THE EFFECTS OF NITROGENOUS FERTILIZER ON SUGARCANE VARIETIES AND VARIETAL DIFFERENCES IN THIRD LEAF NUTRIENT CONTENT

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Abstract

Nutrient requirements of sugarcane in South Africa have been determined largely for variety NCo 376 which constitutes about 70% of the industry's crop. The increasing incidence of diseases in NCo 376 in recent years is leading to the use of other varieties and so it is necessary to ascertain whether present norms of fertilizing can be applied to these other varieties. In a trial conducted at the Pongola field station, the response of NCo 376 to increased nitrogen (N) levels in terms of cane and sucrose yields, number and height of shoots and N % dry matter, was greater than that of N52/219 or J59/3, when harvesting took place in spring. Differences in response between varieties were smaller when the crops were cut in autumn; N52/219 responded least in crops harvested in both spring and autumn.

The N content of the third leaves of young cane provided a good indication of response to increased N levels, as reflected by cane and sucrose yields, but N % threshold values did not differ substantially between the varieties which were tested. The available information on third leaf nutrient content in variety trials indicates that the newer varieties may differ significantly from NCo 376 in this respect, so that the threshold value for third leaf N content should change with variety.

Introduction

The variety NCo 376 has been used in most of the experiments to determine the nutrient requirements of sugarcane in South Africa. Although NCo 376 is still the most important local variety, it is likely to be replaced by varieties with greater disease resistance. The nutrient requirements of varieties of grain crops can differ considerably particularly if they reach maturity and lodge at different times (Alessi,[1] Mengel,[6] Winslow[10]). Sugarcane varieties differ in the amount of fertilizer they require for optimum yields (Fasihi & Malik[3]), the amount of nutrient they extract from a deficient soil (van Dillewijn[9]) and in the chemical composition of their stalks and leaves (Halais & Nababsing,[4] Orlando *et al*,[7] van Dillewijn[9]). Varieties of sugarcane developed in Mauritius for example, are used in factorial N and potassium (K) trials in all the major climatic zones so that the threshold values for nutrients in the leaves of the new varieties can be established (Halais & Nababsing,[4] ISSCT[5]).

The increasing occurrence of smut and mosaic in NCo 376 in recent years is beginning to necessitate changes in the varietal composition of the national crop, so it is appropriate to collate the available information on the nutrient requirements of commercial varieties. In early variety trials NCo 310 and N52/219 responded more than NCo 376 did to excessive rates of N fertilizer but these differences were not statistically significant and they were not associated with responses in third leaf N content (SA Sugar Association Experiment Station[8]).

Methods

Trials were established at Pongola on a deep Hutton form soil (Shorrock series) in spring 1978 and in autumn 1979 to investigate the response of three varieties of sugarcane to four levels of N fertilizer. The results of soil analyses at the time of planting are shown in Table 1. The varieties NCo 376, N52/219 and J59/3 were used and each received either 0, 45, 90 or 135 kg N/ha in the plant crop and 0, 50, 100 or 150 kg N/ha in the ratoon crops. All plots received 83 kg phosphorus (P)/ha at the time of planting.

A total of 83 kg of P fertilizer/ha was applied to the four ratoon crops of the 1978 trial and a total of 63 kg P was applied to the ratoon crops of the 1979 trial. K fertilizer was applied at a rate of 100 to 125 kg/ha to the plant, second and fourth ratoon crops of both trials. Cane in the 1978 trial was cut in spring each year and that in the 1979 trial was cut in autumn each year. Overhead sprinklers were used to apply 60 mm of effective water on a minimum 28-day cycle and irrigation was stopped six to eight weeks before the crops were harvested.

TABLE 1

Analysis of soil sampled to a depth of 150 mm prior to the planting of trials in 1978 and 1979

Trial	pH	Clay %	Organic matter %	ppm P	ppm K	ppm Ca	ppm Mg	ppm Zn
1978	6,3	23	1,5	19	229	526	203	0,6
1979	6,5	23	1,5	22	131	633	272	2,0

The height and population of stalks were recorded regularly in all crops. All plots were sampled on two to four occasions to determine the nutrient content of the third leaves. Stalks were taken from each plot for quality determinations at various times before, and at the time of harvesting. Cane yields in each plot were determined from the mass of cane cut from an area of 34 m² in a gross plot area of 59 m². The treatments were replicated four times, in a factorial design.

The nutrient contents of the third leaves of all varieties in the numerous experiments which comprise the agronomy variety programme, were compared with those of NCo 376.

Results and Discussion

Effect on cane yield

The effect of applying increasing amounts of N on cane yields when the crops were harvested in spring are shown in Figure 1. Effects were most marked in later ratoons and tended to be greatest in NCo 376 and least in N52/219. There was little response to fertilizer in the plant crop with any of the varieties and it appears that the virgin soil was able to provide sufficient N for yields up to 150 t/ha. NCo 376, which yielded considerably more cane than the other varieties did in the plant crop, responded to the first two increments of 50 kg N/ha applied to the first ratoon while J59/3 responded to the first increment and N52/219 showed no response. NCo 376 responded to each increment in subsequent ratoons while J59/3 responded to two increments in the second and third ratoon and to all three increments in the fourth ratoon. N52/219 responded to two increments in the third ratoon and three increments in the fourth ratoon but showed little response in the earlier crops.

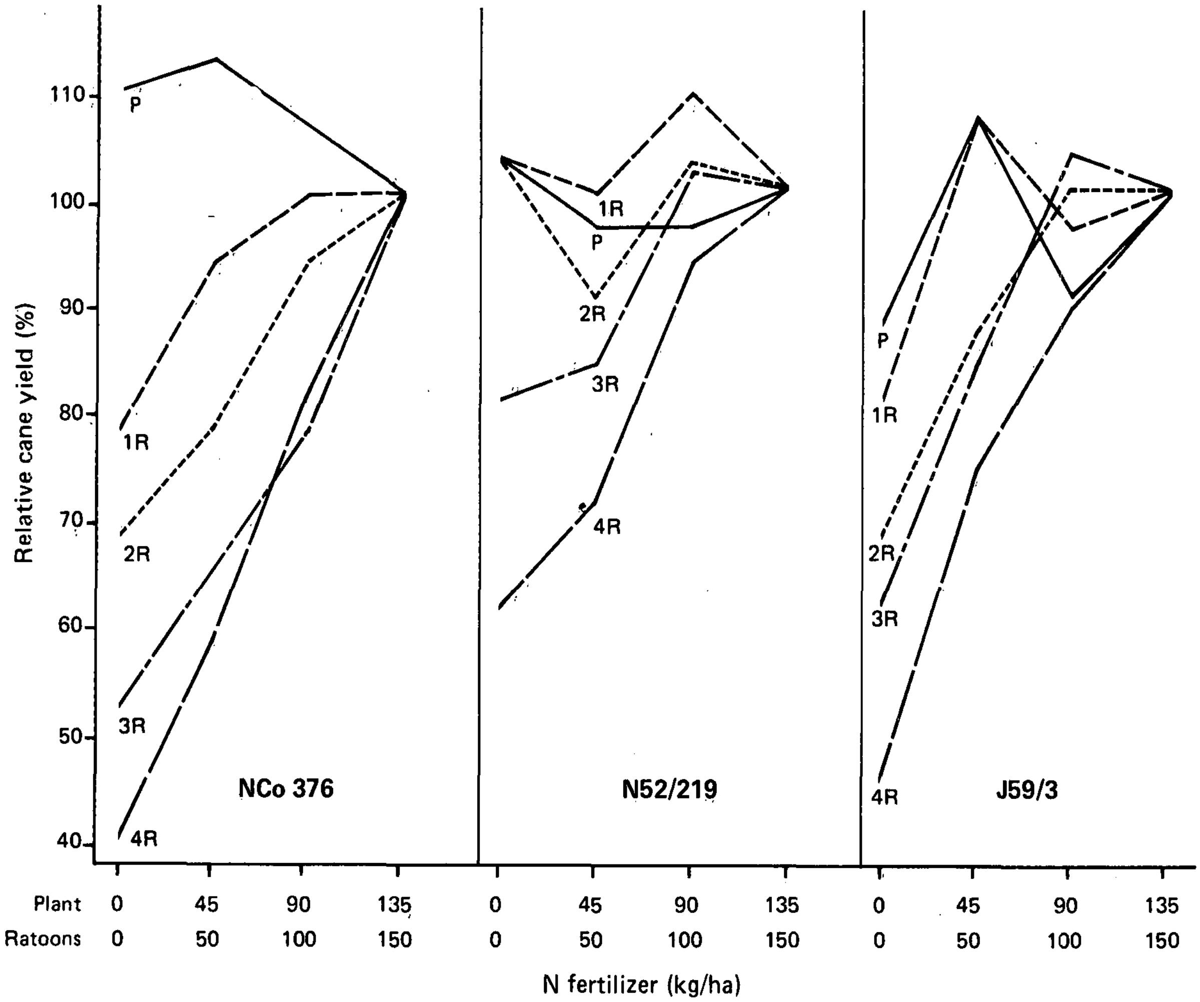

FIGURE 1 Effect of N fertilizer on cane yield (relative to yield at highest N level) of three varieties grown to the fourth ratoon on a spring cycle at Pongola.

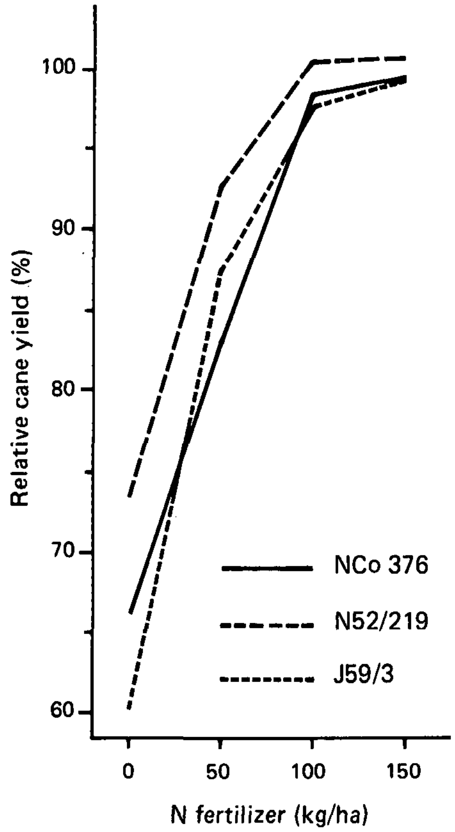

FIGURE 2 Effect of N fertilizer on cane yield (relative to yield at 150 kg N/ha) of three varieties in the third ratoon harvested in autumn.

N52/219 showed a greater response to fertilizer in the autumn than in the spring cycle, but differences between the responses of NCo 376 and J59/3 in the two cycles were small (Figure 2).

The responsiveness of NCo 376 to fertilizer could be due to its rapid removal of nutrients from the soil. The first crop of NCo 376 may have removed about 35 kg more N per hectare than the plant crop of N52/219 if the data on nutrient removal obtained by Bishop[2] can be applied to all of these varieties; Bishop found that one kilogram of N was removed for each ton of millable cane produced. However, there was apparently little difference in the amount of N removed by N52/219 and J59/3 which produced similar cane yields at the lower levels of N.

Effect on lodging

The small response obtained from applying fertilizer to N52/219 in the spring cycle may have been the result of the detrimental effect of lodging on growth (Figure 3). The larger amounts of N fertilizer caused increased lodging in all varieties in both cycles but lodging was worse in the spring than in the autumn cycle. Lodging was generally more severe in N52/219 than in NCo 376 and this may have prevented N52/219 from responding to the higher levels of N fertilizer. J59/3 was considerably more prone to lodging than N52/219 and it seems likely that J59/3 with its open stool formation and bent stalks may continue to grow rapidly even when it is lodged, while N52/219 which is prone to stalk breakage, is adversely affected by lodging.

Effect on sucrose content and yield

The response of NCo 376 to applied N was also evident from the sucrose analyses of ratoons 1, 2 and 3 in which the sucrose content was reduced markedly by increasing the N application from 100 to 150 kg/ha. The quality of cane in the first three ratoons of NCo 376 in the autumn cycle trial declined markedly when more than 50 kg N/ha was applied (Figure 4). Cane quality in N52/219 and J59/3 was reduced by additional amounts of N but these effects were small (less than 7%) and inconsistent compared with those occurring in NCo 376 (up to 18%). The sucrose yield of NCo 376 nevertheless increased more due to fertilizer than did the yields of the other varieties when they were harvested in spring but there was little difference in response between varieties when they were harvested in autumn (Figure 5).

Effect on tiller number

An increase in the amount of N fertilizer had a marked effect on the number of tillers before the formation of a complete leaf canopy, particularly in the spring cycle (Figure 6) and the effect was greatest with NCo 376. Many of the tillers which grew as a result of increased application of N died after the canopy had completely formed and the effect of N on stalk numbers at harvest was comparatively small. The population of stalks of NCo 376 was nevertheless increased more than that of the other varieties by increased amounts of N.

Effect on stalk height and flowering

Stalk height during the first six months of the ratoon crops was increased markedly in both cycles by increases in N applications but the response of N52/219 was considerably less than that of the other two varieties. The effect of N on stalk height at the time of harvest was reduced but still evident in NCo 376 and J59/3.

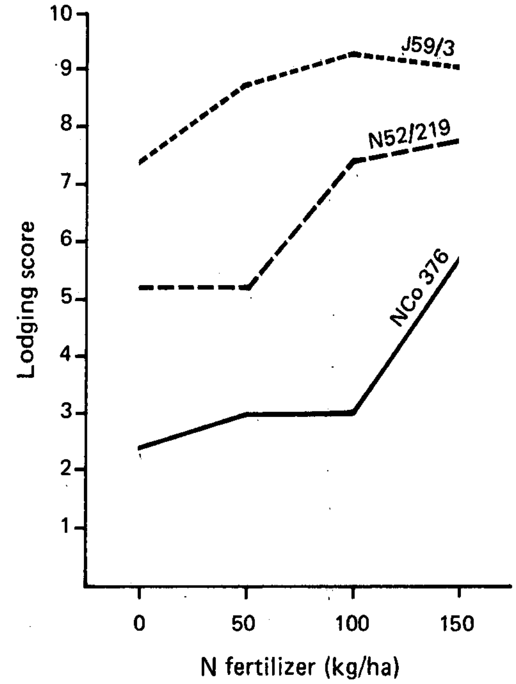

FIGURE 3 Effect on N fertilizer on lodging in three sugarcane varieties in a first ratoon spring crop at Pongola. (1 = no lodging, 10 = fully lodged).

In the first ratoon with the spring cycle about 60% of the stalks of NCo 376 and N52/219 produced flowers in plots which had not been fertilized. Each increment of 50 kg N/ha reduced flowering and only about 10% of the stalks in plots receiving 150 kg N/ha produced flowers.

Effect on N content of leaves

The first two samples of third leaves taken between three and six months after planting or ratooning provided a good

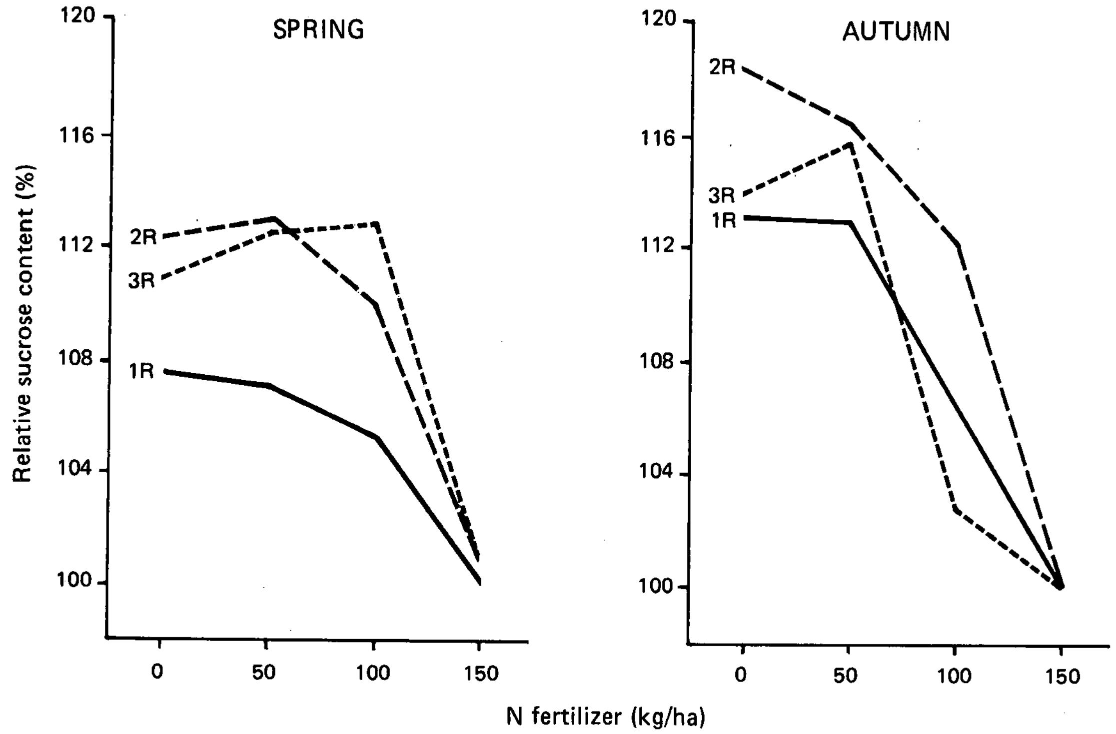

FIGURE 4 Effect of N fertilizer on sucrose content of NCo 376 (as a % of content at highest N level) harvested in spring or autumn when 12 months old.

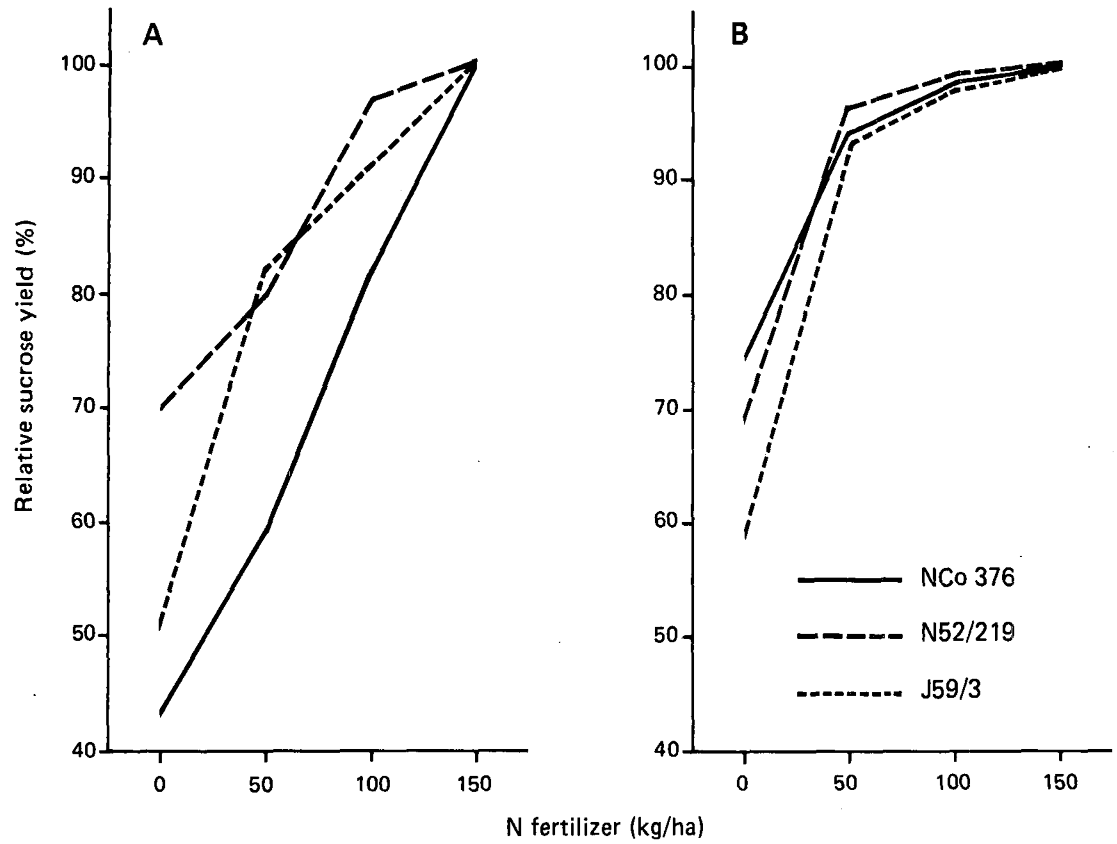

FIGURE 5 Effect of N fertilizer on sucrose yield (relative to yield at highest N level) of three varieties in a 4th ratoon harvested in spring (A) and in a 3rd ratoon harvested in autumn (B).

indication of the extent to which cane yields would be affected by application of N. The yield response obtained in NCo 376 and J59/3 was closely related to the response observed in the N content of third leaves ($r^2 = 0,70$). The relationship between the effect of N application on N content and its effect on the cane yield of N52/219 was less clear ($r^2 = 0,48$). The effect of applied N on the sucrose yield of NCo 376 could be associated with the N content of the third leaf with a certainty of about 70%, but the ability of the third leaf N content to predict sucrose yield was less certain in N52/219 and J59/3 (certainties of 40% and 63% respectively).

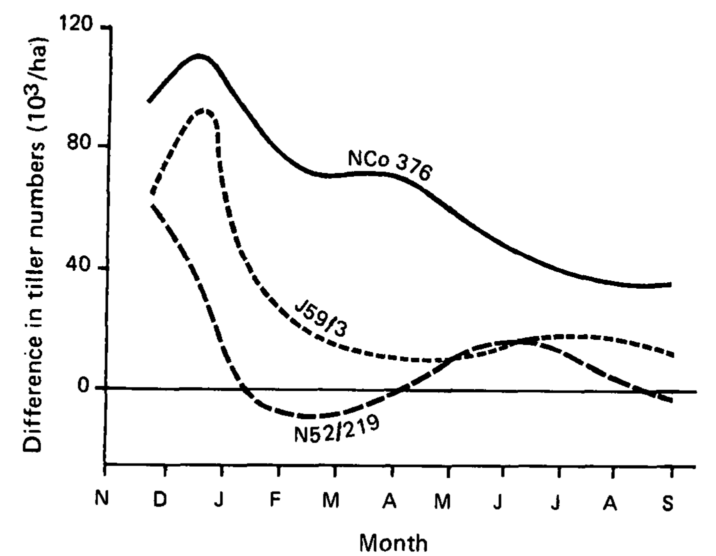

FIGURE 6 Differences in tiller numbers between cane receiving 150 kg N/ha and that receiving no N during the 3rd ratoon of the spring crop.

TABLE 2

Mean data for nine crops in two experiments relating yields of three varieties to third leaf nitrogen contents

Treatment kg N/ha	Tons suc/ha			N % third leaf		
	NCo 376	N52/219	J59/3	NCo 376	N52/219	J59/3
0	14,13	14,25	12,87	1,88	1,85	1,86
50	16,03	14,87	16,31	2,00	1,92	1,99
100	17,22	16,25	16,46	2,11	2,03	2,05
150	17,15	15,70	16,97	2,20	2,05	2,09

Reference to Table 2 shows that, when all nine crops in the two experiments are taken into account, maximum sucrose yields of NCo 376 and N52/219 were obtained when 100 kg of nitrogen was applied per hectare. For variety J59/3, the use of 150 kg N may have been warranted. On average, maximum yields of sucrose were obtained when the third leaf N content of NCo 376 was 2,11%, of N52/219 2,03%, and of J59/3 2,09%.

Leaf N, P and K contents

The differences in N, P and K contents of third leaves between NCo 376 and the other varieties, determined from about 400 samples from agronomy trials, were found in most cases to be statistically significant (Table 3). The noteworthy differences (all significant, P = 0,01) are underlined.

Some of the newer varieties (N12, N13 and N14) appear to have inherently low concentrations of N in the third leaves and these may result in an incorrect diagnosis of nutrient deficiencies. Leaf K contents of varieties differed to a greater extent than did N contents. The mean K % dry matter in the third leaves of J59/3 and N11 was considerably greater than that of NCo 376. Average foliar P contents also differed by amounts that could result in nutritional problems being incorrectly diagnosed. Mean P % dry matter in third leaves of varieties N6, N12, N14 and N52/219 was 0,02 units lower than the average for NCo 376.

TABLE 3

Mean difference in third leaf nutrient content between various commercial varieties of sugarcane and the standard variety NCo 376 (% dry matter)

Variety	N	P	K	No. of samples
CB36/14	−0,13	−0,01	+0,04	237
J59/3	−0,06	0	+0,24	123
N52/219	−0,06	−0,02	+0,10	239
N55/805	−0,04	−0,01	+0,01	403
NCo 293	−0,06	−0,01	−0,06	126
NCo 310	−0,10	−0,01	+0,02	166
NCo 334	−0,13	0	+0,06	131
NCo 382	−0,12	−0,01	−0,10	180
N6	−0,19	−0,02	−0,01	171
N7	+0,03	+0,01	−0,05	172
N8	−0,02	+0,01	−0,03	163
N11	−0,06	0	+0,20	79
N12	−0,12	−0,02	+0,03	16
N13	−0,18	−0,01	+0,03	27
N14	−0,15	−0,03	−0,08	24

Conclusions

Although increasing amounts of N fertilizer may affect some characteristics of different varieties differently, there is as yet no strong evidence that any released varieties respond to higher rates of N fertilizer than NCo 376 does. Some varieties may be less responsive than NCo 376 because of their tendency to lodge, a characteristic which is aggravated by excessive N fertilizer. Varieties differ in third leaf nutrient contents to an extent which warrants consideration when nutrient deficiencies are diagnosed. These differences do not appear to be related to differences in the responsiveness of varieties to fertilizer.

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