A VARIABLE-RATE CHEMICAL APPLICATION SYSTEM FOR COTTON IN SOUTH TEXAS

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Abstract

Precision farming is a management method that takes advantage of Global Positioning Systems and Geographic Information Systems to optimize crop productivity at any point in the field. The use of this technique requires knowledge of the spatial variability present in a field, and equipment capable of applying production inputs at variable rates. We propose the use of plant height as a surrogate variable to assess growth potential within a production field. Plant height is an important integrator of the production environment and can be used to identify areas of the field with production problems. This study used spatial variability in plant height of a cotton field at Kingsville, Texas for the application of mepiquat chloride (Pix). The MEPRT software was used to develop a relationship between plant height and pix application rate. The coefficient of variability in plant height was reduced from 12.2% on May 29, prior to the application of Pix, to 7.9% on June 16. The amount of pix applied ranged from 4 to 8 oz per acre, with a mean of 6.0 oz per acre. Although the yield increments due to the variable rate application of pix were negligible, the improved uniformity of the field may benefit from the application of harvest aid chemicals and harvest efficiency. We concluded that further evaluation of the economic benefits of variable rate pix application in rain-fed areas are needed to determine the usefulness of Variable Rate Application Systems (VRAS) in South Texas.

Introduction

Variable Rate Application Systems (VRAS) offers the opportunity to improve economic and environmental sustainability of agriculture by matching levels of input to meet the potentials of the crop at any point in a field. It combines knowledge about soils and crop variability with Global Positioning Systems (GPS) and Geographic Information Systems (GIS). These technologies, linked with controllers and direct injection systems, allow the accurate adjustment of application rates as the soil or crop conditions vary across the field.

Successful use of VRAS depends on our ability to readily assess field variability and to relate the information to optimum rate of application. Because of the dynamics of crop development, geo-referenced databases of plant parameters may need to be generated several times during the growing season. Therefore, techniques to readily assess field variability is the key to the adaptation of this technology. These techniques should be easy to use, economical and directly related to crop management.

Our research group is currently investigating the usefulness of plant height as an integrator of cotton productivity. We are also evaluating techniques to automate the measurement of plant height and the development of geo-referenced plant height maps for use as inputs to VRAS.

Discussion

Plant Height and Plant Productivity

In cotton production, plant height can be used as an integrator of the production environment. Prior to bloom, plant height is sensitive to changes in physical soil characteristic that affect water availability to the crop. After bloom, plant height is sensitive to physiological stresses caused by the developing fruit load. Plant height is also sensitive to insect damage. Insect damaged crops often grow rank, particularly in well watered and fertilized conditions. Researchers have proposed the use of plant height as an indicator of plant vigor and potential productivity. More recently, researchers have developed parameters related to plant height for use in crop management. These include height to node ratio and Average Length of Top Five Internodes (ALT5).

We propose the use of plant height as a surrogate variable to assess variability in growth potential within production fields. To accomplish this objective we are currently evaluating two methods of generating plant height databases. The first method involves the development of a tractor-mounted sensor to measure plant height continuously while traveling through the field. The plant height sensor utilizes an infrared light curtain to measure height values. The recorded values were within 1.3 in. of hand measured values. The second method consists of the use of a crop simulation model. This technique requires accurate estimation of the spatial variability of physical properties of the soil. These two techniques may be useful in producing plant height maps such as the one displayed in Figures 1-3. The maps display hand measured variability of plant height of a cotton field on May 29, June 16 and July 14, 1997.

The availability of techniques to readily generate a time course of plant height databases (Figures 1-3) allows the estimation of maps depicting plant height growth rates. Such maps are displayed in Figures 4 and 5. Plant height growth rates can be used as an estimator of plant vigor and may have applications in insect's management, plant nutrition studies, and for the application of plant growth regulators and harvest aid chemicals.

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Relationship Between Plant Height and Pix Rates

Our agronomic research group at Texas A&M University, Corpus Christi has developed a computer program, denominated MEPRT to estimate the optimum application rate of Pix. The model determines the application rate by estimating the amount of product needed to increase the concentration to a pre-determined level. An estimation of plant weight is needed to calculate the amount of product to apply. The program estimates plant weights with a regression model that uses plant density, number of main stem nodes and plant height as independent variables.

A strong correlation between plant height and weight exists prior to the development of the fruit load. Figure 4 illustrates this observation. Plant height is plotted in relation to total plant weight for eight cultivars ranging in maturity from early to full-season. The relationship is linear until 77 days after emergence (DAE, early bloom). As the boll load develops, mainstem elongation rate is reduced and eventually stops. However, plant weight continues to increase, reflecting reproductive weight gain. For this reason, the slope or the relationship is considerably reduced at 89 DAE and becomes non-existent at 103 DAE. The relationship between plant height and weight up to the second week of bloom can be used to estimate rates of Pix required to increase the concentration of the product to a desired level.

Variable Rate Applications of Pix

The MEPRT software was used to develop a relationship between plant height and Pix application rate. Figure 1 shows plant height variability on May 29, prior to bloom. Variable rates of Pix were applied using plant height measurements made on June 3 (not shown). At this time, plant height averaged 16.4 inches and the Coefficient of Variation (COV) was 12.2%. The amount applied ranged from 4 to 8 ounces per acre, with a mean of 6.0 oz. per acre. On June 16, the plant heights were measured again (Figure 2) and Pix was applied for a second time. At this time, plants averaged 25.3 inches in height and the COV was reduced to 7.9%. During the second Pix application, credit was given for the amount previously applied in each location. Rates applied varied from 2.5 to 5.3 oz. per acre, with a mean of 3.7 oz. per acre. The total amount of Pix applied during the season averaged 9.7 oz. per acre.

Figure 3 displays variability in plant height 28 days after the second application. This map clearly shows that variable rates of Pix application helped to improve the uniformity of the field. Measurements made on August 5 (data not presented) showed that the coefficient of variability of plant height measurements dropped to 7.6% (from 12.2% on June 3, prior to the first application of Pix). The yield benefits of variable Pix application rates were negligible (data not shown). This lack of response was mainly attributed to the dry season experienced by the crop during the reproductive period, masking any benefits of the growth regulator. The improved uniformity in plant height can be beneficial to improve the effectiveness of harvest aid chemicals applications. Further evaluation of the economic benefits of variable rate Pix applications in rain-fed areas are needed to determine the usefulness of VRAS in South Texas.

Summary

This study demonstrated the technical feasibility of implementing variable rate application systems for cotton production in terms of:

1. development of variable rate application equipment
2. development of geo-referenced databases reflecting the spatial variability of biological parameters
3. development of computer controls and logic depicting the relationship between geo-referenced biological database with rates of application.

This VRAS can be used for the application of growth regulators, foliar fertilizers, pesticides and harvest aid chemicals, providing that geo-reference databases are available to guide the applications. Further evaluations of the economic benefits of variable rate applications of these agrochemicals in rain-fed areas are needed to determine the usefulness of this technology in South Texas.

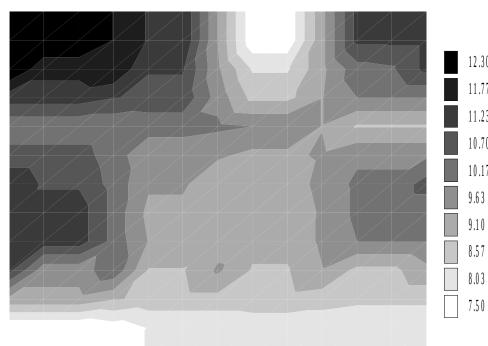

Figure 1. Ego-referenced plant height map measured on May 29, 1997 (prior to the application of Pix), Kingsville, TX.

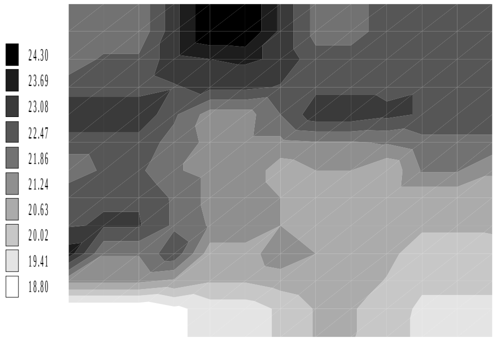

Figure 2. Ego-referenced plant height map measured on June 16, 1997 (prior to the application of Pix), Kingsville, TX.

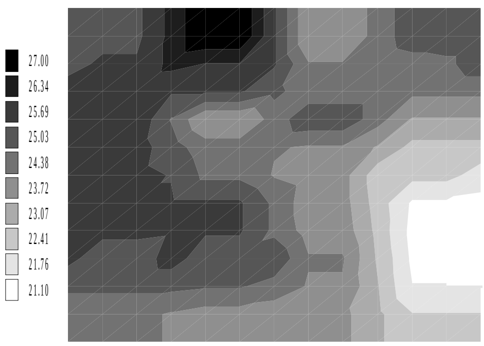

Figure 3. Ego-referenced plant height map measured on July 14, 1997 (prior to the application of Pix), Kingsville, TX.

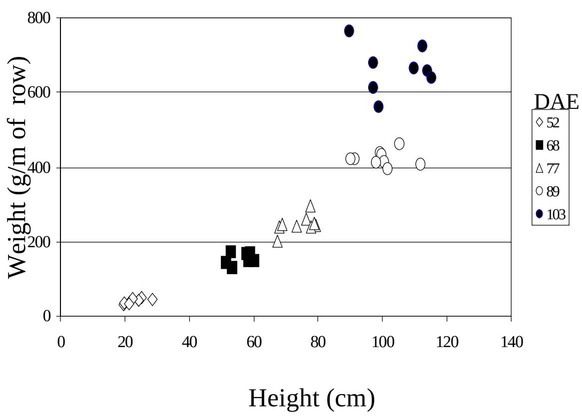

Figure 4. Relationship between plant height and total plant weight for eight cotton cultivars grown under irrigated conditions. Corpus Christi, TX, 1991.

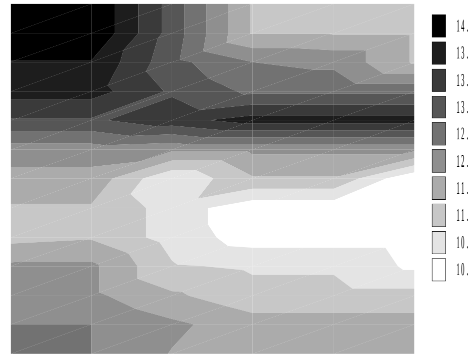

Figure 5. Geo-referenced plant height growth rates (May 29 and June 16, 1997), King Ranch, Kingsville, TX.

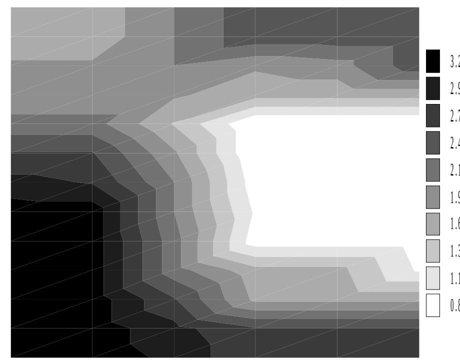

Figure 6. Geo-referenced plant height growth rates (June 16 and July 17, 1997), King Ranch, Kingsville, TX.