corpus Christi, TX, in 1995. The research showed that ALT5 measurements are more sensitive to changes in growth rates induced by the application of MC than using the height-to-node ratio for the entire plant. The data also suggest that ALT5 measurements may be used to quantify the effects of water and nutrient stress on main stem elongation rate.

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Introduction

Mepiquat Chloride (MC) is the most widely used plant growth regulator applied by growers in commercial cotton production. MC allows producers to regulate vegetative growth to match current weather conditions. Plant Growth Regulators (PGRs) can be compared in function to some genes in plant chromosomes because they can turn metabolic processes off (or on) just like genes do. The advantage of PGRs over genes fixed into the plant genome by plant breeders is that their activity is under the control of the field manager. PGRs like MC give producers the flexibility to modify plant growth to suit current weather conditions. A problem that field managers face; however, is to know when to turn growth processes on or off to maximize benefits. This study is one of several experiments designed to better understand the use of PGRs for the management of cotton crops.

This study proposes the use of the average length of the uppermost five internodes (ALT5) of the main stem as an indicator of the actual stem elongation rate. ALT5 can also be used to predict potential plant height at the end of the vegetative growth period. The reason for considering only the top five internodes of the plant is that internodes below this zone have already completed most of their elongation phase and will no longer contribute to plant height (Landivar, unpublished data). The objectives of the study were to develop and evaluate a rapid technique that field managers could use to adjust final plant height through internode elongation rate. Specific objectives of this presentation are to (1) present the assumptions made in the design and calibration of the technique and (2) to demonstrate the technique necessary to use ALT5 to forecast final plant height at the cessation of vegetative growth (cutout).

Materials and Methods

Data used to design the ALT5 technique were collected during 1991 at Corpus Christi, Texas, using cultivar DPL-50. Uppermost fully unrolled leaves were tagged weekly from the time of the appearance of the first matchhead square until one week past the initiation of bloom. Internodes developing below the tagged leaves were measured every other day until they were fully elongated. These data were used to determine the elongation period of each internode. In 1995 an experiment was conducted to validate the effectiveness of ALT5 to forecast final plant height. This experiment was also conducted at Corpus Christi, TX, using cultivar DPL-50. The 1995 growing season can be characterized as a typical year for the Lower Coastal Bend Region of Texas. Rainfall was adequate until the appearance of the first bloom (June 1). Cotton plants experienced water stress in late June and during July. Stress limited main stem elongation rate and reduced yield potentials. Experimental treatments were as follows: (1) untreated control, (2) MC applications made to maintain

ALT5 below 1.6 inches and (3) MC applied to maintain ALT5 below 1.4 inches. Final plant height was measured at harvest in all the treatments.

Results and Discussion

The ALT5 technique is based on the following two assumptions; (1) individual internodes attain their maximum length in a period of 12 to 15 days after their initiation and (2) the time course of plant height development follows a sigmoidal growth pattern. Assumption one is supported by data collected in 1991 at Corpus Christi, TX. The data for internodes 8 and 14 are displayed in figures 1 and 2, respectively and show that internodes elongate at an increasing rate during the first five to six days and then enter a phase of rapid linear development. Elongation proceeds at a linear rate for approximately five to six days and continues at a decreasing rate until growth becomes negligible, 12 to 15 days after initiation. This pattern of development has been observed for all internodes of the plant. However, it seems that the elongation period of an internode is controlled by temperature (Hodges et al., 1993). Under cooler temperatures, an internode may elongate for up to 15 days while this period may be reduced to 12 days under warmer temperatures.

Figure 3 shows a hypothetical time course of plant height development for cotton displaying a distinct linear phase of growth from 40 to 80 days after emergence. This sigmoidal growth pattern represents a typical time course of development for biological organisms. The ALT5 technique was designed to be used during the linear phase of plant height development**.** This period of time is designated in Figure 3 as phases 2 and 3. Since the slope of a linear function is a constant, growth rate measurements made at any time during the linear phase of development are assumed to be representative of current and future elongation rates and can be used to estimate potential plant height at the end of the vegetative growth phase (80 to 100 days after emergence or end of phase 3).

A color-coded ruler or stick has been developed to facilitate the measurement and estimation of ALT5 (Figure 4). The ruler is calibrated to relate ALT5 measurements to potential plant height at the cessation of vegetative development (end of phase 3 in figure 3). ALT5 can be readily measured by identifying and measuring the length of the uppermost five internodes of the main stem. Care is suggested in identifying internode one (the uppermost internode). The uppermost internode should be 0.5 inches in length or greater in order to be included in the measurement. We suggest examining the terminal of the main stem and searching for the uppermost internode with a length of 0.5 inches; then counting four additional internodes (see figure 5). Determine ALT5 by placing the ruler at the base of the fifth internode and measure the distance to the top of internode one. This distance divided into five gives ALT5. The value can be read directly from the right side of the ruler.

Plant height is equivalent to the product of multiplying the number of main stem internodes times the average length of the internodes. Commercial upland cottons typically produce from 18 to 20 internodes as the crop approaches cutout. Then, the product of multiplying ALT5 measurements times the expected number of internodes at the cessation of vegetative development may be used as an estimate of potential height. Table 1 shows data from an experiment designed to evaluate the ability of the ALT5 technique to estimate potential plant height at the cessation of vegetative growth (90 DAE). ALT5 values for treatment one (control) ranged from 1.4 during the squaring period up to 1.8 inch at 83 DAE. Plant height for the control treatment at the end of the measurement period (90 DAE) was 34 inches. Measurements of ALT5 predicted a final plant height of 31 to 34 inches as early as 69 DAE (early bloom). Treatments 2 and 3 obtained a plant height of 30 and 27 inches at 90 DAE, respectively. The ALT5 technique predicted these final plant height measurements as early as 62 DAE (late squaring period) for treatment 2 and 55 DAE for treatment 3. Knowledge of the exact number of mainstem nodes at cutout can improve the accuracy of the predictions. In spite of this limitation, the technique accurately forecasted the differences in growth potential of the treatments.

Considering the analysis presented in Table 1 we suggest the use of the following ranges to forecast plant height at the time when the plants obtain 20 internodes. If the ALT5 value is less than 1.4 inches (red area) the plants are growing at a rate that would result in a height of approximately 30 inches or less. If the ALT5 value is in the range of 1.4 to 1.8 Inches (yellow area), plant height at the cessation of vegetative growth may be from 30 to 36 Inches in height. If ALT5 is between 1.8 and 2.4 inches or greater (green area), the final height can be 36 to 52 inches or greater. The use of these color ranges reduces the impact of errors in measurements due to the failure in identifying the proper number of internodes.

MC applications may be considered any time the measured ALT5 value forecast a final plant height above the optimum. Optimum plant height may be defined as the size required to provide canopy closure and maximize light interception. Optimum plant height can be approximated by multiplying row spacing times 1.10. For example, full canopy closure and maximum light interception in fields planted in 38- inch rows would occur with a plant height of approximately 42 inches.

For practical purposes we suggest the following use of ALT5 measurements to determine the need for MC applications. If ALT5 is in the red area, plant height control is not needed. Therefore, applications of MC for this purpose are discouraged. If ALT5 values are in the

yellow area, the user may consider the application of MC. MC may be applied at this time to fields with a history of excessive vegetative growth, fields with substantial fruit loss early in the season, fields planted with indeterminate cultivars or because of any other reason that may lead to excessive height. If ALT5 values are in the green area, application of MC may be needed because plants are growing at a rate that would result in excessive vegetative growth. The ALT5 technique cannot be used to determine the rate of application. This is because selection of the proper MC rate requires additional information about the crop and its environment. Information on current and future water supply, stage of development, percent retention, type of cultivar, soil type, etc. need to be considered in addition to ALT5 information in order to select the proper application rate.

Conclusion

Initial evaluation and validation of this technique to estimate potential plant height has proven satisfactory. The technique accurately predicted plant height of cotton plants in an experiment conducted in Corpus Christi, TX, in 1995. The research showed that ALT5 measurements are more sensitive to changes in growth rates induced by the application of MC than height-to- node ratio for the entire plant (Figure 6). The data presented in Figure 6 also suggest that ALT5 measurements may be used to quantify the effects of water and nutrient stress on main stem elongation rate.

References

1. Hodges, H.F., K.R. Reddy, J.M. McKinion and V.R. Reddy. 1993. Temperature effects on cotton. Mississippi Agricultural and Forestry Experiment Station, Bulletin 990. Mississippi State University, MS.

Table 1. Utilization of ALT5 measurements taken at various observation intervals, to predict final plant height using two internode length criteria and two internode projection numbers, Texas A&M Experiment Station, Corpus Christi, TX, 1995.

Internode Criteria	Eval. (DAE)	ALT5	Potential Plt Ht w/Proj. INTNDs.		Act Plt Ht - INTND # (90 DAE)
			18	20	
		----------Inches----------			
Control	55	1.4	25	28	34 - 19
(Trt 1)	62	1.5	27	30	
	69	1.7	31	34	
	76	1.7	31	34	
	83	1.8	32	36	
1.6-Inch	55	1.4	25	28	30 - 18
(Trt 2)	62	1.7	31	34	
	69*	1.7	31	34	
	76*	1.6	29	32	
	83	1.6	29	32	
1.4-Inch	55	1.4	25	28	27 - 17
(Trt 3)	62*	1.6	29	32	
	69*	1.5	27	30	
	76	1.4	25	28	
	83	1.5	27	30	

* Differences in plant height in treatments 2 and 3 were obtained by applications of MC when ALT5 measurements exceeded 1.6 and 1.4 inches, respectively. The symbol (*) indicates the time of MC application.

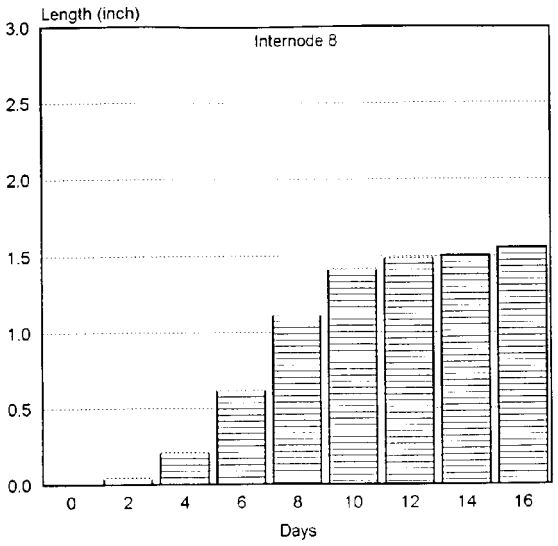

Fig. 1. Time course of development for internode 8 cultivar DPL-50, Corpus Christi, TX, 1991.

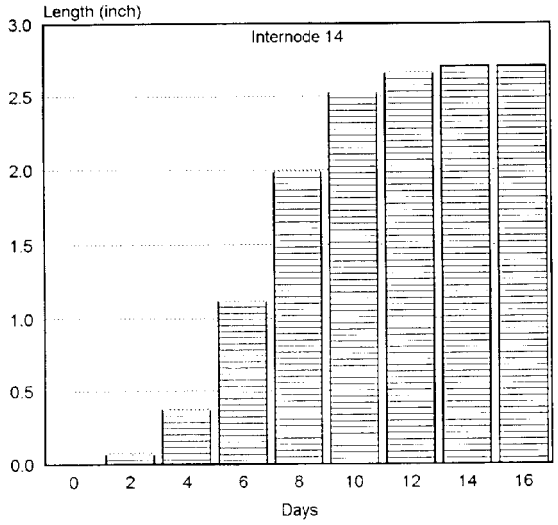

Fig. 2. Time course of development for internode 14 cultivar DPL-50, Corpus Christi, TX, 1991.

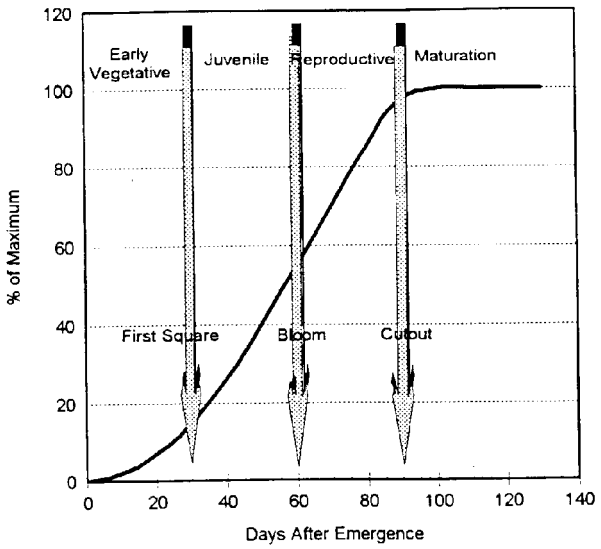

Figure 3. Ontogenetic phases of cotton crops development in relation to time course of plant height increase and time of first square, bloom and cutout.

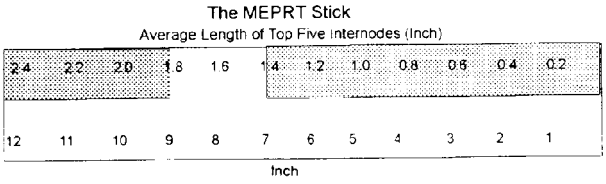

Fig 4. Color coded stick used to measure ALT5. Upper left box is colored green, center yellow and upper right is red. Upper scale is length in inches divided by five to give the average length of five internodes.

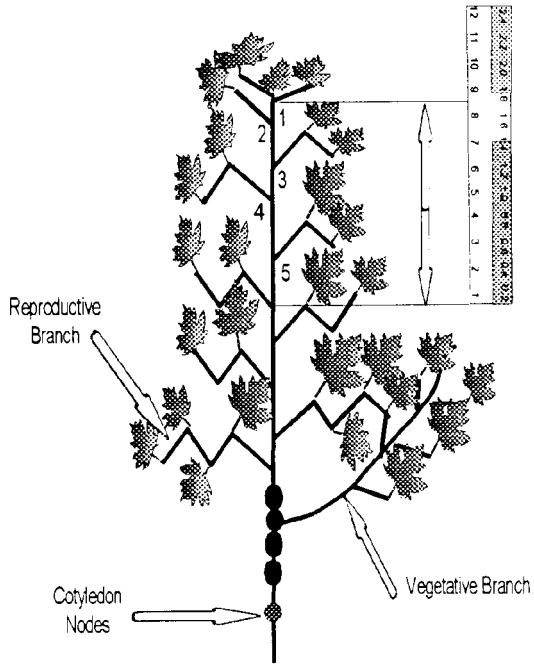

Fig. 5. Diagram of a cotton plant displaying internodes included in the measurements of ALT5.

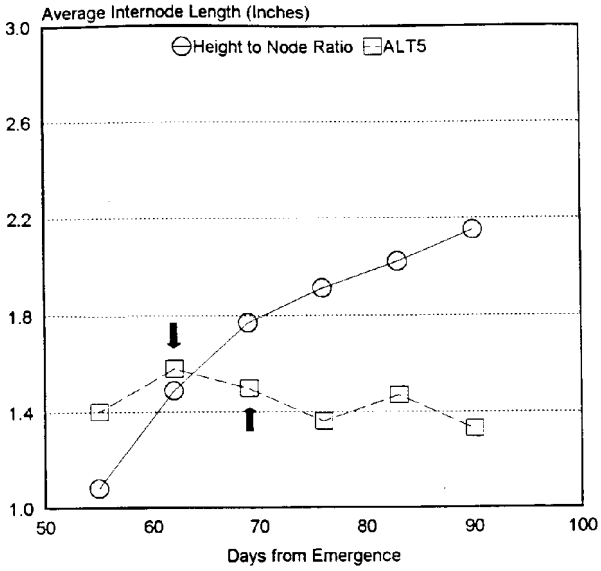

Fig. 6. Response of ALT5 and height to node ratio for applications of MC. The arrows indicate the applications of MC. Corpus Christi, TX, 1995.