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VARIABLE RATE OF IRRIGATION WATER AND NITROGEN IN COTTON: POTENTIAL OF SITE-SPECIFIC MANAGEMENT OF COTTON APHIDS

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Abstract

A 3-year study was conducted near Lamesa, Texas, to characterize the effect of irrigation water and nitrogen application on leaf moisture and leaf nitrogen content in cotton and the resulting influence on cotton aphid population dynamics. The treatments consisted of three irrigation levels and three nitrogen fertility treatments within each water level. Treatments were deployed in a randomized complete block design with nine replications, resulting in a total of 81 experimental units for the entire test. Each grid point was approximately 0.4 acre. Three nitrogen fertility treatments included blanket-rate-N, variable-rate-N, and no nitrogen. The three water levels (high, medium, and low) were 85, 75, and 65% ET replacement. Cotton aphid abundance, percentage leaf moisture, and percentage leaf nitrogen were measured per week from each plot during the entire growing season. The leaf water content did not vary among nitrogen treatments and various level of irrigation. Leaf nitrogen content did not vary with nitrogen application method (variable-N versus blanket-N), but both the blanket application and variable rate application resulted in significantly higher leaf nitrogen content than in zero nitrogen plots in 2003.

The overall effect of irrigation level and nitrogen application method on insect, yield and plant quality related variables and the relationship among different variables were evaluated for 2003 data. The discriminant function analysis, MANOVA, and Mahalanobis analysis showed no significant difference between high and medium water level, but the low water level was significantly different from medium and high water levels. Similarly, multivariate data analysis suggested that the variable rate and blanket application of nitrogen were similar in overall cotton production.

Introduction

Cotton aphids, *Aphis gossypii* Glover (Homoptera: Aphididae), and cotton fleahoppers, *Pseudatomoscelis seriates* (Reuter) (Hemiptera: Miridae), are two significant insect pests of cotton in the Texas High Plains. Based on economic impact, the cotton aphid was the sixth and seventh ranked pest of cotton in the United States in 2002 and 2003, respectively (Williams 2004). The cotton fleahopper is a key pest of cotton at squaring stage. Injury by both adults and immatures to squaring cotton often causes excessive loss of small squares during the early fruiting period of plant development (first 3 weeks of squaring). Increased damage is observed on smooth leaf varieties, which may extend the susceptible period into early bloom (Parker et al. 2000).

Lady beetles are credited with significantly influencing cotton aphid populations in Texas cotton. Parajulee et al. (1997) documented that the lady beetle complex comprised 75% of the total predators in irrigated cotton during a three-year study in the Rolling Plains region of Texas, and Slosser et al. (1998) observed that lady beetles comprised 62% of the total predators in dryland cotton during a five-year study in the Rolling Plains region. However, the proportion of lady beetles in the total predator complex in cotton can be influenced by vegetation diversity and weather patterns.

Irrigation and nitrogen fertility are the two primary input variables affecting cotton production in Texas. Amounts of irrigation water and nitrogen affect insect pests and natural enemies, cotton plant growth parameters, and lint yield and quality. Because irrigation and nitrogen application rates influence several variables (insects, plant growth parameters, and quality traits) simultaneously, the amount of irrigation water and nitrogen fertilization should be decided based on multiple factors that affect cotton production. Information on the multivariate evaluation of different levels of irrigation water and nitrogen in the cotton ecosystem is mostly lacking from the Texas High

Plains. Thus, this study was designed to evaluate the overall effect of irrigation and nitrogen on insects, plant growth parameters, and lint yield and quality parameters, and to evaluate the relationship among those variables.

Materials and Methods

The study was conducted on a 50-acre of a center-pivot cotton field at the AG-CARES farm near Lamesa, Texas. The treatments consisted of three irrigation levels and three nitrogen fertility treatments within each water level. Treatments were deployed in a randomized complete block design with nine replications, resulting in a total of 81 experimental units for the entire test. Each grid point was approximately 0.4 acre. Three nitrogen fertilizer application treatments included blanket-rate-N, variable-rate-N, and no nitrogen. Nitrogen fertility treatments were applied at planting and at first-square stage. Blanket-N rates were applied on the basis of the average of 0-24" soil nitrate. Variable-N rates were applied according to the soil nitrate maps. Grid points were 12 rows wide on 36-inch row spacing. The three water levels (high, medium, and low) were targeted at: 1) 85% ET replacement, 2) 75% ET replacement, and 3) 65% ET replacement.

Nine different variables were measured from each plot. The variables measured included insect related variables (cotton aphids, cotton fleahoppers, and total predators), yield related variables (lint yield, seed yield, and micronaire), and plant quality related variables (leaf moisture, leaf nitrogen, and seed nitrogen).

Cotton aphid abundance was monitored weekly in July-August; continuing until aphid populations declined. Cotton aphids were estimated by randomly inspecting 10 leaves from the upper half and 10 leaves from the lower half of plants from each plot. Cotton fleahoppers and predators were sampled by beat bucket method (3 plants per bucket and 3 locations per plot).

Yield was estimated by hand harvesting 40 row-ft (10 ft. x 4 samples) of cotton per plot and percent lint recovery was calculated after ginning the samples at the Texas Agricultural Experiment Station, Lubbock, Texas. Cotton samples were sent to the International Textile Center for High Volume Instrument (HVI) measured fiber quality analysis. Percentage leaf moisture and leaf nitrogen were estimated weekly from 10 5th mainstem node leaves from each plot. The cotton seed nitrogen content was also analyzed for each plot.

Data Analysis

The weekly aphid data were converted to average number of aphids per leaf, fleahopper and total predator data were converted to numbers per acre, lint and seed yield were measured in pounds per acre, and lint quality was recorded as micronaire unit. All weekly data were averaged over the entire season for further analysis. Univariate ANOVA was run for combined years and by year to evaluate the effect of water level and nitrogen application on aphid abundance and other variables. The treatment means were separated using protected LSD. Correlation analysis was performed to evaluate the linear relationship among the variables. Because most of the variables were correlated and were measured in different units, principal component analysis (PCA) was conducted by using a correlation matrix of all nine variables. The structure of data was determined by PCA and the data set was reduced for further multivariate analysis. Principal components that accounted for the two highest percentage variations were selected. These two PCs were then used to determine the variables with highest loadings (contributing to majority of variation in data) (Kachigan, 2003). The MANOVA and Mahalanobis distance analyses were conducted to evaluate the significance of irrigation and nitrogen effects and the relative differences between treatment levels (Weinfurt, 2003). All statistical analyses were run using matlab function written by Dr. Rich Strauss (2004) (Texas Tech University).

Results and Discussions

Seasonal cotton aphid abundance was highest in 2003 (7 aphids/leaf) followed by 2004 (5 aphids/leaf) and 2002 (2 aphids/leaf). Analysis of variance of seasonal average data showed no significant effect of irrigation or nitrogen treatments on cotton aphid abundance. However, irrigation and nitrogen treatments significantly affected plant quality parameters such as leaf moisture and leaf nitrogen. Increased amount of irrigation water significantly increased leaf moisture content. Both the blanket application and variable rate application of nitrogen resulted in significantly higher leaf nitrogen content compared with that of zero nitrogen treatment.

The simple correlation analysis showed strong correlations among many variables (Table 1). The PCA of the correlation data matrix produced 9 principal components out of which only PC1, PC2 and PC3 had >1 eigen value (Fig. 1), indicating the most significant components for describing these data.

PCA loadings to the first three components and their 95 percent confidence intervals (produced by 1,000 iterations of bootstrapping of the data set) showed that leaf nitrogen, lint yield, and seed yield explained the most variation in the data (Table 2). The cotton aphid and fleahopper had significant and moderate loading on PC1. Leaf moisture, seed nitrogen, and micronaire did not provide significant loading to PC1, thus those variables were not used for further analysis.

Although the discriminate analysis (DF1 and DF2) did not clearly differentiate the overall effect of irrigation and nitrogen treatments, the MANOVA showed a significant difference between the centroid of both irrigation and nitrogen treatments. The Mahalanobis distance analysis showed no significant difference between high and medium water level group centroid ($P=0.50$), but low water treatment was significantly different from medium and high water treatments (Fig. 2). With this result, we can conclude that the water treatment had significant effect on the 6 measured variables while there was no significant gain for using a high water regime over medium water regime. Similarly, the data representing the three nitrogen treatments overlapped (Fig. 3), but the Mahalanobis distance analysis showed that the zero nitrogen treatment was significantly different from blanket-N or variable rate nitrogen; there was no significant difference between blanket-N and variable-N rates. These results indicate that the nitrogen treatment had an overall significant effect on the 6 measured variables and there was no significant difference between effects of base rate and variable rate of nitrogen application in cotton production.

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Table 1. Correlation matrix (correlation coefficients and their probabilities) of nine selected variables affecting overall cotton production in the Texas High Plains.

	Aphid	Fleahopper	Total predator	Leaf moisture	Leaf nitrogen	Seed nitrogen	Lint yield	Seed yield	Micronaire
Aphid (r)	1.000	0.007	-0.456	-0.049	-0.284	0.176	-0.315	-0.249	0.201
(p)		0.953	<.0001	0.663	0.010	0.117	0.004	0.025	0.072
Fleahopper (r)	0.007	1.000	0.157	0.007	0.431	0.127	0.216	0.289	-0.084
(p)	0.953		0.161	0.952	<.0001	0.258	0.053	0.009	0.456
Total predator (r)	-0.456	0.157	1.000	-0.032	0.318	-0.061	0.397	0.343	-0.158
(p)	<.0001	0.161		0.780	0.004	0.590	0.000	0.002	0.159
Leaf moisture (r)	-0.049	0.007	-0.032	1.000	0.144	-0.107	0.224	0.226	0.135
(p)	0.663	0.952	0.780		0.200	0.340	0.044	0.042	0.231
Leaf nitrogen (r)	-0.284	0.431	0.318	0.144	1.000	0.081	0.667	0.703	-0.214
(p)	0.010	<.0001	0.004	0.200		0.471	<.0001	<.0001	0.055
Seed nitrogen (r)	0.176	0.127	-0.061	-0.107	0.081	1.000	-0.153	-0.053	0.088
(p)	0.117	0.258	0.590	0.340	0.471		0.172	0.638	0.436
Lint yield (r)	-0.315	0.216	0.397	0.224	0.667	-0.153	1.000	0.758	-0.267
(p)	0.004	0.053	0.000	0.044	<.0001	0.172		<.0001	0.016
Seed yield (r)	-0.249	0.289	0.343	0.226	0.703	-0.053	0.758	1.000	-0.277
(p)	0.025	0.009	0.002	0.042	<.0001	0.638	<.0001		0.012
Micronaire (r)	0.201	-0.084	-0.158	0.135	-0.214	0.088	-0.267	-0.277	1.000
(p)	0.072	0.456	0.159	0.231	0.055	0.436	0.016	0.012	

Table 2. Component loadings and their 95% confidence intervals (CI).

Variables	PC1 Loading	PC2 Loading	PC3 Loading	CI-PC1 Loading		CI-PC2 Loading		CI-PC3 Loading	
Aphid	-0.507	0.547	0.148	-0.701	-0.225	-0.211	0.773	-0.623	0.712
Fleahopper	0.418	0.579	-0.183	0.041	0.649	-0.299	0.789	-0.715	0.543
Total predator	0.584	-0.294	-0.283	0.322	0.732	-0.653	0.380	-0.700	0.472
Leaf moisture	0.220	0.048	0.842	-0.107	0.533	-0.823	0.869	-0.008	0.879
Leaf nitrogen	0.832	0.305	0.006	0.657	0.896	-0.047	0.512	-0.333	0.344
Seed nitrogen	-0.111	0.669	-0.324	-0.610	0.231	-0.080	0.916	-0.806	0.603
Lint yield	0.861	-0.017	0.168	0.772	0.915	-0.260	0.306	-0.142	0.297
Seed yield	0.857	0.139	0.143	0.710	0.912	-0.194	0.409	-0.214	0.356
Micronaire	-0.396	0.222	0.448	-0.712	0.090	-0.464	0.742	-0.545	0.778

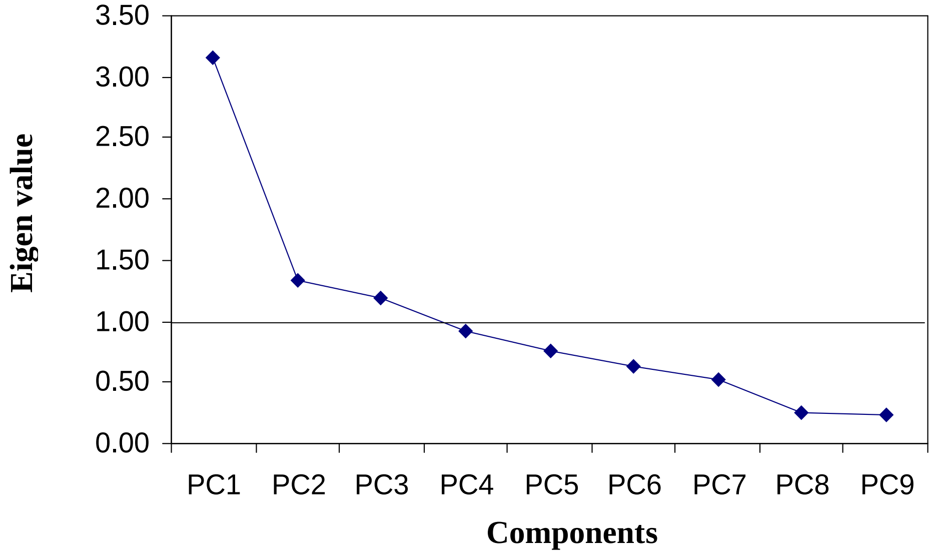

Fig. 1. Scree plot of the eigen values for all principal components.

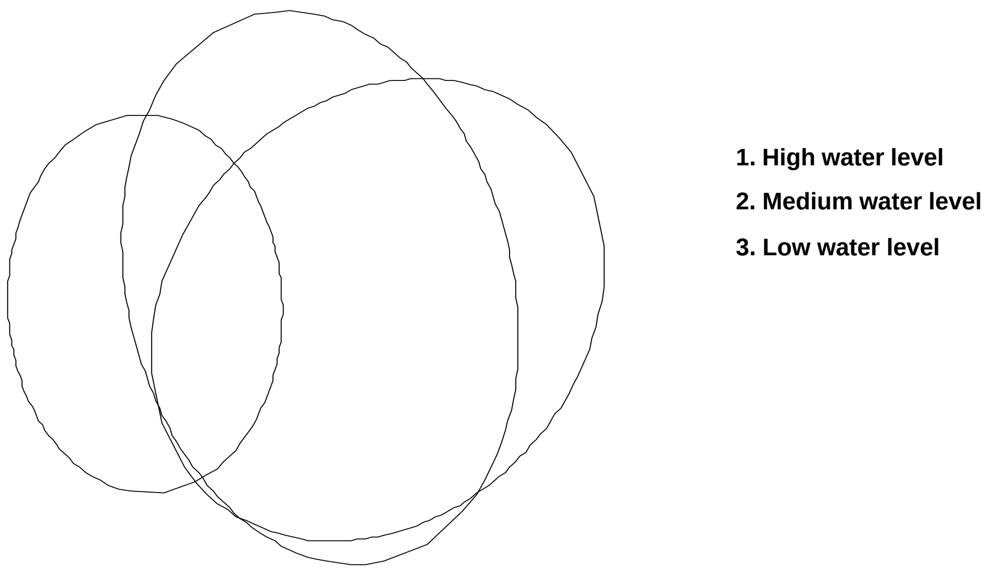

Fig. 2. Projected scores of variables on DF1 and DF2 from different water treatment plots and the 95% confidence ellipse around their centroid.

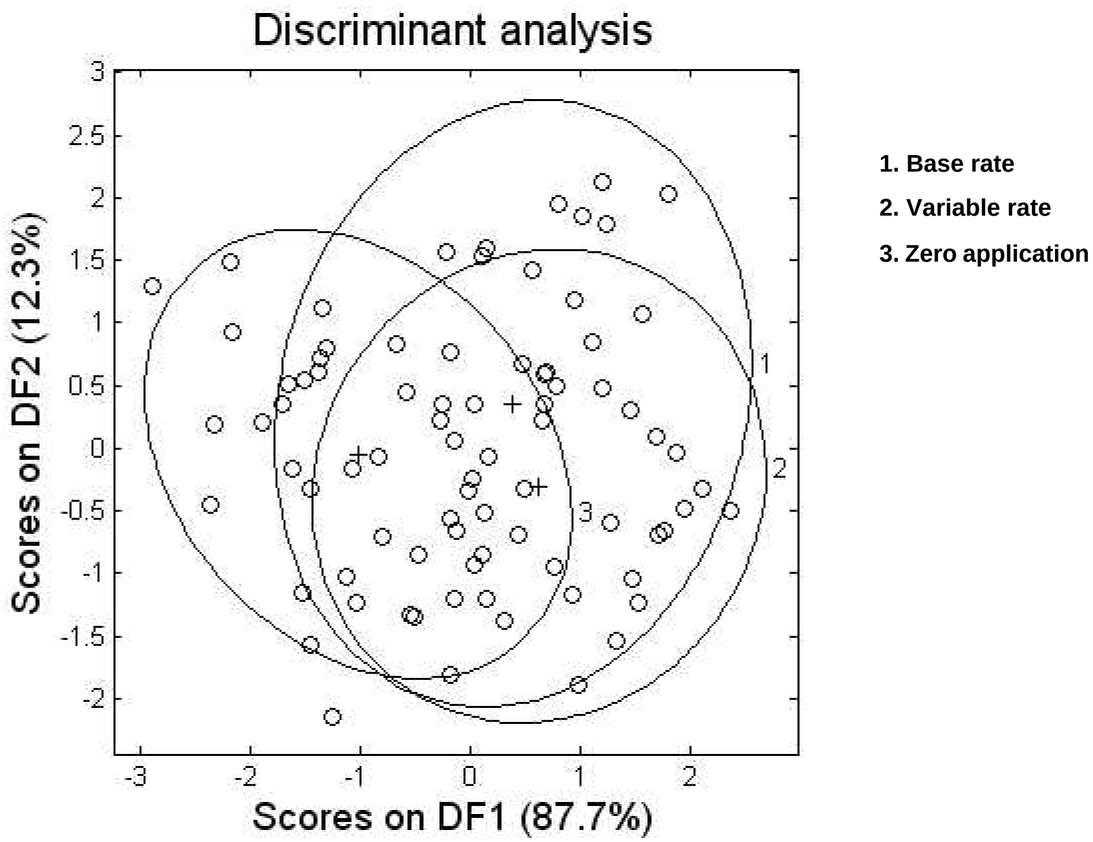

Fig. 3. Projected scores of variables on DF1 and DF2 from different nitrogen treatment plots and the 95% confidence ellipse around their centroid.