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YIELD AND QUALITY OF SUGAR CANE AS AFFECTED BY NITROGEN AND ZINC FERTILIZATION

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ABSTRACTS: *Two field experiments were carried out at Shandaweel Research Station, (ARC). Souhag governorate (Latitude 26-27° N, 31-32° E longitude, elev 67m) Upper Egypt in the two successive growing seasons of 2009/2010 and 2010/2011 to study the effect of nitrogen and zinc fertilization on yield and quality of sugar cane crop. Each trial included nine treatments represents the combination between three nitrogen levels (160,190 and 220 kg N/fed) and three levels of zinc (0, 25 and 50 g Zn /fed). A complete randomized block design with four replications was used.*

Results showed that effect of nitrogen on juice quality parameters in terms of sucrose % , purity % and sugar recovery % was negatively and significantly. Mostly, increasing N- fertilizer up to 220 kg N/fed increased the values of the studied traits. Increasing the applied dose of nitrogen significantly and positively increased millable cane number (thousand /Fed.), cane yield and reducing sugar % in both seasons as well as sugar yield in the 1st season.

Meanwhile, juice quality parameters in terms of sucrose % , purity % and sugar recovery % As well as millable cane number (thousand /Fed.) , cane yield and sugar yield were positively responded to zinc application , however, this effect on reducing sugar % was negative. Generally, applying 50 g Zn/fed produced the highest production of millable cane number,sucrose%,sugar recovery%,cane yield and sugar yield.

The interaction between nitrogen and zinc levels was insignificant for all the studied characters.

Key words: *Sugar cane , nitrogen, zinc, fertilization.*

INTRODUCTION

Nitrogen is considered one of the most important elements which has a direct effect on plant growth, yield and juice quality. Zinc is one of the micro- nutrients which is necessary for growth and has a direct role in growth hormone formation which directly affect on growth consequently the final yield. Zinc probably can be relied on to give a response more often than any other micronutrients when applied to crops. Perhaps a wider variety of plants grown under a wider variety of conditions will respond to zinc than any other micronutrient. This should give an indication of the importance zinc plays in plant nutrition. Some of the more common symptoms of zinc deficiency, as far sugarcane, white streaking between leaf viens is detect. As deficiency progresses this takes on a bronze cast. Varma *et al. (1987)* showed that application of different rates of zinc (3.75, 5.0 and 7.5 kg/ha) at 75,105 and 135 days after planting increased cane yield and improved juice quality. Narasimham and Ramalingaswamy (1991) found that sugar yield was significantly increased as N - application rate increased from 0 to 112 kg/ha. Sugar yields obtained were 10.6, 13.9 and 13.6 ton/ha at 0, 112 and 224 kg N/ha, respectively. Abd-El-Gawad, *et al.* (1992-a) found that cane yield was positively and significantly responded to nitrogen fertilizer up to 240 kg N/fed. Moreover, application of 33g Zn/fed or 66 g Zn/fed gave an advantage in cane yield amounted to 1.74 and 2.23 tons/fed, respectively over that of unfertilized treatment. Abd-El-Gawad, *et al.* (1992-b) obtained a high value of sucrose % when zinc element was added at the rate of 33 g Zn/fed. They found a negative response in juice purity due to the increase in nitrogen doses (120, 180 and 240 kg N/fed). Abd El-Hadi *et al.* (1994) mentioned that juice quality in terms of purity and sugar recovery percentages were not clearly affected by adding nitrogen fertilizer at rates of 150,175 and 200 kg N/fed. El-Geddawy *et al.* (1997) found that both cane and sugar

yields were significantly increased by increasing nitrogen up to 210 kg/fed. Also they demonstrated that sucrose, purity and recovery percentages showed a reverse relationship due to nitrogen fertilizer application. Vitti, *et al*. (2007) mentioned that the N - rate showed a highly significant linear effect on cane production.Ismail, *et al*. (2008) stated that increasing N - fertilization significantly increased leaf area index up to 232.5 kg N/fed and significantly increased number of millable cane, cane and sugar yields/fed up to 279 kg N/fed. However, Stalk length and quality traits were insignificantly affected by N - level. El-Zeny, *et al.* (2010) found that application sulfate Zinc levels up to 20 kg/fed significantly increased cane yield and sugar recovery percentage. Osman, *et al*.(2010) showed that increasing N levels up to 240 kg N/fed increased number of millable cane, cane and sugar yields/fed but decreased sucrose and sugar recovery percentage.

This study was conducted to find out the relative performance of the commercial sugar cane variety G.T.54-9 to nitrogen and zinc application with respect to their influence on the quantitative and qualitative properties of sugar cane.

MATERIALS AND METHODS

The present work was conducted at Shandaweel Research Station, Souhag governorate (Latitude *26-27° N, 31-32°* E longitude, elevation 67 m) Upper Egypt in the two successive seasons of 2009/2010 and 2010/2011 to study the effect of nitrogen and zinc fertilization on yield and quality of sugar cane plant. Each trial included nine treatments represented the combination between three nitrogen levels (160,190 and 220 kg N/fed) and three doses of zinc (0, 25 and 50 g Zn /fed). A completely randomized block design with four replications was used. Physical and chemical properties of the upper 30 cm of soil of the experimental site were clay loam available N 25.8 ppm , P_2O_5 20.52 ppm and K_2O 520 ppm. Plot area was 42 m^2 with 6 ridges of 7 meters in length and 1.0 m apart. Sugar cane plant (G.T. 54-9 cultivar) was planted in spring season during the 1st week of April in both seasons.

Nitrogen fertilizer was soil added as urea (46% N) in two equal doses; the first dose was applied after two months from planting (1st June) and the second one was added one month later (1st July). Zinc was foliar applied in the form of zinc sulphate after two months from planting. Potassium fertilizer at rate 100 kg potassium sulphate (48% K_2O) was added one dose with the first nitrogen dose. Calcium super phosphate at rate of 400 kg (15.0% P_2O_5) was added with preparing the soil to planting. Other cultural practices were done according to the region.

Characters studied:

1. Number of millable cane /fed.
2. Sucrose percentage.
3. Reducing sugar percentage
4. Purity %: It was calculated according to the following equation:
   Purity %= Sucrose % x 100 /brix %
5. Sugar recovery percentage .
6. Cane yield (tons/fed.
7. Sugar yield (tons/fed) was estimated according to the following equation:

Sugar yield=cane yield (tons/fed)x sugar recovery%.

where:

-Sugar recovery % = [richness% x purity %] x 100

-Richness%=(sucrose/100 gm juice x richness factor) /100

-Sucrose/100 gm juice = (sucrose/100 cm^3 juice) / juice density

-Juice density was taken from Schibler table according to the Sugar Company.

-Richness factor (extracted juice) =

100 - [(Fiber % x 1.3) + 2.5]

1.3 = percent water free from sugar

2.5 = physical impurities %

The collected data were statistically analyzed according to Snedecor and Cochran (1981).

RESULTS AND DISCUSSIONS

1. Number of millable cane:

Results presented in Table (1) clarified that nitrogen levels, gave a significant and ascending increase in the number of millable cane in the two seasons. Increasing N levels up to 220 kg N/fed increased millable cane number by (4.80 and 1.94) and (8.45 and 3.86 thousand plants/fed) compared with the other nitrogen treatment, i.e.160 and 190 kg N/fed in the first and second season, respectively.

Table (1): Millable cane number (1000 plants/fed) as affected by nitrogen and zinc application and their interaction during 2009/2010 and 2010/2011 seasons.

Zinc levels (g. Zn/fed)	2009/2010 season				2010/2011 season			
	Nitrogen levels (kg N/fed)							
	160	190	220	Average	160	190	220	Average
0	42.00	46.30	48.17	45.49	48.78	54.03	56.47	53.09
25	44.43	47.50	49.77	47.23	50.60	55.18	58.50	54.76
50	47.50	48.70	50.40	48.87	50.73	54.68	60.52	55.31
Average	44.64	47.50	49.44		50.04	54.63	58.49	
LSD at 5% level								
Nitrogen levels (N)	1.02				1.96			
Zinc levels (Z)	1.02				NS			
NxZ	NS				NS			

Concerning the zinc application, number of millable cane (MC) was significantly responded to zince application in the first season only. It is noticed that application of 50 g. Zn/fed produced the highest value of millable number compared with the other zinc levels in both seasons. This effect on the millable cane number may be due to the effective role of zinc element in Indol Acetic Acid which plays a distinct role in merestim activity which in turn affect number of millable cane.

The interaction between zinc and nitrogen levels had no significant effect on this trait. However, increasing the applied dose of zinc was acombanied by increasing in millable cane number under the various level of nitrogen.

1. Sucrose percentage:

Data obtained in Table (2) revealed that nitrogen levels affected significantly sucrose % in both seasons. the collected data illustrated that the low level of nitrogen application (160 Kg N/fed.) significantly surpassed the other nitrogen levels in that trait. This finding was fairly true in the two growing seasons. This result is in line with that recorded by El-Geddawy *et al.* (1997).

Regarding zinc application, a significant response for sucrose % due to zinc application in the two seasons. Applying 50 g. Zn/fed attained a real superiority amounted by 4.52, 4.39% in the 1st season corresponding, 3.35, 0.46% in the 2nd season, respectively, over the other two levels of zinc i.e. 0 and 25 g Zn/fed This finding is in general agreement with that obtained by Abd El-Gawad *et al.* (1992-b).

The interaction between zinc and nitrogen levels had no significant effect on sucrose percentage in both seasons.

3. Reducing sugar percentage:

The results obtained in Table (3) revealed that reducing sugars percentage was significantly affected by nitrogen levels in both seasons. Increasing N levels up to 220 kg N/fed increased the values of reducing sugar percentage. This result is in harmony with that reported by Abd El-Gawad, *et al.* (1992-b) and El-Geddawy *et al.* (1997).

Concerning zinc levels, it was noticed that reducing sugars percentage was significantly affected by zinc levels in both seasons. Increasing zinc levels up to 50 g Zn/fed produced the lowest value of reducing sugars percentage. This result clears that zinc application significantly decreased reducing sugar percentage throughout its superior effect on sucrose percentage. This result is in accordance with that reported by Abd El-Gawad, *et al.* (1992-a).

Table (2): Sucrose percentage as affected by nitrogen and zinc application and their interaction during 2009/2010 and 2010/2011 seasons.

Zinc levels (g. Zn/fed)	2009/2010 season				2010/2011 season			
	Nitrogen levels (kg N/fed)							
	160	190	220	Average	160	190	220	Average
0	19.00	18.27	18.43	18.57	19.32	18.93	18.92	19.06
25	18.88	18.39	18.55	18.61	20.13	19.45	19.25	19.61
50	19.70	18.86	19.66	19.41	19.92	19.48	19.71	19.70
Average	19.19	18.50	18.88		19.79	19.29	19.29	
LSD at 5% level								
Nitrogen levels (N)			0.35				0.33	
Zinc levels (Z)			0.35				0.33	
NxZ			NS				NS	

Table (3): Reducing sugar percentage as affected by nitrogen and zinc application and their interaction during 2009/2010 and 2010/2011 seasons.

Zinc levels (g Zn/fed)	2009/2010 season				2010/2011 season			
	Nitrogen levels kg/fed							
	160	190	220	Average	160	190	220	Average
0	0.88	0.99	1.06	0.98	1.00	1.11	1.34	1.15
25	0.78	0.92	1.01	0.90	0.90	1.04	1.15	1.03
50	0.79	0.88	0.88	0.85	0.96	0.99	1.05	1.00
Average	0.82	0.93	0.98		0.95	1.05	1.18	
L.S.D at 5% level for:								
Nitrogen levels (N)			0.04				0.06	
Zinc levels (Z)			0.04				0.06	
NxZ			NS				0.09	

The interaction between nitrogen and zinc fertilizers significantly affected reducing sugar percentage in the 2nd season only. However, it is clearly that the plants fertilized with the highest nitrogen levels (220kgN/fed) without znic (0 zn) produced the highest values of reducing sugars percentage, while the lowest value of reducing sugars was obtained by adding 25 g Zn/fed with 160 kg N/fed.

4. Purity percentage:

Data presented in Table (4) cleared that the purity percentage was significantly and negatively responded to the tested nitrogen levels in the two seasons. Adding 160 kg N/fed gave the highest value of purity percentage in the two seasons compared to the other two N levels(190 and 220 kg N/fed.). This result is in harmony with that reported by El-Geddawy *et al.* (1997).

Regarding the effect of zinc application, purity percentage was somewhat increased as th applied dose of zinc increased from zero to 50 gm.Zn./Fed. However, this increment was not reach the level of significance in both seasons .

The results showed no significant effect for the interaction between the levels of nitrogen and zinc fertilizers on purity

percentage in both seasons. This response may be indicate to that the highest level of the applied zinc was not enough to attain the distinct effect on purity percentage. This means that the two tested factors were act indepently. However, the data show that the combination between 50 g.Zn./Fed. with 160 kg. N/fed. produced the highest value of purity percentage, in the two seasons.

5. Sugar recovery percentage:

Results given in Table (5) pointed out that increasing nitrogen levels decreased sugar recovery percentage in both seasons. This effect mainly due to the injury effect of nitrogen element on purity and sugar extraction and consequently on sugar recovery

Concerning zinc application treatments, there was a positive and significant response on the values of sugar recovery percentage up to 50 gm./Fed. This finding was fairly true in the two seasons. The distinct effect of zinc element in sugar recovery percentage mainly due to the encouragement effect of zinc on sucrose percentage as shown in Table (2) as well as, the pronounced role of zinc on plant growth and photosynthesis process.

Regarding the influence of the combination between the two tested factors on sugar recovery percentage , results shown in Table (5) revealed that the values of sugar recovery percentage was insignificantly affected by the various interaction treatments in this study.

Table (4): Purity percentage as affected by nitrogen and zinc application and their interaction during 2009/2010 and 2010/2011 seasons.

Zinc levels (g Zn/fed)	2009/2010 season				2010/2011 season			
	Nitrogen levels kg/fed							
	160	190	220	Average	160	190	220	Average
0	81.01	81.77	75.93	79.57	80.78	78.29	75.04	78.06
25	79.36	80.69	75.79	78.61	82.02	79.52	77.38	79.64
50	84.57	81.95	79.12	81.88	83.54	79.62	76.11	79.76
Average	81.65	81.47	76.95		82.14	79.14	76.17	
LSD at 5% level								
Nitrogen levels (N)			2.71				1.88	
Zinc levels (Z)			NS				NS	
NxZ			NS				NS	

Table (5): Sugar recovery percentage as affected by nitrogen and zinc application and their interaction during 2009/2010 and 2010/2011 seasons.

Zinc levels (g Zn/fed)	2009/2010 season				2010/2011 season			
	Nitrogen levels kg/fed							
	160	190	220	Average	160	190	220	Average
0	11.78	11.32	11.42	11.50	11.97	11.73	11.73	11.81
25	11.70	11.40	11.50	11.53	12.48	12.05	11.93	12.15
50	12.21	11.69	12.18	12.02	12.35	12.07	12.22	12.21
Average	11.89	11.47	11.70		12.26	11.95	11.96	
LSD at 5% level								
Nitrogen levels (N)			0.31				0.30	
Zinc levels (Z)			0.35				0.33	
NxZ			NS				NS	

6. Cane yield (tons/Fed.) :

Results given in Table (6) pointed out that cane yield was significantly affected by the tested nitrogen levels in the first and second seasons. Increasing N- level from 160 kg N/fed up to 190 and 220 kg N/fed increased cane yield by (3.52 and 6.29) and (2.96 and 5.96) tons/fed in the 1st and 2nd seasons,respectively.The relative advantage of nitrogen fertilizer on cane yield due to the pronounced effect of nitrogen fertilizer on millables cane number (Table 1).This result is in general agreement with that reported by Abd El-Gawad *et al*. (1992-b) and El-Geddawy *et al.* (1997).

Concerning zinc application, cane yield was significantly affected by zinc fertilizer in the second season only. It is clearly that applying 50 g Zn/fed outyielded the other zinc levels (0 and 25 g Zn/fed) by 2.78 and 2.29 tons/fed. in the second season, respectively. However, it could be noted that the same treatment of zinc fertilizer recorded the highest value of cane yield /Fed. in the 1st season too , but this advantage was insignificant. This result may be due to that Zinc is an essential micronutrient involved in the same enzymatic funcations as Mn and Mg. Only carbonic an hydras has been found to be specifically activated by Zn .Hence, it is worthy to notice the importance of Zinc in carbohydrate metabolism, and corresponding improving the quality of sugar cane. The increase in the values of cane yield as a result to zinc application mainly due to the pronounced effect of zinc application on millable cane number (Table 1) which reflected on cane yield.This result was confirmed by those obtained by Abd El-Gawad *et al*. (1992-b) and El-Geddawy *et al.* (1997).

The results showed that ther was insignificant effect on cane yield due to the interactions between the studied factors. This means that there is a close relationships between nitrogen and zinc application , increasing nitrogen levels under the studied zinc levels was always accompanied by increase in cane yield.

7. Sugar yield:

Results obtained in Table (7) clarified that nitrogen levels significantly increased sugar yield in the first season. However, its clearly that adding 220 kg N/fed produced the highest sugar quantity in both growing seasons. This result is in general agreement with that reported by Abd El-Gawad *et al.* (1992-a).

Table (6): Cane yield (tons/fed) as affected by nitrogen and zinc application and their interaction during 2009/2010 and 2010/2011 seasons.

Zinc levels (g. Zn/fed)	2009/2010 season				2010/2011 season			
	Nitrogen levels (kg N/fed)							
	160	190	220	Average	160	190	220	Average
0	47.67	48.79	53.23	49.96	53.00	53.00	54.90	53.63
25	48.00	51.13	53.27	50.80	51.00	53.33	58.03	54.12
50	47.20	53.33	55.23	51.92	51.33	57.60	60.28	56.41
Average	47.62	51.14	53.91		51.78	54.64	57.74	

LSDat 5% level		
Nitrogen levels (N)	2.53	2.19
Zinc levels (Z)	NS	2.19
N x Z	NS	NS

Table (7): Sugar yield (tons/fed) as affected by nitrogen and zinc application and their interaction during 2009/2010 and 2010/2011 seasons.

Zinc levels (g Zn/fed)	2009/2010 season				2010/1999 season			
	Nitrogen levels kg/fed							
	160	190	220	Average	160	190	220	Average
0	5.61	5.52	6.07	5.73	6.34	6.21	6.43	6.32
25	5.61	5.82	6.12	5.85	6.36	6.42	6.92	6.56
50	5.76	6.23	6.72	6.23	6.33	6.95	7.36	6.88
Average	5.66	5.85	6.30		6.34	6.52	6.77	

L.S.D at 5% level for:

Nitrogen levels (N)	0.34	NS
Zinc levels (Z)	0.34	0.35
Nx Z	NS	NS

Regarding zinc application, sugar yield was significantly responded to the applied doses of zinc in the two seasons. It is noticed that 50 g Zn/fed produced the highest sugar quantity, which amounted to 1.96, 2.48 tons/fed and 1.12, 2.29 tons/fed higher than the other zinc levels i.e. 0 and 25 g Zn/fed in the first and second season, respectively. This result may be due to the importance of Zinc for biochemicals reactions in many plants, and it acts as a co-enzyme in some biologically important enzymes in most plants(Kositsin and Khalidova,1976 and Vallee,1976).This result is an agreement generally with that reported by Varma *et al.* (1987).

The fruitful of nitrogen and zinc fertilizer on sugar yield is mainly due to their encouraged effects on millable cane number , cane yield , sucrose % , purity % and sugar recovery % (Table 1 ,6 , 2 , 4 and 5)

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تأثير التسميد النتروجينى والزنك على محصول وجودة قصب السكر

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الملخص العربي

شمال خط °أقيمت تجربتان حقليتان فى محطة البحوث الزراعية بشندويل بمحافظة سوهاج (خط عرض ٢٦ – ٢٧ شرق خط جرينتش) خلال موسم الزراعة ٢٠٠٩/٢٠١٠ و ٢٠١٠/٢٠١١ وذلك لدراسة تأثير °الاستواء وخط طول ٣١–٣٢ ثلاث مستويات من التسميد النتروجينى (١٦٠ ، ١٩٠ و ٢٢٠ كجم ن / فدان) وثلاث مستويات من الزنك (صفر و ٢٥ و ٥٠ جم زنك/ فدان) على محصول وجودة قصب السكرحيث استخدم تصميم قطاعات كاملة العشوائية فى تنفيذ التجربه, وتمت دراسة صفات عدد العيدان القابلة للعصير للفدان والنسبة المئوية للسكروز ونسبة السكريات المختزلة والنسبة المئوية للنقاوة ونسبة ناتج السكر ومحصول العيدان بالطن للفدان ومحصول السكر بالطن للفدان وقد أوضحت النتائج مايلى:

١– أدى زيادة التسميد النتروجينى من ١٦٠ الى ٢٢٠ كجم ن/فدان الى زيادة معنوية لكل من صفات عدد النباتات القابلة للعصير/فدان والنسبة المئوية للسكريات المختزلة ومحصول العيدان بالطن/ فدان فى كلا الموسمين، كما أدت الى زيادة معنوية لصفة محصول السكربالطن/فدان فى الموسم الأول فقط. بينما أدى ذلك الى نقص معنوى لصفات النسبة المئوية للسكروز والنسبة المئوية للنقاوة ونسبة ناتج السكرفى كلا الموسمين.

٢– أدى زيادة التسميد بالزنك حتى ٥٠ جم/فدان الى زيادة معنوية لكل من صفات عدد النباتات القابلة للعصير/فدان والنسبة المئوية للسكروز ونسبة ناتج السكر ومحصول السكر/فدان فى كلا الموسمين, بينما زاد محصول العيدان/فدان معنويا فى الموسم الثانى فقط. بينما لم تستجب صفة النسبة المئوية للنقاوة معنويا لإضافة الزنك فى كلا الموسمين.

٣– لم يكن للتفاعل بين التسميد النتروجينى والزنك تأثيرا معنويا للصفات المدروسة فى كلا الموسمين، ومع ذلك فان التسميد بمعدل ٢٢٠ كجم نتروجين/فدان +٥٠ جم زنك /فدان قد أعطى أعلى القيم لكل من محصولى العيدان والسكر للفدان فى كلا الموسمين.