EFFECT OF NITROGEN LEVELS ON YIELD AND JUICE QUALITY OF SOME SUGAR CANE VARIETIES (*SACCHARUM* SPP, L)

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Abstract

Two field experiments were conducted at El-Mattana Agricultural Research Station Farm at Qena Governorate during 2001/2002 and 2002/2003 seasons to study the effect of nitrogen rates (150, 180, 210 and 240 Kg N/fed) on yield and quality of some sugar cane varieties (G.T.54/9, F.160, G.87/37 and Ph 8013). Results revealed that: Differences among varieties in sucrose, Brix and purity percentages were significant in both seasons .

The variety Ph 8013 gave the highest sucrose and Brix in the first season, while G.T.54/9 gave the highest sucrose, Brix in the second season and purity percentages in both seasons. On the other hand, F.160 variety gave the lowest reducing sugar %. Regarding pol % and recoverable sugar % Ph 8013 and G.T.54/9 gave the highest percentage of these traits in first and second seasons, respectively.

F.160 gave the thickest stalks, whereas G.87/37 gave the tallest stalks in both seasons. The highest number of millable stalks/m^2resulted from G.T.54/9. Regarding yield of stalks and sugar/fed., Ph 8013 outyielded the other varieties in stalk and sugar yield/fed. in the 1st season, while in the second season G.T.54/9 significantly surpassed the other varieties in sugar production.

Increasing nitrogen level up to 240 kg N/fed decreased sucrose and purity percentages, while Brix increased as N level increased up to 240 kg N/fed on the other hand ,reducing sugar % was not significantly affected by N levels.

The maximum pol % in cane and recoverable sugar were recorded at the lowest level of nitrogen rate (150 kg N/fed). Increasing nitrogen rate up to 240 kg N/fed increased diameter, length of stalk, number of millable cane and stalk yield (ton/ fed), while sugar yield increased as N level increased up to 240 and 180 kg N/fed in the first and second seasons, respectively.

The interaction between varieties and nitrogen levels was significant in recoverable sugar and cane yield in 2nd season, while in stalk length in both seasons. The highest cane yield per fed. was obtained from variety F.160 with 210 Kg N/fed.

INTRODUCTION

Sugarcane is considered the main source of sugar in Egypt. It is cultivated in 311,986 feddans mainly in middle and upper Egypt that yields an average of 49.9 tons of cane/fed (sugar crops council, Annual Report 2002).

Growing sugarcane in Egypt depends only on one commercial variety, G.T.54/9. Therefore, there is a great effort to release new varieties to avoid the risk of growing one variety for a long time.

There are many factors affecting cane yield, growth and juice quality. Among these factors, cane varieties and nitrogen fertilizer are important factors. Some investigators have reported differences among sugar cane varieties in yield and quality. Mohamed (1990), in Egypt, reported that G.75/393 variety surpassed the other two varieties (G.T.54/9 and G.74/96) in stalk length. However, G.T.54/9 gave the highest stalk diameter, sucrose, brix and purity percentages. El Sayed (1996) showed that F.153 variety surpassed the G.74/96 in number of stalks/m^2, stalk length, purity and Brix as well as reducing sugar. Nassar (1996) in Egypt, reported differences among varieties: G.T.54/9, G.85/37 and F.153 in brix, sucrose, fiber percentages and stalk yield as well as sugar yield/fed. He added that G.85/37 variety had the highest sugar yield (ton/fed). Mohamed (2001), in Egypt, evaluated three local varieties; G.85/37, G.T.54/9 and G.84/47. He found that G.85/37 variety recorded the highest stalk diameter, stalk weight and stalk length as well as yield of millable stalks and sugar yield/fed than the other varieties. Concerning the effect of nitrogen levels on yield and juice quality of sugar cane, Taha (1983), in Egypt, reported that brix, sucrose, reducing sugar percentage and number of millable cane/meter increased as the nitrogen rate increased up to 120 kg N/fed, while purity was not significantly affected by the increase in nitrogen levels. He added that there was an increase in cane yield as nitrogen rate increased up to 150 kg N/fed. Yadav and Sharma (1983), in India, reported that increasing nitrogen rate from 75 to 225 kg N/ha. increased the number of millable cane and cane and sugar yield. Bangar *et al.* (1992), in India, used 300 and 450 kg N/ha. They found a significant positive correlation between the applied nitrogen and sugar yield. Abd El-Hadi *et al.* (1994), in Egypt, studied the effect of nitrogen rate viz, 150, 175 and 200 kg N/fed. They found that sugar yield has maximized with 200 kg N/fed. On the other hand, purity and rendement sugar were not significantly affected by nitrogen rates. Moreover, Mokadem (1998) revealed that number of tillers, stalk height and stalk diameter as well as sugar yield increased by

increasing nitrogen rate up to 210 kg N/fed Altaf *et al.*. (1998), in Egypt, reported that cane yield was highest with 200 kg N/fed, while the highest sugar yield resulted from 150 kg N/fed. However, Ramadan (1992) found that stalk length and stalk diameter, number of millable cane and net cane yield increased as nitrogen rate increased up to 300 kg N/fed; while sucrose, purity, pol and sugar recovery percentages were reduced as N level increased. He added that the highest sugar yield /fed was obtained with the application of 250 kg N/fed. Mohamed (2001) and Attalla and El-Sogheir (2003), in Egypt, grew sugar cane under different nitrogen rates, 120, 150, 180, 210 and 240 kg N/fed. They found that stalk diameter, number of millable cane/fed and net cane yield as well as brix and reducing sugar percentages increased as nitrogen rate increased up to 240 kg N/fed; while the highest values of sucrose, pol and sugar recovery percentages were obtained with 180 kg N/fed. The differential response of cane varieties to N levels was reported by some warkers. Mohamed (2001) reported that variety x nitrogen rate interaction was significant for fiber, brix and sugar recovery percentage. Mohamed (1990) studied the effect of three nitrogen rates (180, 210 and 240 kg N/fed) and harvest time on three can varieties (G.T.54/9, G.74/96 and G.75/393). He found that the highest sugar yield was obtained when plants of G.T.54/9 and G.75/96 varieties received 180 and 210 kg N/fed in plant and first ratoon crop, respectively. While the highest sugar yield for G.75/393 variety was obtained when received 240 kg N/fed in plant and first ratoon crops. However, this work was raised to study the effect of four nitrogen fertilization levels on yield and quality of four sugar cane varieties.

MATERIALS AND METHODS

Two plant cane experiments were conducted at El-Mattana Agricultural Research Station farm at Qena during 2001/2002 and 2002/2003 seasons, to study the effect of four nitrogen fertilization levels, i. e. 150, 180, 210 and 240 kg N/fed, on yield and quality of four sugar cane varieties i. e. G.T.54/9, F.160, G.87/37 and Ph 8013. Soil of experimental site has loam texture with pH 7.3 and 7.1, 0.1 and 0.17% total nitrogen, 14.8 and 15.1 ppm available phosphorus, 335 and 360 ppm available potassium, as well as 1.5 and 1.6% organic matter in both seasons, respectively.

A split-plot design with four replicates was used. Nitrogen rates were distributed randomly in the main plots, while varieties used in this study were distributed

randomly in the sub-plots. Each sub-plot consisted of 5 rows one meter wide and 7.0 meter long. Thus the size of each sub plot was (35 m^2).

Cane was planted using the dry method on March 5th, 2001 and March 4th, 2002 by planting thirty three budded cane cutting in each row. Fields were irrigated right after planting.

Nitrogen fertilization was added as urea (46 %) and splited into two equal doses. The first application was after 60 days from planting and the second one was added one month later. Phosphate fertilization in the form of super phosphate (15.5 %) at the rate of 31 kg P_2O_5/fed and potassium fertilization at the raté of 48 kg K_2O as potassium sulphate (48 %), where phosphorus was added during land preparation, potassium was applied after 90 days age in both seasons. Irrigation and other cultural practices procedures were practiced as usual. Harvest took place after 12 months in both seasons.

At harvest a random sample of 25 millable stalks was taken from each sub-plot, stripped, cleaned and squeezed by electric pilot mill. The following traits were studied:

1- Stalk length was measured from soil surface to the top visible dewlap (cm).
2- Stalk diameter was measured at the middle part of the stalks.
3- Brix reading, wich represents total soluble solids in juice, was estimated by using digital refractometer modle ATAG, Japan.
4- Sucrose /100 cm^3 juice (Apparent sucrose) was determined by using Saccharometer according to A. O. A. C. (1955).
5- Apparent purity %, was calculated according to the following equation:

$$\text{Purity \%} = \frac{\text{Sucrose \%}}{\text{Brix \%}} \times 100$$

6- Reducing sugars/100 cm^3 juice, determined by using fehling solution.
7- Fiber % in cane was determined by taking 100 grams of the finally shreded cane and washed for 5 - 6 times with heated distilled water to completely remove all the sugar contents dried at 105 $^{\circ}$C for 24 hours and weighed .
8- Pol cane % (Richese) was calculated according to the following equation:

$$\text{Pol \% cane} = \frac{\text{Sucrose/100 g juice x pol factor}}{100}$$

where : Sucrose/100 g juice = sucrose/100 cm^3 ÷ juice density

Juice density was taken from Schiblers table according to sugar company.

Pol factor (absolute juice in cane or juice extraction) was calculated according to the following equation:

Pol factor = 100 – [(fiber % cane X 1.3) + 2.5]

Where: 1.3 = brix free water

2.5 = the trash deduction % cane

9- Recoverable sugar (rendment), was calculated according the following formula outlined by Spencer and Mead (1945)

$$\text{Sugar recovery \%} = \frac{\text{Pol \% - 0.8}}{\text{Purity \%}} \times \frac{\text{purity \% - 40}}{\text{100 - 40}}$$

10- Sugar yield (ton/fed) was calculated using the following equation:

Sugar yield (ton/fed) = net cane yield (ton/fed) X sugar recovery/100

Where: net cane yield was estimated on plot basis.

11- Number of millable cane/fed was calculated on plot basis.

All data recorded were subjected to normal statistical analysis as shown by Snedecor and Cochran (1967). Comparison among means was done using LSD at 5 % level of significant.

RESULTS AND DISCUSSION

1- Varietal differfnces:

Data presented in Table 1 reveal significant differences among Varieties in sucrose, brix and purity percentages in both seasons. The highest values of sucrose (18.9 and 18.5 %) as well as the highest values of brix (22.3 and 21.2 %) were donated from Ph 8013 and G.T.54/9. The other varieties ranked in between. G.T.54/9 had the highest values of purity (88.2 and 87.3 %), followed by Ph 8013 (84.8 and 84.9 %) in the 1st and 2nd seasons, respectively.

Reducing sugar percentage was significantly differed among varieties only in the seacond season (Table 1). The highest reducing sugar % resulted from G.T.54/9, while the variety F.160 gave the lowest reducing sugar % in both seasons.

Varieties exhibited significant differences in pol % and recoverable sugar % in both seasons. The variety Ph 8013 possessed a superiority in pol and recoverable sugar % in the 1st season and G.T.54/9 was the highest one in this respect in the second season. The superiority of Ph 8013 and G.T.54/9 in recoverable sugar % might be due to higher sucrose and purity percentages as mentioned before. Differences among sugar cane varieties in juice quality traits were reported by Mohamed (1990), El- Sayed (1996), Nassar (1996) and Attalla and El-Sogheir (2003).

Regarding stalk diameter and length; F.160 produced the thickest stalks, while G.87/37 had the tallest stalks among the tested varieties in both seasons (Table 2). It can be concluded that the taller the stalk the thinner was the internode. These results are in line with those of Mohamed (2001) who found that G.T.54/9 was the lowest one in stalk diameter among the tested varieties. Varieties differed significantly in number of millable stalks per m^2 in both seasons. G.T.54/9 significantly surpassed the other varieties in No of millable stalks followed by Ph 8013, G.87/38 and F.160, in descending order.

Varieties exhibited significant differences in stalk yield in the 1st season and sugar yield in both seasons. Ph 8013 possessed a superiority over all varieties in stalk and sugar production in the first season, whereas G.T.54/9 was significantly the highest one in sugar production in the 2nd season. The superiority of Ph 8013 and G.T.54/9 in sugar yields/fed might be due to higher juice quality traits in terms of sucrose, purity and recoverable sugar percentages as well as the higher stalk yield per fed. These results are in harmony with the results obtained by Mohamed (1990), El-Sayed (1996), Nassar (1996) and Mohamed (2001).

Table 1. Juice quality traits of four cane varieties, during 2001/2002 and 2002/03.

Varieties	Sucrose %		Brix %		Purity %		Reducing Sugar %		Pol %		Recoverable sugar %	
	Seasons											
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
G.T. 54/9	17.2	18.5	19.5	21.2	88.2	87.3	0.49	0.98	14.65	15.80	12.56	13.56
F.160	18.0	14.6	21.6	18.3	83.3	79.8	0.41	0.77	15.08	12.22	12.41	9.53
G.87/37	18.4	15.4	21.8	18.3	84.4	84.2	0.43	0.84	15.42	12.97	12.81	10.64
Ph 8013	18.9	15.7	22.3	18.5	84.8	84.9	0.43	0.86	16.11	13.43	13.52	11.16
L.S.D at 0.05%	0.7	0.6	0.7	0.4	1.4	2.4	n.s	0.07	0.60	0.16	0.65	0.82

Table 2. Yield and yield components of cane varieties, during 2001/2002 and 2002/03.

Varieties	Stalk diameter (cm)		Stalk length (cm)		No. of millable cane/m²		Stalk yield (ton/fed)		Sugar yield (ton/fed)	
	Seasons									
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
G.T.54/9	3.01	2.91	269	260	16.9	16.7	48.2	48.6	6.03	6.57
F.160	3.02	3.27	282	274	13.2	13.3	49.3	50.1	6.07	4.72
G.87/37	2.97	3.07	292	289	13.6	14.2	48.1	49.3	6.14	5.23
Ph 8013	2.95	3.06	278	287	14.8	14.7	49.8	48.2	6.68	5.37
L.S.D at 0.05%	n.s	0.13	7	10	0.9	0.9	1.3	n.s	0.31	0.54

2- Nitrogen effect

Results in Table 3 reveal significant effect of nitrogen levels on sucrose, brix and purity percentages in both seasons. The increase in nitrogen level was associated with a decrease in sucrose and purity percentages, also brix gradually increased as N level increased up to 240 kg N/fed. On the other hand, differences in reducing sugar due to nitrogen did not reach the level of significance (Table 3).

Differences among nitrogen levels in pol % in cane and recoverable sugar percentages were significant in both seasons. The maximum pol % in cane (15.92 and 13.96) and recoverable sugar (14.04 and 12.43 %) were recorded at the lowest level of nitrogen rate (150 kg N/fed), followed by 180, 210 and 240 kg N/fed, in a descending order. Such increase in pol % in cane and recoverable sugar percentages, might have resulted from the increase in sucrose and purity percentages accompanying lower N levels as mentioned before. These results are in agreement with those obtained by Taha (1983), Ramadan (1992), Abd El- Hadi *et al.* (1994) and Mokadem (1998). On the other hand, Zahoor *et al.* (1997), reported that juice quality traits in terms of brix, pol % in cane and purity as well as sucrose percentage were not affected by different levels of nitrogen fertilization.

Data presented in table 4 reveal that diameter and length of the stalk were significantly affected by N levels. Stalk diameter and stalk length increased by 5.17 and 14.55 % in the first season and by 6.35 and 13.02 % in the second season as N rate increased from 150 to 240 kg N/fed, respectively. These findings are in line with those obtained by Bangar *et al.* (1992), Ramadan (1992), and Mohamed (2001).

Number of millable cane per m^2 was consistently and signicantly increased as N level increased. The highest No of millable cane/m^2 (15.9 and 16.1 in the first and second season, respectively, were obtained from 240 kg N/fed), indicating the important role of N in stimulating cane growth and increasing tillering efficiency as reported by Ramadan (1992), Abd El- Hadi *et al.* (1994), Mokadem (1998) and Mohamed (2001).

Differences among N level in stalk and sugar yield were significant in both seasons, except for sugar yield in the first season. Stalk yield gradually increased as N level increased up to 240 kg N/fed. It is worth mentioning that difference between 210 and 240 kg N in stalk yield was not significant while sugar yield significantly increased as N level increased up to 180 kg N/fed, further N application was not associated with remarkable increase in sugar yield (Table 5). The increase in stalk yield accompanying N application might have been due to the favorable effect of N on vegetative growth of cane plants which was reflected in more tillering capacity, taller and thicker stalks as mentioned before. These results are in harmony with those obtained by Yadav and Sharma (1983), Mohamed (1990), Ramadan (1992), Altaf *et al.* (1998) and Mohamed (2001).

It is worth mentioning that the increase in stalk yield did not compensate for the reduction in sucrose, purity and recoverable sugar percentage accompanying higher N levels and consequently sugar yield was maximized with 180 kg N/fed. In this connection Altaf *et al.*.(1998) obtained the highest sugar yield with 150 kg N/fed while Attalla and El-Sogheir (2003) reported sugar yield increase with increasing nitrogen rate up to 240 kgN/fed.

Table 3. Juice quality as affected by nitrogen levels, during 2001/2002 and 2002/03.

N kg/fed	Sucrose %		Brix %		Purity %		Reducing Sugar %		Pol %		Recoverable sugar %	
	Seasons											
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
150	18.6	16.2	20.6	17.7	90.4	91.5	0.45	0.86	15.92	13.96	14.04	12.43
180	18.2	16.2	21.2	18.3	86.0	88.5	0.42	0.82	15.45	13.74	13.05	11.80
210	18.1	15.7	21.5	19.6	84.1	80.1	0.44	0.94	15.24	13.25	12.62	10.49
240	17.5	16.0	21.8	20.6	80.4	77.7	0.44	0.84	14.65	13.47	11.59	10.30
L.S.D at 0.05%	0.6	0.3	0.5	0.5	1.9	5.3	n.s	n.s	0.50	0.26	0.65	0.43

Table 4.Yield and yield components as affected by nitrogen levels .

N kg/fed	Stalk diameter (cm)		Stalk length (cm)		No. of millable cane/m^2		Stalk yield (ton/fed)		Sugar yield (ton/fed)	
	Seasons									
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
150	2.90	2.99	261	261	13.7	13.4	43.2	45.4	6.07	5.64
180	2.97	3.05	272	273	14.2	14.3	48.7	48.0	6.34	5.67
210	3.02	3.09	289	280	14.8	15.1	51.1	51.0	6.45	5.26
240	3.05	3.18	299	295	15.9	16.1	52.2	51.7	6.05	5.32
L.S.D at 0.05%	0.05	0.10	5.0	7.0	0.5	0.4	1.3	1.1	n.s	0.25

3- Interaction effect

The interaction between varieties and N levels exhibited significant effected on recoverable sugar % in the second season (Table 5). The highest percentage of recoverable sugar (14.12) was achieved from G.T.54/9 fertilized with 150 kg N/fed. Stalk length was significantly affected by N x variety interaction in both seasons. The tallest stalks (308 and 320 cm) was obtained from Ph 8013 received 240 kg N/fed, in the first and second seasons respectively. Cane yield per fed was significantly affected by variety x N level interaction, the highest cane yield (54.8 ton/fed) was obtained from F.160 with 210 kg N/fed.

On the basis of the aforementioned results it can be concluded that sugar yield could be maximized by using the high yielding varieties G.T.54/9 and Ph 8013 with the application of 180 - 210 kg N/fed under the conditions of this investigation.

Table 5. Recoverable sugar %, stalk length and net cane yield as affected by varieties and nitrogen rate interaction.

Nitrogen rate kg/fed.	Varieties	Recoverable sugar %	Stalk length cm		Cane yield ton/fed.
			Seasons		
		2nd	1st	2nd	2nd
150	G.T.54/9	14.12	252	249	45.0
	F.160	11.42	260	262	44.3
	G.87/37	11.97	272	273	47.3
	Ph 8013	12.25	253	262	45.1
180	G.T.54/9	14.09	264	256	48.7
	F.160	10.32	272	273	48.3
	G.87/37	11.16	290	288	48.0
	Ph 8013	11.54	262	278	47.0
210	G.T.54/9	13.81	274	263	49.5
	F.160	7.81	291	275	54.8
	G.87/37	9.69	301	293	50.4
	Ph 8013	10.25	290	289	49.2
240	G.T.54/9	12.23	277	272	51.1
	F.160	8.56	306	287	52.7
	G.87/37	9.78	304	303	51.6
	Ph 8013	10.61	308	320	51.4
L.S.D at 0.05 %		0.68	10.0	13.0	2.3

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تأثير معدلات التسميد الأزوتى على محصول وجودة العصير الناتج لبعض أصناف قصب السكر

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أقيمت تجربتان حقليتان خلال موسمي الزراعة ٢٠٠١ /٢٠٠٢ و ٢٠٠٢ /٢٠٠٣ لدراسة تأثير مستويات التسميد الآزوتي (١٥٠ ، ١٨٠ ، ٢١٠ ، ٢٤٠ كجم/ فدان) على محصول وجودة بعض أصناف قصب السكر (Ph 8013 , G 87/31 , F.160, G.T.54/9) وقد أظهرت النتائج المتحصل عليها ما يلي:-

اختلفت الأصناف معنويا فى نسبة السكروز والبركس والنقاوة حيث أعطى الصنف Ph 8013 أعلى نسبة سكروز وبركس فى الموسم الأول بينما أعطى الصنف G.T.54/9 وأعلى نسبة سكروز وبركس فى الموسم الثاني وأعلى نسبة نقاوة فى كلا الموسمين . وكانت الاختلافات غير معنوية بالنسبة للسكريات المختزلة فى الموسم الأول أعطى الصنف G.T.54/9 أعلى نسبة من السكريات المختزلة وعلى العكس من ذلك أعطى الصنف F. 160 اقل نسبة من السكريات المختزلة .

تفوق كل من الصنف G.T.54/9 و Ph 8013 فى حلاوة العصير السكروز المستخلص فى الموسم الثاني والأول عل الترتيب .

نتج أكبرقطر للساق ومحصول العيدان القابلة للعصير من الصنف F.160 فى الموسم الأول بينما نتج أعلى طول للساق من الصنف G.87/37 فى كلا الموسمين . كما تفوق الصنف G.T.54/9 فى عدد العيدان القابلة للعصير وكذلك فى محصول السكر فى الموسم الثاني بينما فى الموسم الأول أعطى الصنف Ph 8013 أعلي محصول من السكر رغم ان الاختلافات لم تكن معنوية .

أدي التسميد الآزوتي حتى ٢٤٠ كجم نيتروجين للفدان الى انخفاض فى جودة العصير المتمثلة في نسبة السكروز والنقاوة والسكر المستخلص بينما زادت قيم البركس والسكريات المختزلة . كما أدي زيادة التسميد الآزوتي الى زيادة قطر وطول السيقان وعدد العيدان القابلة للعصير وكذلك محصول العيدان بينما كانت أعلى قيمة لمحصول السكر أمكن الحصول عليها من التسميد بمعدل ١٥٠ - ١٨٠ كجم نيتروجين للفدان فى الموسم الثاني بينما لم تكن هناك اختلافات معنوية فى الموسم الأول .

كان تأثير التفاعل بين الأصناف ومعدل التسميد الآزوتي معنويا فى نسبة السكر المستخلص فى الموسم الثاني وطول السيقان فى كلا الموسمين . ونتج اعلى محصول من العيدان من زراعة الصنف F.160 وتسميده بمعدل ٢١٠ كجم للفدان .