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NOTES

COTMAP, A TECHNIQUE FOR EVALUATING STRUCTURE AND YIELD OF COTTON PLANTS

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Abstract

Analysis of the structure and fruiting behavior of cotton, *Gossypium hirsutum* L., is complicated by its indeterminate growth habit and size variation among individual plants. We present COTMAP, a technique in which the primary fruiting sites (first and second sympodial positions) are individually mapped and fruit on remaining sites are considered collectively. Yield variables calculated by COTMAP include total bolls, boll distribution, and boll retention in prime fruiting sites. Plant structure variables include node of first fruiting branch, number of monopodia, number of sympodia, number of effective sympodia, number of sympodia with at least two flowering positions, total number of main axis nodes, plant height, and average internode length. Data from three tests of mepiquat chloride (*N,N*-dimethyl-piperidinium chloride) on cotton are used to illustrate the mapping technique. The COTMAP technique has been used to distinguish variation in structural characteristics and fruiting pattern of cotton plants associated with genetic differences, growth regulators, and insect damage.

COTTON PLANTS grow in an indeterminate fashion with vegetative growth continuing after flower initiation. Fruit forms may occur at nodes of sympodia arising from the main axis, monopodia, or secondary axillary positions. A tendency toward orderly development of fruit on sympodia has long been recognized (McClelland, 1916). Several detailed descriptions of cotton plant development have been published including Tharp (1960) and more recently Mauney (1986).

Simple analysis of individual fruiting positions on cotton plants is difficult because positions are not independent. An aborted fruit will alter the sequence and retention of subsequent fruit (Kerby and Buxton, 1981). Summarizing various studies that encompassed contrasting cultivars and locations, Mauney (1986) indicated that, invariably, more than 80% of cotton yield was produced on the first and second nodes from the main axis. In field tests over 3 yr in Arizona, he found over 90% of yield associated with these nodal positions (Mauney, 1979). He concluded that increased yield was achieved by utilizing a greater number of main axis nodes rather than more nodes per sympodium. Similarly, Kerby et al. (1987) reported that ca. 80% of bolls on Acala type cotton grown in California were located on the first and second sympodial positions from the main axis.

A plant mapping technique that provides detailed information on the first two sympodial nodes from the main axis would effectively describe the prime fruiting sites of the cotton plant. Based on this rationale, positions closest to the main axis are individually mapped and bolls on remaining sites are handled collectively with the COTMAP technique. Other plant measurements include node number of first sympodia, number of monopodia, highest sympodia with two nodes, and plant height. The data are entered

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without manipulation into a microcomputer program, written in BASIC, which calculates and analyzes the yield and plant structure variables. Documentation of this microcomputer program has been published (Watson and Bourland, 1989).

This paper describes the COTMAP technique and illustrates variables determined by the technique using data from three tests of mepiquat chloride, a plant growth regulator commonly applied on cotton.

Materials and Methods

The effects of mepiquat chloride on cotton were evaluated in two tests in 1987 and one in 1988. In 1987, tests were planted on 30 Apr. (early) and 19 May (late) on a Marietta sandy loam (fine-loamy, siliceous, thermic Fluvoquentic Eutrochrept) at the Plant Science Research Center, Mississippi State, MS. A split-plot design with treatments (mepiquat chloride and untreated) as whole plots and cultivars (DES 119 and Deltapine 90) as subplots, replicated six times, was used for each planting. Each two-row subplot was 13.3 m long with 1.0 m between rows. Plots were planted at ca. 15 seed m^{-1} of row without systemic fungicides or insecticides. After emergence, plants were thinned to ca. seven plants m^{-1} of row. Designated plots in the early and late plantings were treated with 49 g ha^{-1} of mepiquat chloride on 6 and 16 July, respectively. Standard fertilization and pest control practices without irrigation were followed. Since cultivar by treatment interactions were not significant, only data for treatments meaned over cultivars will be presented.

The 1988 test was planted 12 May using Deltapine 50 on the Cotton Branch Experiment Station at Marianna, AR. The soil was Callaway silt loam (fine-silty, mixed, thermic Glossaquic Fragiudalf). A randomized complete-block design with four replicates was used. Plots were four-rows 13.5 m long with 1.0 m between rows. With no thinning, plant density was ca. 22 plants m^{-2}. Mepiquat chloride at 49 g ha^{-1} was applied to specified plots on 28 June. The plots were sidedressed with aldicarb [(2-methyl-2-(methylthio) propionaldehyde 0-(methylcarbamoyl)oxime] at 0.84 kg a.i. ha^{-1} on 15 June. Recommended fertilization, irrigation (furrow-irrigated five times), and pest control practices were followed.

Following defoliation and prior to harvest of each test, 10 plants $plot^{-1}$ were randomly chosen and mapped. Sequentially, each plant was examined for node number of the first, i.e., lowest, sympodial branch on the main axis (FN), number of monopodia (M), and cumulative bolls on sympodia arising from monopodia (MB). Sympodia associated with the main axis were then examined for bolls in the first two positions using a scale of 0 = no bolls (NB), 1 = boll in first position only (FB), 2 = boll in second position only (SB), and 3 = bolls in both positions (BB). The total number of bolls on the outer (>2) sympodial nodes from main axis (OB) of each plant also were recorded and the highest sympodium with two nodal positions (H2) was noted. Cumulative number of bolls on sympodia arising from secondary axillary positions (XB) were counted after sympodia were coded. Finally, plant height (PHT) in cm was measured as the distance from cotyledonary node to apex.

These data were then entered into an interactive microcomputer program (Watson and Bourland, 1989). The program calculates totals and means on an individual plot basis, then performs analysis of variance on the plant structure and yield variables. In addition to FN, M, H2, and PHT, plant structure variables include number of sympodia (S) on main axis, number of effective sympodium (ES, defined as number of highest sympodium with a boll in the first position), total number of nodes on main axis above cotyledonary node (TN), and average length of main axis internodes (IL = PHT/TN). Yield variables determined by COTMAP include total number of bolls per plant (TB = FB + SB + 2BB + MB + XB); percentage of TB associated with first sympodial positions (%B1 = [B1 / TB] × 100), second sympodial positions (%B2 = [B2 / TB] × 100), outer sympodial positions (%OB = [OB / TB × 100), sympodia arising from monopodia (%MB = [MB / TB] × 100), and second axillary positions (%XB = [XB / TB] × 100); and percentage of nodes with bolls, i.e., boll retention, in first sympodial positions (BR1 = [(FB + BB) / S] × 100), second sympodial positions (BR2 = [(SB + BB) / S] × 100), and early sympodial positions defined as first and second positions on the lowest five sympodia (EBR = sum over first five sympodia, [FB + SB + 2BB]/10 × 100).

Results and Discussion

Illustration of COTMAP

A full discussion of the effects of mepiquat chloride is beyond the scope of this paper. The following data are presented to demonstrate the use of the COTMAP technique. The COTMAP detected consistent effects of mepiquat chloride on plant structure in each of the three tests (Table 1). As found in numerous other studies, including reports by Cathey and Meredith (1988), Kerby (1985), and Kerby et al. (1986), mepiquat chloride treatment was associated with reduced plant height and internode length. A reduction in TN by an average of 0.8 nodes was primarily due to fewer sympodia produced on treated plants. The three variables associated with sympodial branches, S, ES, and H2, were highly correlated ($r > 0.9$), as expected. However, they may differ in studies where fruit retention is modified. Since mepiquat chloride was applied after development of the first sympodia, FN was not affected. Number of monopodia was increased significantly by the growth regulator in only one of three tests.

As found by Kerby et al. (1986), mepiquat chloride did not affect number of bolls but appeared to modify distribution of bolls (Table 2). Treated plants tended to have fewer bolls in the two positions closest to the main axis, %B1 and %B2, and more on sympodia associated with monopodia, %MB. This tendency was most evident in the 1987 late planting. Compared to the other tests, %B1 was highest in the 1988 Arkansas test, which also had the highest plant density. Without thinning of plants in this test, proportion of TB in the

Table 1. Effects of mepiquat chloride (MC) on plant structure variables determined by COTMAP.

Treatment by test	Plant structure variable†							
	FN	M	S	ES	H2	TN	PHT	IL
	no.						cm	
1987—Mississippi, early								
MC	7.3	2.9	10.5	8.9	8.9	16.8	97	5.8
Check	7.1	2.8	11.7	9.6	9.8	17.7	110	6.2
LSD (0.05)	NS	NS	0.5	0.6	0.6	0.3	5	0.3
1987—Mississippi, late								
MC	6.5	2.4	8.8	7.9	7.2	14.3	82	5.7
Check	6.6	2.0	9.5	8.3	7.9	15.1	92	6.2
LSD (0.05)	NS	0.2	0.6	NS	0.7	0.6	4	0.3
1988—Arkansas								
MC	5.6	2.2	13.8	9.7	10.3	18.3	86	4.6
Check	5.7	2.1	15.2	10.8	11.7	19.0	102	5.2
LSD (0.05)	NS	NS	1.2	NS	1.2	0.7	4	0.2

† Plant structure variables are FN (first fruiting node), M (no.of monopodia), S (no. of sympodia), ES (effective sympodia), H2 (highest sympodia with two nodes), TN (total main axis nodes), PHT (plant height), and IL (average internode length).

Table 2. Effects of mepiquat chloride (MC) on yield variables† determined by COTMAP.

Treatment by test	TB	Boll distribution					Boll retention		
		B1	B2	OB	MB	XB	BR1	BR2	EBR
	no.	%					%		
1987—Mississippi, early									
MC	17.3	36	20	9	30	5.0	56	39	56
Check	17.4	36	23	9	27	5.4	53	41	56
LSD (0.05)	NS	NS	2	NS	NS	NS	NS	NS	NS
1987—Mississippi, late									
MC	14.6	44	25	6	24	1.0	71	52	72
Check	13.7	48	28	6	18	0.6	69	49	73
LSD (0.05)	NS	4	3	NS	3	NS	NS	NS	NS
1988—Arkansas									
MC	11.2	61	20	3	13	2.2	49	22	49
Check	11.8	68	21	3	7	0.7	53	22	55
LSD (0.05)	NS	NS	NS	NS	4	NS	NS	NS	NS

† Yield variables are TB (total bolls); B1, B2, OB, MB, and XB (proportion of TB associated with first, second, and outer sympodial nodes from main axis, monopodia, and second axilliary nodes, respectively); BR1 and BR2 (boll retention in first and second sympodial nodes from main axis); and EBR (boll retention in 10 early fruiting positions).

first and second positions (%B1 + %B2) was similar to that reported in the review by Mauney (1986). No differences in boll retention were detected.

Comparison to Other Mapping Techniques

Typically, cotton plant mapping procedures require recording the status of individual nodes and positions of each plant on separate pieces of paper. Common problems encountered have been to effectively summarize and statistically analyze the voluminous data. Munro and Farbrother (1969) developed a technique, referred to as composite plant diagrams, which combined a multiple plant sample into a single diagram. Similarly, Smith et al. (1986) have developed a microcomputer program, DIAGRAMER, which assists with summarizing plant map data. In contrast to COTMAP, DIAGRAMER defines fruit distribution in horizonal zones of sympodia.

Advantages of both composite plant diagram and the DIAGRAMER methods over COTMAP are that stage of fruit forms, e.g., square, bloom, and boll, are distinguished and detailed information for every node is provided. However, collection of these detailed data is tedious and neither method provides direct statistical analyses of defined variables.

Compared to other mapping procedures, COTMAP is more cost and time efficient. Less than one minute per plant usually is required for two persons (one mapping and one recording) to collect data from relatively large (ca. 1 m tall), productive (ca. 1000 kg ha^{-1}) plants. Also, COTMAP establishes defined variables to describe the plant. Many of the variables determined by COTMAP, e.g., FN and PHT, have long been used to evaluate responses of cotton plants. These commonly used measurements are combined with other measurements as a set of defined variables that can be statistically analyzed.

We have effectively used COTMAP to evaluate responses to plant growth regulators, insect control, and genotypic selection in cotton. As used in these tests, COTMAP was designed for an end of season evaluation of plants. By defining bolls as specified younger fruit forms, COTMAP may be used before maturity, but stage of fruit development can not be delineated. Files are written in ASCII format and can be utilized by SAS and other commonly used software.

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EVALUATION OF A NEW IN VITRO CELL SELECTION TECHNIQUE

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Abstract

In vitro cell selection is a novel means of recovering elite plant types. This study evaluated a new in vitro cell selection technique [Host-Pathogen Interaction System (HPIS)] that exposes calli to a pathogen without physical contact between the organisms. The material components that make up the HPIS are a double-sided petri dish (Lutri-plate®), a polycarbonate Nucleopore® membrane, caulking cord, and the appropriate agar media. Callus of 'Penncross' creeping bentgrass (*Agrostis palustris* Huds.) and two isolates of

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