Effect of nitrogen and fruiting position on fiber properties, boll retention and yield components of cotton

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ABSTRACT

A field experiment was carried out at the EMPARN Experimental Station of Ipanguaçu-RN in a fluvic neosoil soil, with the objective of evaluating the effect of nitrogen and fruiting position on fiber properties, boll retention and yield components of commercial cotton cultivar CNPA 7H. Treatments were arranged in a randomized complete block design, with eight treatments and four replications, and analyzed in a split plot scheme, where the treatments in the plots corresponded to the four levels of nitrogen (N_1 = 0,00; N_2 = 50,00; N_3 = 100,00; N_4 = 150,00 kg ha^{-1}) and the fruiting positions 1 and 2 (PF_1 and PF_2) of sympodial branches, to the others two treatments of the split plots. Crop management employed was the one recommended by Embrapa for the region. The results indicated that variation in nitrogen levels influenced significantly yield components, boll retention and fiber properties, with exception of fiber length. In general, most open bolls were produced at the fruiting position 1 (PF_1), between sympodial branches five and 10.

Index terms
Nitrogen, fruiting position, boll retention, cotton fiber

Introduction

The production and the technological properties of the cotton fiber (*Gossypium hirsutum* L. r. latifolium Hutch.) are determined by genetic and environmental factors. The available information in the literature regarding to the variations that may occurs in the technological patterns of the cotton fiber in function of fluctuations of the environment is, in certain way, contradictory considering the interactive effects that exist among the genotype and the surrounding environment. It is known however, that some environmental factors such as the mineral nutrients, nitrogen (N) and phosphorus (P), are responsible for a significant variability that are verified in the technological properties of the cotton fiber (Danforth *et al*., 1990; Siqueira *et al*., 1994; Muhidong, 1995; Bradow *et al*., 1997).

Through studies conducted by Mauney *et al*. (1978) and Faver and Gerik (1996), it has been demonstrated that deficiency of mineral elements, essentials to the cotton plant nutrition, has significantly influenced the transference of photosynthetic compounds from the leaves to the fruiting structures, affecting, consequently, the fiber formation and development. Staut (1996) verified that the presence of P significantly influenced the uniformity of fiber length. According to Nelson (1949), there is evidence of the participation of P on the technological characteristics of the fiber and a significant effect on the boll weight. On the other hand, Cassman *et al*. (1990) and Bradow *et al*. (1997), attested the participation of N in the technological properties of the cotton fiber. The fiber resistance and elongation are positively correlated to the concentration of N.

Using isotopes on cotton cultivation, Bradow *et al.* (1997) and Guinn (1998) identified that nitrogen and others inorganic nutrients are transported in higher quantities to the fruiting structures nearest of the caulinar axis. The stalk leaves as well as the branch subtended laves, contributes with more quantities of assimilates to the fruits located in the first fruiting position than to those located in the subsequent fruiting positions. The migration of assimilates from the fruiting branch is relatively low. The subtended leaves of the fruit structure are the main suppliers of assimilates to the correspondent fruits, as reported by Guinn (1998). Significant physical and technological differences are observed between the bolls produced on the first, second and other fruiting positions. The differences are certainly due to the relatively better access and, consequently, higher absorption of assimilates by the fruits located in the firsts fruiting positions. According to Danforth *et al.* (1990), in the sympodial branch, boll weight and technological properties of the fiber, decreases from the first to the subsequent fruiting positions. With respect to the participation of the fruiting positions in the yield of the cotton plant, Landivar and Hickey (1997) verified that the first and second fruiting positions of the first ten sympodial branches, respond for 92% of the total bolls production.

The present work was carried out with the aim of evaluating the effect of nitrogen and fruiting position on fiber properties, boll retention and yield components of cotton.

Experimental procedure

The experiment was carried out at the Ipanguaçu Experimental Station of EMPARN- Agricultural Research Enterprise of Rio Grande do Norte State, which is located at 6^0 S latitude and 38^0 W longitude, and at 210 meters altitude. The soil is a kind of Neosoil Fluvic, with alkaline pH, having high levels of phosphorous and reasonable supplies of cationic macronutrients.

The experiment was arranged in a randomized complete block design, with eight treatments and four repetitions, in a split plots scheme, in which the four levels of the nitrogen: (N_0 Check) 0,00; (N_1) 50,00; (N_2) 100,00; (N_3) 150,00 kg ha^{-1} corresponded to the treatments applied to the main plots, and to the two fruiting positions in the sympodial branches: fruiting position 1 (FP_1), and fruiting position 2 (FP_2), represented the sub-plots. The experimental plots were constituted of four lines of 5 m, spaced one from another of 1 m. The useful area was represented by the two central rows, with 1 meter of border in each extremity.

The crop management employed was the one recommended by Embrapa for the irrigation production system of the region, except for the nitrogen, which was one of the factors studied. The genotype used was the Embrapa's commercial variety CNPA 7H. At planting, foundation fertilization was applied to all treatments. Phosphorus and potassium elements was furnished by the triple super-phosphate and potassium chloride fertilizers, at the doses of 120 kg ha^{-1} of P_2O_5 and 100 kg ha^{-1} of K_2O respectively. Cover fertilization, where nitrogen was furnished in the forms of ammonia sulfate and urea, was fractioned into two applications: One-third, 10 days after emergency and the other two-thirds, 20 days later.

The bolls were harvested manually, by fruiting position. Only fruiting position 1 (FP1) and 2 (FP2), were considered in this study. Fiber properties evaluated were: fiber length (mm), fiber uniformity (%), fiber elongation (%), fiber micronaire (mg in^{-1}), and fiber resistance (g tex^{-1}), while yield components included boll weight (g), 100 seeds weight (g) and fiber percentage (%). The evaluations of boll retention by fruiting position as well as the contribution of each fruiting position to the number of bolls harvested were accomplished in a percent basis. Fiber analyses were made in the fiber technology laboratory of Embrapa by using the HVI (High Volume Instruments).

Results and Discussion

Results from the analysis of variance of the data (ANOVA) of the variables studied in relation to nitrogen (N) variations levels and fruiting position in the sympodial branch of cotton plant, as well as the regression analyses in relation to the N variations, are in Table 1. From the F test values obtained, one can concluded that fruiting position (FP) significantly (p=0,01) affected fiber uniformity, micronaire, fiber elongation, boll weight and 100 seed weight, while fiber percentage, resistance and length was not significantly affected (p>0,05).

The results of the means values comparisons from the variables studied in relation to the fruiting position of the boll in the sympodial branch are presented in Table 2. Among the variables that were significantly affected by fruiting position, it can observed that, except for elongation, FP_1 presented higher means values for all fiber properties and yield components than did PF_2. However, it is important to mention that, although the differences are not statistically significant, variables such as fiber resistance and fiber length, presented higher means values for FP_2 than for FP_1, i.e. fiber elongation. Although the technological qualities of the cotton fiber decreased from the fruiting position nearest to the main stem to the one immediately after it within the same sympodial branch (Danforth *et al.*, 1990), it was not verified for all of the fiber properties evaluated in this study.

It can be seen from Table 1 that the variation in the levels of nitrogen induced highly significant differences (p=0,01) for most of the variables evaluated, except for fiber resistance in which, differences were only significant at (p=0,05) and for fiber length, which were not significant (p>0,05). This makes it evident that, besides the yield components (boll weight and weight of 100 seeds), variation in N levels affected significantly almost all the technological properties of the cotton fiber. It is remarkable that the increment of N did not significantly influenced fiber length.

The analysis of the polynomial regression, beginning with the breakdown of the degree of freedom of each variable, permits the determination of the equation that express the influence of nitrogen over the variables the best (Table 1). The models of the equations representing the influence of N on the behavior of the variables evaluated are presented in Table 3. The N levels affected linearly the micronaire and strength and, in a quadratic form, fiber percentage and uniformity. Fiber elongation, boll weight and 100 seeds weight, had its behaviors characterized by cubic effect. For these three last variables, it was verified that the maximum values are obtained with the application of 136, 110 and 103 kg ha^{-1} of N, respectively. Still from Table 1, it can be noticed that the interaction effect between the two factors studied for all variables evaluated, was not statistically significant (p>0,05) except for 100 seeds weight in which the effects provided by N doses were dependents (p=0,05) of the fruiting positions in the sympodial branch. Thus, to study the influence of this interaction in the variable, weight of 100 seeds, it was proceeded a breakdown of the effects of the fruiting positions (FP_1 and FP_2) in each dose of N. The results of the mean values comparison of 100 seeds weight obtained in each fruiting position in function of the N levels applied, are found in the Table 4. It can be verified that, even though there was no significant differences (p>0,05) among the two fruiting positions submitted to 50 kg ha^{-1} of N (N2), the FP_1 has proportionate means values for 100 seeds weight superior to those of FP_2 submitted to 0 (N_1), 100 (N_3) and 150(N_4) kg ha^{-1} of N.

The percentage contribution of FP_1 and FP_2 to number of bolls harvested, in function of the nitrogen doses applied, is illustrated in Figure 1. As it can be observed, the first sympodial branch emerged in the fifth node of the main stem to all the treatments related to the N doses. It is also verified that, in Figure 1, the number of sympodial branches produced by the plant and, consequently, the production of bolls harvested, were smaller in the plots without application of N (0 kg ha^{-1}) than in those where the doses of N were 50, 100 and 150 kg ha^{-1}. Consequently, while in the plots that received nitrogen fertilization (N_2, N_3 and N_4) were produced eleven sympodial branches, in those of the treatment without application of N (N_1), were produced only nine. Furthermore, while in the treatment N_1 the production of bolls in the FP_1 occurred from the fifth to the thirteen nodes in the stalk, the others treatments (N_2, N_3 and N_4) had boll production from the fifth to the fifteen nodes in the stalk.

The fruiting position of the branch in which the boll is produced, has significant participation on the bolls and seeds weight (Table 2). However, the influence of the fruiting position is more pronounced when the comparison is done in relation to the boll retention by position. The percentage of harvested bolls, distributed by doses of nitrogen and fruiting position, are presented in Table 5. It can be observed that, in the average, 80,5% of the bolls harvested were located in FP_1, what is in agreement with Guinn (1998). Analyzing the Figure 1 and Table 5, it is noticeable that, in the plots corresponding to 0 kg ha^{-1} of N, 92% of the total bolls harvested were produced in fourteen fruiting positions; while, in the 50, 100 and 150 kg ha^{-1} dose of N, were produced 94, 96 and 97 %, respectively, in sixteen fruiting positions.

Regarding to boll retention, it was observed that the quantity of harvested bolls increased from the fifth to the ninth node of the main stem. From the following node on, it begun to decrease (Figure 1). Again, analyzing Figure 1 and Table 5, it can verified that, in plots corresponding to the check treatment, (0 kg ha^{-1} of N), 81% of the harvested bolls were originated from nine points of FP_1, while the FP_2 contributed only with 11%. On the other hand, treatments corresponding to the 50, 100 and 150 kg ha^{-1} of N doses, there was increments of the contribution of FP_2. In fact, under the highest N dose (150 kg ha^{-1}), FP_2 contributed with 17% of the bolls harvested, which was superior to the obtained with other N doses. Also, from Figure 1, it can be observed that most of the bolls were found up to 2/3 of plant height, more precisely, between the fifth and the tenth node of the plant, what corresponded, on the average, to approximately 78% of the harvested bolls. These bolls are originated from the median phase of the flowering period of the plant and, for this reason, with more probability of being transformed in harvestable bolls. Meredith and Bridge (1973) affirm that the number of bolls in condition to be harvested decreases from the moment the flowers begin to appears in the superior half part of the plant.

In this study about 80% of the bolls harvested were originated from FP_1; while 14% were originated from FP_2. The rest of the boll production were originated from others fruiting positions of the branches and from the vegetative branches. Landivar and Hickey (1997) found similar conclusions, what corroborates with the data presented here. The results obtained in this experiment, for most of the characteristics evaluated, are similar to those reported by Vieira (1999), for the same cultivar.

Conclusions

Boll retention, boll weight, 100 seed weight, as well as the technological properties of the fiber, except length, are affected by nitrogen; The influence of nitrogen on cotton seed weight depends on the position of the bolls in the fruiting branch of the cotton plant; The fruiting positions located near the main stem contributes with higher proportion to the production of bolls in the plant; Besides the effect on yield components such as boll weight and seed weight, fruiting position also influences fiber micronaire, uniformity and elongation; Not all fiber technological qualities decreases from a fruiting position nearest to the main stem to the next in the same sympodial branch.

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Table 1. *Analysis of the variance and polynomial regression of the variables studied.*

Variables	Source of Variation	F	Variables	Source of Variation	F
100 seed weight (g)	Nitrogen (N)	83,76**	Boll weight (g)	Nitrogen (N)	73,36**
	Cubic effect	18,97**		Cubic effect	104,68**
	Fruiting position (FP)	19,73**		Fruiting position (FP)	49,80**
	N x FP	2,93*		N x FP	1,51^{ns}
Fiber percentage(%)	Nitrogen (N)	7,34**	Micronaire (mg in^{-1})	Nitrogen	10,30**
	Quadratic effect	4,77*		Linear effect	30,86**
	Fruiting position (FP)	0,01^{ns}		Fruiting Position (FP)	14,99**
	N x FP	0,96^{ns}		N x FP	0,94^{ns}
Fiber strength (g tex^{-1})	Nitrogen (N)	4,02*	Fiber length (mm)	Nitrogen (N)	0,87^{ns}
	Linear effect	11,83**		–	–
	Fruiting position (FP)	0,22^{ns}		Fruiting position (FP)	0,34^{ns}
	N x FP	0,09^{ns}		N x FP	0,29^{ns}
Fiber uniformity (%)	Nitrogen (N)	4,66**	Fiber elongation (%)	Nitrogen (N)	55,42**
	Quadratic effect	9,00**		Cubic effect	157,01**
	Fruiting Position (FP)	12,66**		Fruiting position (FP)	9,87**
	N x FP	1,39^{ns}		N x FP	1,20^{ns}

^{ns} Not significant at 5% level of probability by F test.
*, ** Significant at 5% and 1% level of probability, respectively (F test).

Table 2. *Mean comparison for the variables studied in relation to the fruiting position in the sympodial branch.*

Fruiting position (FP)	100 seed weight (g)	Fiber percentage (%)	Boll weight (g)	Micronaire (mg in^{-1})	Fiber strength (g tex^{-1})	Fiber length (mm)	Fiber uniformity (%)	Fiber elongation (%)
FP 1	13,40a	36.98a	7,08a	4,42a	27,70a	31,28a	85,83a	8,36a
FP 2	12,69b	36,93a	6,36b	4,12b	27,74a	31,45a	84,87b	8,83b

[1] Means followed by the same letter, in the column, do not differ statistically by the F test at 5% level of probability.

Table 3. *Polynomial regression equations obtained for the variables studied in function of the nitrogen doses applied.*

Variable	Equation	r^2	Minimum		Maximum	
			N	Y	N	Y
100 seed weight (g)	$Y= 12,08 - 0,063X+0,0019X^2 - 0,000103X^3$	1,00	19,75	11,50	103,23	14,49
Fiber percentage (%)	$Y= 36,35 - 0,013X+0,00018X^2$	0,88	36,11	36,11	-	-
Boll weight (g)	$Y= 6,03 - 0,043X+0,0013X^2 - 0,0000067X^3$	1,00	19,47	5,64	109,88	8,11
Fiber uniformity (%)	$Y= 85,56 - 0,022X+0,00016X^2$	0,72	68,75	84,80	-	-
Fiber elongation (%)	$Y= 7,45 - 0,014458x+0,000597X^2 - 0,000026X^3$	1,00	13,31	7,36	135,94	9,81
Micronaire (mg in^{-1})	$Y= 3,98 + 0,0038X$	0,99	-	-	-	-
Fiber strength (g tex^{-1})	$Y= 26,64 + 0,0148X$	0,98	-	-	-	-

Table 4. *Means comparison of 100 seed weight in function of fruiting position in the branch and nitrogen doses.*

	Nitrogen doses ((kg ha^{-1})*			
Fruiting position (FP)	0	50	100	150
FP_1	50,8a	50,2a	62,7a	50,7a
FP_2	46,0b	50,5a	59,1b	47,4b

* Means followed by the same letter, in the column, do not differ statistically by F test at 5% level of probability

Table 5. *Boll retention in function of nitrogen doses and fruiting position in the branch.*

	Boll retention in %, by fruiting position (FP)		
Nitrogen doses (kg ha^{-1})	FP_1	FP_2	Total
0	81	11	92
50	80	14	94
100	81	15	96
150	80	17	97

Figure 1. *Percent contribution of fruiting positions (FP_1 and FP_2) for number of bolls harvested in function of N doses applied.*