COTTON APHID RESPONSE TO NITROGEN FERTILITY IN DRYLAND COTTON

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Abstract

Cotton aphid, *Aphis gossypii* Glover, response to nitrogen fertility and planting date was investigated at the Texas Agricultural Experiment Station at Chillicothe in 1992-1994. Nitrogen was applied at 0, 32, 62, and 88 lb./acre just prior to planting cotton in late April, late May, and late June. Aphid density and percentage leaf nitrogen were estimated once a week. There was a significant, positive linear correlation between aphid density and fertility level in the late May planting date only. Nitrogen fertility levels of 62-88, 32-62, and 32 lb/acre are recommended for cotton planted in late April, late May, and late June, respectively; these levels provided acceptable yields in each planting date without increasing severity of cotton aphid infestations.

Introduction

The cotton aphid, *Aphis gossypii* Glover, became a serious problem on cotton in the Texas Rolling Plains in 1975. Population densities returned to low levels from 1976 to 1980, but since then, with the exception of 1983, infestations have fluctuated from moderate to heavy, with high densities occurring in 1981, 1990, 1991, 1993, and 1995 (Boring 1975-1995). This general trend of increasingly high infestation levels since the mid-1980's has occurred throughout West Texas (Leser et al. 1992, Rummel et al. 1995).

While yield reductions caused by the cotton aphid in the Texas Rolling Plains generally have been low, this pest reduced yields an estimated 5.94% in 1991 (Head 1992). When populations exceed 50 aphids per leaf for 3 wk, yield reductions exceeding 100 lbs lint per acre occur in irrigated cotton (Fuchs and Minzenmayer 1995).

Several reports have linked severity of cotton aphid infestations with amount of nitrogen applied to cotton. McGarr (1943) found that aphid numbers were positively correlated with percentage of nitrogen fertilizer when cotton was treated with calcium arsenate. Isely (1946) reported that the number of nymphs per female and length of reproductive period were higher for cotton aphids reared on plants given complete soil nutrients compared with aphids reared on plants deficient in nitrogen. In irrigated cotton, Villamayor (1976) reported that cotton aphid numbers were greater on cotton receiving nitrogen compared to numbers on cotton without nitrogen. Cotton aphid numbers were positively correlated with quantity of nitrogen fertilizer applied, and cotton irrigated at 10-day intervals and fertilized with 60 kg N/f had greater cotton aphid numbers than cotton irrigated at 20-day intervals and fertilized with 30 kg N/f (El-Fattah 1975).

Although planting date is known to significantly affect cotton aphid population dynamics (Slosser et al. 1992), the effect of nitrogen fertility level on cotton aphid populations in dryland cotton has not been studied in detail. Therefore, the objective of this study was to determine the influence of planting date and the interaction with nitrogen fertility on cotton aphid populations.

Materials And Methods

Experimental Design

This study was conducted at The Texas Agricultural Experiment Station at Chillicothe in 1992, 1993, and 1994. 'Paymaster 145' cotton was planted each year in north-south row directions on 40" row spacings. Cotton was grown dryland each year. A 3 X 4 factorial experiment, with treatments arranged in a randomized complete block design with three replications, was utilized. Factor A was three planting dates: 27 April, 22 May, and 25 June, 1992; 26 April, 28 May, and 24 June, 1993; and 6 May, 31 May, and 24 June, 1994. In subsequent discussions, these are referred to as late April, late May and late June plantings. Seeds were planted at 6.7, 4.2, and 4.2/row ft in late April, late May, and late June plantings, respectively. Factor B was four nitrogen fertility levels of 0, 32, 62, and 88 lbs N/acre applied just prior to each planting. Phosphorous and potassium were omitted from the fertilizer. Planting date and fertility level treatments were kept in the same locations throughout the experiment. Individual plots were 20 rows wide by 100 ft long (0.15 acre).

Aphid Sampling

Cotton aphids were sampled at weekly intervals from 28 July to 9 September 1992 (n = 7), 28 July to 27 September 1993 (n = 10), and 27 July to 30 August 1994 (n = 6). These dates represent the period of rapid aphid population increase and decrease each year. Sample size was 20 top-half and 20 bottom-half leaves in each plot, but as aphid numbers increased in mid-August, sample size was reduced to 10 top and 10 bottom leaves (coinciding with densities of several hundred aphids per leaf), and finally to 5 top and 5 bottom leaves (coinciding with numbers exceeding 800-1000/leaf). Aphids were individually counted until populations reached about 100/leaf, after which numbers were estimated by counting groups containing 5 or 10 aphids per group. A leaf was picked from the plant, and examined immediately, every 2 to 3 steps along a selected row. Rows were randomly selected, and all top-half leaves were taken from the same row, and the sampler then selected a different row for bottom-half leaves.

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Leaf Nitrogen Determinations

On each sample date for aphids, 30 top-half and 30 bottom-half leaves were picked, minus the leaf petiole, from each plot. Rows were randomly selected as discussed previously for aphid sampling. Top-half and bottom-half leaves were placed in separate Ziplock® plastic bags and labelled with collection date, plot identification, and leaf location. These bags were immediately placed in an ice chest. Upon return to the laboratory at Vernon, Tex., leaves were stored at 15°F in a chest freezer for later analysis.

Percentage leaf nitrogen content was determined with a near infrared spectrophotometry (Technicon Infra Analyzer, Model 450)(NIRS) technique developed in our laboratory (WEP, unpublished data). The NIRS estimates of percentage nitrogen were based on a multiple regression and correlation analysis of the relationship between NIRS predicted N and actual Kjeldahl N (AOAC 1990). The model is based on four wavelengths (1818, 2139, 2180, and 2348 nm), and R^2 = 0.955 (n = 107, SE = 0.026) with an estimated prediction error of 0.263. Quality control procedures in our laboratory for Kjeldahl nitrogen determinations utilize a coefficient of variation of 2.00%. Expressed as a percentage, the estimated prediction error of the NIRS model was 1.64%.

Yield

Yield data were obtained by hand-picking two, 13.1 row ft sections in each plot after plant growth had been terminated by a killing freeze. Samples were taken on 30 November 1992 and 1994 and on 8 November 1993. A small laboratory gin was used to separate the lint and seed.

Data Analyses

Aphid counts and percentage nitrogen values were averaged over all sampling dates each year for analysis. Data were analyzed by analysis of variance for a 3 X 4 factorial experiment, arranged as randomized complete blocks. Mean squares and F-ratios were calculated as defined by McIntosh (1983) for experiments combined over years. Analyses (MSTAT Development Team 1988) were performed using the FACTOR and RANGE programs of MSTAT-C, and means were separated using protected least significant difference (LSD) (α = 0.05). When only two means were compared, LSD was used. Linear regression analyses were conducted using the REGR and MULTIREG programs of MSTAT-C.

Results And Discussion

Aphid Populations

The main effect for planting date was significant, and aphid numbers were higher in late June cotton than those in late April and late May plantings (Table 1). The main effect for nitrogen fertility level at planting was not significant, and the planting date by fertility level interaction was not significant. However, there was a significant, positive linear correlation between fertility level at planting and aphid density in the late May planting date (r = 0.946, P = 0.054). Linear correlations were not significant for the late April (r = -0.019, P > 0.300) or late June (r = 0.717, P = 0.283) plantings.

The differential effects of nitrogen fertility level on aphid population development, as indicated by linear regression and correlation, may be related to plant phenology at the time aphid populations increase. The percentages of fruiting forms (squares plus bolls) that were bolls during early August, when aphid populations began to increase, were about 61, 38, and 1% for the late April, late May, and late June plantings, respectively. Thus, the late April cotton had a high boll load and was maturing during August, while the late June cotton was immature and just beginning to develop flowers. The late May cotton was intermediate between these extremes and was flowering heavily.

Leaf Nitrogen

The main effects for planting date and nitrogen fertility level at planting significantly influenced leaf nitrogen levels during August (Table 2). Leaf nitrogen was higher in the late June planting than in either the late April or late May plantings.

Highest levels of leaf nitrogen occurred when cotton was fertilized with 88 lb N/ac at planting, and lowest levels occurred at 0 lb N/ac. There were significant linear correlations between nitrogen fertility levels at planting and percentage leaf nitrogen levels during August in the late April (r = 0.918, P = 0.082) and late May (r = 0.934, P = 0.066) planting dates. The linear correlation was not significant for the late June planting date (r = 0.733, P = 0.267). Thompson et al. (1976) reported that leaf nitrogen concentrations at the end of the season were directly related to initial application rates. This supports our findings for the late April and late May plantings because cotton is rapidly maturing during August in these planting dates. Thompson et al. (1976) also reported that early season leaves have uniformly high levels of nitrogen regardless of initial application rate, which is what we found during August for cotton planted in late June.

There was a positive linear correlation between aphid density (Table 1) and percentage leaf nitrogen (Table 2) during August only in the late May (r = 0.877, P = 0.123) planting date. The linear correlations were not significant for the late April (r = 0.380, P > 0.300) and late June (r = 0.550, P > 0.300) planting dates. The range of leaf nitrogen percentages was relatively small in the late April planting date, with a low value of 3.61 and a high of 3.88 (Table 2). Perhaps the average leaf nitrogen percentages were too low and the range too narrow to elicit an aphid density response, resulting in uniform aphid densities in the late April planting date (Table 1). In the late June planting date, the range in leaf nitrogen percentages was small, with a low value of 4.02 and a high of 4.35. However, average percentages exceeded 4.0% in all fertility levels. Although aphid numbers were high, there were no density responses to initial fertility levels (Table 1).

Timing of population increase occurred during August in all three planting dates, and peak population densities occurred between mid-August and mid-September. The data reported herein indicate that nitrogen fertility at planting influences ultimate aphid density in dryland cotton planted in late May only. However, highest aphid densities during August have always occurred in cotton planted in late June, and late June cotton is just beginning to flower during August. O'Brien et al. (1993) reported that populations increase rapidly at onset of flowering in Mississippi. In our study, average nitrogen levels in leaves exceeded 4% in late June-planted cotton, which indicates that an immature plant, with a low boll load and high leaf nitrogen content during August, is most susceptible to aphids.

Yield

The main effects for planting date and nitrogen fertility level at planting significantly influenced yield (Table 3). Yields decreased as planting was delayed after late April; this is the same trend reported by Bevers and Slosser (1992) for dryland cotton. Yields increased with increasing nitrogen from 0 to 62 lb N/ac, but significant increases were not obtained at 88 lb N/ac. The planting date by fertility level interaction was not significant.

Summary

Pettit et al. (1994) suggested that manipulation of fertility level could be a useful cotton aphid management strategy, provided that the nitrogen level selected to reduce aphids did not reduce yields also. In this context, Villamayor (1976) reported that nitrogen fertilized cotton plants suffered more insect damage, but the fertilized plants produced higher yields than did unfertilized plants. The interaction LSD = 96.4 lbs lint/acre (∝ = 0.05, data in Table 3) is useful for selecting nitrogen application levels within each planting date for dryland cotton not treated with insecticides. For cotton planted in late June, nitrogen fertility ranging from 0 to 32 lb/acre provided acceptable yields (Table 3) while minimizing aphid densities (Table 1). For late May cotton, 32-62 lb N/acre produced the highest yields (Table 3) without aggravating aphid infestations (Table 1). For late April cotton, 62-88 lb N/ac produced the highest yields (Table 3) without increasing severity of aphid infestations (Table 1). These recommendations to reduce nitrogen inputs with planting dates after late April are probably justified because yields also decrease with later plantings.

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Table 1. Average number of cotton aphids per leaf in relation to planting date and nitrogen fertility at planting. Chillicothe, TX.

Planting	Lbs. N Applied at Planting[a]				
Date	0	32	62	88	Average
Late April	50	56	44	54	51 B
Late May	33	38	39	45	39 B
Late June	88	85	114	103	98 A
Average	57a	60a	65a	67a	

[a] Values followed by a common lowercase letter or by a common uppercase letter are not significantly different (P>0.05, LSD).

Table 2. Average percentage leaf nitrogen in relation to planting date and nitrogen fertility at planting. Chillicothe, TX.

Planting	Lbs N Applied at Planting[a]				
Date	0	32	62	88	Avg
Late April	3.6Bc	3.8Bb	3.7Cbc	3.9Ba	3.7B
Late May	3.2Cc	3.8Bb	3.9Ba	4.0Ba	3.7B
Late June	4.0Ab	4.3Aa	4.4Aa	4.3Aa	4.2A
Average	3.6c	3.9b	4.0ab	4.1a	

[a] Values followed by a common lowercase letter within planting dates and by a common uppercase letter within nitrogen fertility levels are not significantly different (P>0.05, LSD).

Table 3. Yield (lb lint per acre) in relation to planting date and nitrogen fertility at planting. Chillicothe, TX.

Planting	Lbs. N Applied at Planting[a]				
Date	0	32	62	88	Average
Late April	688	645	720	775	707A
Late May	515	593	643	580	583B
Late June	133	164	176	180	163C
Average	445b	467ab	513a	512a	

[a]Values followed by a common lowercase letter or by a common uppercase letter are not significantly different (P>0.05, LSD).