NITROGEN APPLICATION EFFECT ON LEAF PHOTOSYNTHESIS, NONSTRUCTURAL CARBOHYDRATE CONCENTRATIONS AND YIELD OF FIELD-GROWN COTTON

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RESEARCH PROBLEM

The indeterminate growth habit of cotton (*Gossypium hirsutum* L.) plants makes them very responsive to changes in the environment and management. Both extra nitrogen (N) application and N deficiency affect the growth and yield. Leaf photosynthesis and plant carbon metabolism are the bases of crop growth and yield development. Therefore, investigating the effect of N deficit on carbohydrate content of plant tissues can help us to understand the physiological mechanism of low N influencing cotton yield.

BACKGROUND INFORMATION

Many earlier studies have shown that N deficit is one of major factors influencing cotton plant growth and yield. Low N stress significantly decreases leaf area development, boll retention and lint yield. But little is known about the response of nonstructural carbohydrate concentrations in different plant tissues to N deficit. A better understanding of the effect of N deficit on plant carbon metabolism of field-grown cotton is important because the accumulation and partitioning of photo-assimilate is fundamental for yield development. The objective of this study was to determine the effect of the moderate N deficit on leaf photosynthesis, concentrations of chlorophyll and nonstructural carbohydrates, and lint yield.

MATERIALS AND METHODS

A field experiment was conducted at the Arkansas Agricultural Research and Extension Center, University of Arkansas in Fayetteville. Cotton (cv. Deltapine 20) was planted on 15 May 1995. Each plot consisted of five rows spaced 1 m apart, 10 m in length, oriented in a south-north direction, and hand-thinned to nine plants m^{-1} row when the seedlings had three true leaves. Preplant fertilizer was applied at a rate of 50-27-67 lb N-P-K $acre^{-1}$. The two treatments were (1) high N and (2) low N. Based on preplant fertilizer, the high N treatment received an additional side-dressing of 50 lb N $acre^{-1}$ on 30 June 1995 at the early square stage, and the low N treatment received no

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additional N application. Control of insects and weeds, and furrow irrigation were given as needed during the growing season in an attempt to minimize plant stress and optimize yield. The experiment was arranged a randomized complete-block design with three replications. Measurements were made of net photosynthetic rate, chlorophyll content, and nonstructural carbohydrates concentrations of uppermost fully expanded main-stem leaves at 22 and 40 days after the side-dressing application of N (21 July and 7 August) using methods described by Zhao and Oosterhuis (1998). At harvest, the seedcotton from the two 1-m middle rows of each plot was hand picked and the number of harvestable bolls recorded. Seedcotton was weighed and ginned to determine average boll weight, lint percentage, and lint yield.

RESULTS

Three weeks (21 July) after the initiation of N fertilizer treatment, there were no significant differences in leaf net photosynthetic rate and chlorophyll concentration between high N and low N treatments (Table 1). However, 17 days later (7 August) at the boll development stage, the low N plants showed a significantly lower leaf photosynthetic rate (decreased 16%) and lower chlorophyll concentration (decreased 20%) than the high N treated plants. Leaf hexose concentration did not differ between the two N treatments on 21 July. However, the leaves of the low N plants had significantly lower sucrose, higher starch, and higher total nonstructural carbohydrate concentrations at both measuring times compared to high N treated plants. These results indicated that N deficiency during fruiting reduced cotton leaf photosynthesis, and also photosassimilite translocation from leaves to fruits.

Nitrogen deficit significantly decreased cotton lint yield. Under our experimental conditions, the lint yield of low N treatment was 161 lb $acre^{-1}$ lower than the high N treatment (Table 2). Decreased lint yield for the low N treatment was mainly associated with a decrease in the number of bolls. The average boll weight and lint percentage were not affected by the low N treatment. Our results on the effect of the low N on yield and yield components are similar to the early reports (Jackson and Gerik, 1990; Gerik *et al.*, 1994). A decreased leaf area is also a major cause of reducing yield under N deficit conditions (Miley and Oosterhuis, 1990; Gerik *et al.*, 1994).

PRACTICAL APPLICATION

Insufficient N supply during cotton reproductive growth depressed leaf area, leaf net photosynthetic rate, and leaf chlorophyll content, but increased leaf total nonstructural carbohydrate concentration. The decreased leaf photosynthetic rate from N deficiency might be associated with earlier leaf senescence and slower carbohydrate translocation from leaves to fruits. As a result, fruit abscission of N deficit cotton plants increased and lint yield decreased compared to the plants received sufficient N. Therefore, according to soil nutrient analysis and cotton production recommendations, adequate N during boll development is essential for photosynthesis and yield development.

LITERATURE CITED

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Table 1. Effects of nitrogen application on leaf net photosynthetic rate, chlorophyll content, and nonstructural carbohydrate concentration of field-grown cotton.

	July 21		August 7	
Measurement	High N[z]	Low N	High N	Low N
Net photosynthetic rate (μmol m^{-2} s^{-1})	26.3	25.1	27.5	23.8*
Chlorophyll content (μg cm^{-2})	47.3	47.6	38.9	31.0*
Hexose (g kg^{-1} DW)	4.8	6.4	3.3	7.2*
Sucrose (g kg^{-1} DW)	2.8	1.5*	14.5	4.2**
Starch (g kg^{-1} DW)	235	257*	192	209*
Total nonstructural carbohydrate (g kg^{-1} DW)	243	265*	210	221*

[z] High N received 100 lb N $acre^{-1}$; Low N received 50 lb N $acre^{-1}$.

* and ** indicate significant differences between treatments at $P \leq 0.05$ and 0.01, respectively.

Table 2. Effects of Nitrogen deficit on lint yield and yield components of field-grown cotton.

Treatment[z]	Lint yield	Boll No.	Boll weight	Lint percentage
	(lb $acre^{-1}$)	(boll m^{-2})	(g $boll^{-1}$)	(%)
High nitrogen	970	65.5	4.16	40.0
Low nitrogen	809	57.8	3.92	40.1
LSD 0.05	136	7.2	NS[y]	NS

[z] High N received 100 lb N $acre^{-1}$; Low N received 50 lb N.

[y] Not significant ($P > 0.05$).