EFFECT OF PLANT DENSITY, MINERAL AND BIOFERTILIZERS OF NITROGEN AND PHOSPHOURS ON SUGAR CANE PRODUCTIVITY

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Abstract

The present study was carried out at Shandaweel Agricultural Research Station (Souhag Governorate) for two successive seasons of 2001/2002 and 2002/2003. Each trail included 18 treatments represent the combination between two plant densities (one and half drills of three budded sugar cane cuttings "37800 buds/fed. and double drills 50400 buds/fed), nine fertilizer treatments and mineral: (inoculation with *Azospirillum* only, 180 kg N/fed and inoculation with *Azospirillum* + 90 kg N/fed) and (zero application phosphours, 200 kg superphosphate calcium (15.5% P_2O_5/fed) and inoculation with *Phosphobacterin*). (The commercial sugarcane variety viz. G.T.54-9 was used in the study. Experimental treatments were arranged in a split split plot design with four replications. Plant density were allocated in the main plots while nitrogen fertilizer levels were assigned to the sub .plots and Phosphour treatments were randomely distributed in the sub-sub plots. The results showed that double drills surpassed 1.5 drills in number of plants/m^2, elongation rate (cm/day), stalk diameter (cm) and reducing sugar, purity and sugar recovery percentages. *Azospirillum* + 90 kg N/fed treatment increased number of plants/m^2, elongation rate (cm/day), stalk length (cm) and reducing sugar, brix, purity percentages, number of millable cane (thousand/fed), cane and sugar yield (tons/fed) over other treatments. While 180 kg N/fed surpassed the other treatments in stalk diameter, leaf area and sugar recovery percentage. Phosphours fertilizer 200 kg as superphosphate calcium (15.5% P_2O_5/fed) increased numbre of plants/m^2 and stalk length in the 1st season and number of millable cane (thousand/fed), cane and sugar yield (tons/fed). While inoculation with *Phosphobacterin* surpassed other treatments in elongation rate (cm/day) in both seasons and stalk length in the 1st season only.

INTRODUCTION

Biofertilizers indicated that *Azospirillum* genus comprises nitrogen-fixing bacteria which have been isolated from the roots of numerous grasses, including cereals, sugar cane and forage grasses.

Regarding plant density El-Sayed (1996) revealed that plant density had no significant effect on stalk height, and planting 1.5 drill significantly increased stalk diameter compared with planting two drills. He added that density had no significant effect on brix % reducing sugar %, purity % and sugar recovery %. In addition, he found that planting by two drills (50400 buds/fed) significantly increased number of millable cane, cane and sugar yields compared with planting by one and half drills (37800 buds/fed).

In respect to nitrogen and biofertilizer of nitrogen (inoculated by Azospirillum) Osman (2000) showed that sugarcane mineral and biofertilizers treatments affected significantly number of plants/m^2, stalk height, stalk diameter, leaf area, sugar recovery %, number of millable cane (thousand/fed), net cane yield and sugar yield (tons/fed). While, the results were significant in mineral fertilizers only at brix %. On the other hand, the results showed insignificant differences between mineral and biofertilizers treatments were calculated for elongation rate (cm/day), reducing sugar % and purity due to biofertilizers treatments. Ahmed (2003) found that seeding rate of double drills gave the highest number of millable cane/m^2 and cane and sugar yields/fed. Furthermore, application of 210 kg N/fed produced the highest values of sugar recovery % while 240 kg N/fed gave the highest values of the number of millable cane/m^2, millable cane length, brix and cane and sugar yields/fed. El-Geddawy *et al* (2003 a,b) found that nitrogen fertilization had a significant effect on number of millable cane/fed in both seasons, cane yield superiority in the values of net cane yield for the combination between fertilizer (Azotobacter and Azospirillum) with the middle dose of the mineral N 120 kg N/fed over biofertilizer or mineral N fertilizer alone in the 1st season, the highest value (12.933%) of sugar recovery% was recorded by the application of 180 kg N/fed and/or inoculated by Azospirillum alone. Sugar cane was significantly affected by fertilization treatments, the highest values of sugar yield were gained when sugar cane seed setts were inoculated by Azotobacter and/or Azospirillum in addition to 120 kg N/fed. Meanwhile, sugar cane variety G. 85/37 recorded a superiority of 58268 plants/fed over G.T. 54/9 variety, cane yield and sugar yield., respectively. But regarding sugar recovery % the highest value (12.87%) was recorded from variety G.T. 54/9.

Phosphours and biofertilizer of *Phosphobacterin* Ismail *et al* (2000) found that six levels of phosphorus fertilization 0, 15, 30, 45, 60 and 75 kg P_2O_5/fed. had a significant influence on purity % while their effect on the length and diameter of

stalks, cane and sugar yields were insignificant. The best level of P fertilization was 60 kg P_2O_5/fed. *Phosphobacterin* levels significantly affected stalk length, cane and sugar yields. Mostly applying 500 g Pb/fed gave the highest value for the previous characters. The interaction between P and *phosphobacterin* levels did not significantly affect all the studied attributes. Shankaraiah *et al* (2000) showed the effect of soil inoculation of phosphate solubilizing organisms (PSM) in conjunction with levels and sources of P on growth, yield and quality of both plant and ratoon sugarcane crops. The inoculation with soluble P source viz., SSP (single superphosphate) and in combination with pressmud (PM, filter cake) accentuated their effect as P solubilizers. Enhanced uptake and higher tissue indices of P besides N and K were indicative of better nutrient use efficiency and their positive influence on various growth and yield parameters. Inoculation significantly increased cane yields (8-10%), economy in P fertilizer (25%) and net returns. This study aime to investigate the effect of planting density, mineral and biofertilizers of nitrogen and phosphours on sugar cane productivity.

MATERIALS AND METHODS

The present work was conducted for two successive seasons of 2001/2002 and 2002/2003 in Shandaweel Agricultural Research Station (Souhag Governorate). This study was intiated to invistagate the effect of biofertilizer on growth characters, juice quality, yield and yield components of the commercial sugar cane variety G.T. 54/9. Each trail included 18 treatments represented the combination between two plant densities. i.e. planting with one and half drills of three budded sugar cane cuttings "37800 buds/fed. and double drills 50400 buds/fed), nine fertilization treatments represent the combination between three nitrogen treatments (inoculation with *Azospirillum* only, and 90 or 180 kg N/fed and inoculation with *Azospirillum* and three phosphours treatments (zero application phosphours, 200 kg superphosphate 15.5% P_2O_5/fed and inoculation with *Phosphobacterin*).

Azospirillum brasilense were obtained from Soil, Water and Environmental Reasearch Institute, Agricultural Research Center Giza. Experimental treatments were arranged in a split split plot design with four replications. Plant density was allocated in the main plots while nitrogen fertilizer levels were assigned to the sub plots and Phosphour treatments were randomely distributed in the sub-sub plots. Plot area was

35 m^2. containing 5 rows, 7 m in length and 1m in width. Planting date the 3rd week of March in both seasons.

At planting the seed setts were inoculated by the studied biofertilizer i.e *Phosphobacterin* and *Azospirillum*, using the recommended dose i.e 24 unit/fed for nitrogen, biofertilizer, (unit weight 400 g, unit price equal 2 LE).

Concerning the mineral nitrogen fertilizer the studied doses were applied in two equal doses in the form of Urea (46.5% N). The 1st one was applied after 60 days from planting and the 2nd one 30 days later. The recommanded dose of phosphours 200 kg superphosphate 15.5% P_2O_5/fed was added at soil preparations, meanwhile, potassium fertilizer (48 kg K_2O/fed) was added once with the 1st dose of mineral nitrogen treatments, the biofertilizers *Phosphobacterin* and *Azospirillum* were mixed with soil of the experimental field and dressed on cane cuttings allocated in the furrows, thereafter, were covered by soil. Irrigation took place immediately. The normal cultural practices needed for growing sugar cane plants were followed. Sugarcane were harvested at the age of 12 months. Chemical and physical analysis of the experimental site showed that the upper 30-cm of the soil was clay loam including 39.4% sand, 10.4% silt and 50.61% clay and containing 79.0, 10.7, 198 ppm N, P, K., respectively and a pH of 7.6. All the required agricultural practices were done as recommended by Sugar Crops Research Institute.

Data recorded:

A- Vegetative characters:

1- Number of plants/m^2 was counted in square meter after 150 days from planting.

2- Elongation rate (ER cm/day) of sugar cane was measured twice at 210 and 330 days from planting according to the following formula: $ER = L_2-L_1/ T_2-T_1$

where: L_1 = Stalk length at time T_1, L_2 = Stalk length at time T_2.

A1- At harvest, a sample of 20 stalks represents each treatment was taken at random and the following data were recorded:

3- Stalk length (cm) was measured from soil surface to the top point of visible dewlap.

4- Stalk diameter (cm) was measured at the middle part of the stalk.

5- Leaf area cm^2/plant was determined for the third, fourth and fifth leaf at harvest.

B. Juice quality traits:

At harvest, a sample of 30 stalks representing each treatment was taken at random then juice was extracted using 3 rools lab mill, filterate and weighed.

Juice extraction % was calculated from the following equation:
Juice extraction % = juice weight x 100/stalk weight.
juice extraction percentage (JEP) was about 58-60% from cane weight.
6- Brix percentage was measured using brix Hydrometer standared.
7- Reducing sugar percentage (RS%) was determined in the extracted juice of cane according to chemical control in Egyptian production factories (Anonymous 1981).
8- Purity percentage was calculated according to the following equation:
Purity% = sucrose% x 100/ brix%.
9- Sugar recovery percentage was calculated according to the following equation:
Sugar recovery% = richness% x purity%.
where: richness = (sucrose/100 g cane juice x factor)/100.
Factor =100 - [fiber% + physical impurties% + percent water free sugar].

C- Yield and its attributes:

10- Number of millable cane/fed (in thousands) was counted.
11- Cane stalks of each plot were topped, cleaned from trash, weighed and cane yield (tons/fed) was calculated.
12- Sugar yield (tons/fed) was estimated according to the following equation:
Raw sugar yield = cane yield (tons/fed) x sugar recovery%.

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

RESULTS AND DISCUSSION

I. Vegetative charactersistics at 150 days from planting:

1. Number of plants/m^2:

Results given in Table (1) show that planting sugar cane seed setts by using 1.5 drills tended to produce higher number of plants/m^2 compared with double drills in both seasons but these differences were insignificant. These results are in harmony with those reported by El- Sayed (1996).

Concerning the effect of N-biofertilizer, the results in Table (1) indicate that application of *Azospirillum* + 90 kg N/fed significantly increased number of plants/m^2 compared with *Azospirillum* only and 180 kg N/fed. These results are in harmony with those reported by Osman (2000), Ahmed (2003) and El-Geddawy *et al* (2003 a,b).

Table (1) Effect of planting density, mineral and biofertilizers of nitrogen and phosphours on number of plants/m^2 and elongation rate (ER cm/day) of sugar cane after 150 days from planting in 2001/2002 and 2002/2003 seasons.

Planting density	Nitrogen	Number of plants/m^2								Elongation rate (ER cm/day)							
		2001/2002			Mean	2002/2003			Mean	2001/2002			Mean	2002/2003			Mean
		P1	P2	P3		P1	P2	P3		P1	P2	P3		P1	P2	P3	
1.5 drills	N1	9.35	9.84	9.48	9.56	9.85	10.23	9.10	9.73	0.213	0.230	0.247	0.230	0.233	0.247	0.260	0.247
	N2	9.42	9.88	10.08	9.80	8.71	8.81	9.07	8.86	0.277	0.295	0.278	0.283	0.331	0.349	0.313	0.331
	N3	9.87	9.98	9.73	9.86	9.30	9.28	9.91	9.50	0.285	0.286	0.303	0.291	0.326	0.334	0.326	0.329
Average		9.55	9.90	9.76	9.74	9.28	9.44	9.36	9.36	0.259	0.270	0.276	0.268	0.297	0.310	0.300	0.302
Double drills	N1	8.10	9.90	9.08	9.03	9.88	8.93	8.82	9.21	0.295	0.299	0.287	0.294	0.313	0.338	0.322	0.325
	N2	8.87	9.19	10.06	9.37	9.65	9.16	8.72	9.18	0.303	0.292	0.268	0.288	0.313	0.330	0.344	0.329
	N3	10.02	10.13	10.60	10.25	10.17	9.61	9.04	9.61	0.284	0.306	0.313	0.301	0.305	0.324	0.301	0.310
Average		8.99	9.74	9.91	9.55	9.90	9.23	8.87	9.33	0.294	0.299	0.290	0.294	0.311	0.331	0.322	0.321
NxP	N1	8.72	9.87	9.28	9.29	9.87	9.58	8.96	9.47	0.254	0.265	0.267	0.262	0.273	0.292	0.291	0.286
	N2	9.15	9.54	10.07	9.58	9.18	8.98	8.91	9.02	0.290	0.294	0.273	0.286	0.322	0.340	0.329	0.330
	N3	9.94	10.05	10.16	10.05	9.73	9.44	9.48	9.55	0.285	0.296	0.308	0.296	0.315	0.329	0.313	0.319
Total average		9.27	9.82	9.84	9.64	9.59	9.34	9.12	9.35	0.276	0.285	0.283	0.281	0.304	0.320	0.311	0.312
L.S.D. at 5% level of significant																	
plant density (D)					N.S				N.S				0.026				N.S
Nitrogen and bio fertilizer (N)					0.362				0.448				0.02				0.028
phosphours and Phosphobacterine (P)					0.314				N.S				N.S				0.012
D x N					0.512				N.S				0.029				0.040
D x P					N.S				0.568				0.011				N.S
N x P					0.544				N.S				0.013				N.S
D x N x P					N.S				N.S				0.019				N.S

N1 = Azospirillum only (24 unit/fed - unit weight 400 g), N2 = 180 kg N/fed, N3 = Azospirillum + 90 kg N/fed.
P1 = Zero application, P2 = 200 kg superphosphate calcium (15.5 % P_2O_5/fed), P3 = Phosphobacterin (24 unit/fed - unit weight 400 g).

The results show that application of 200 kg superphosphate produced higher number of plants/m^2 in the 1st season compared with zero application and *phosphobacterine*. The increase in number of plants/m^2 was 0.57 and 0.02 %. This result is in harmony with that reported by Shankaraiah *et al* (2000).

The results show that the highest number of plants/m^2 were 10.25, 9.90 and 10.16 which were recorded by double drills and *Azospirillum* + 90 kg N/fed treatment, double drills and zero application of P_2O_5/fed and *Azospirillum* + 90 kg N/fed and application of 200 kg superphosphate for the three treatments, respectively.

2. Elongation rate (ER cm/day):

The results in Table (1) indicate that elongation rate (ER cm/day) was significantly affected by plant density in the 1st season, whereas the highest value of ER was recorded by double drills treatment.

Regarding the influence of N fertilizer treatments on ER the presented data (Table 1) show that this trait was significantly affected by nitrogen fertilizer in both seasons, where (*Azospirillum* + 90 kg N/fed) produced higher value of ER (0.296) in the 1st season, while 180 kg N/fed produced 0.330 cm/day in the 2nd season. This result is in harmony with that reported by Osman (2000).

Concerning the effect of P-fertilizer level, the results show that using *phosphobacterin* produced higher ER in both seasons compared with zero phosphours application and/or 200 kg superphosphate.

The results in Table (1) indicate that the interaction between plant density and N-fertilizer treatment significantly affected ER in both seasons. Morever, the maximum ER in the 1st season were 0.299, 308 and 0.313 cm/day resulted from the interaction between DxP, NxP and DxNxP., respectively.

II. Vegetative charactersistics at harvest,

1. Stalk length (cm):

Data illustrated in Table (2) clear that stalk length was insignificantly affected by plant density in both seasons. This result is in harmony with that reported by El-Sayed (1996).

The effect of nitrogen fertilizer levels of stalk length was significant in the 1st season. The results showed that application of *Azospirillum* + 90 kg N/fed produced

taller stalks in the 1st season, compared with *Azospirillum* only and 180 kg N/fed. This result is in harmony with that reported by Osman (2000).

Concerning the effect of P-fertilizer levels, the results in Table (2) indicate a significant effect on stalk length in both seasons. The tallest stalk length was recorded with application of 200 kg superphosphate in the 1st season and *phosphobacterine* in the 2nd season. These results are in harmony with those reported by Ismail *et al* (2000) and Shankaraiah *et al* (2000).

The results show that the tallest stalk length was 325.1 cm which was recorded by double drills and *phosphobacterine*.

2. Stalk diameter (cm)

Results given in Table (2) clear that stalk diameter was insignificantly affected by plant density in both seasons, the results show that double drills produced thickest stalk diameter compared with 1.5 drills in both seasons. These increases were significant in the 1st season only. This result is in harmony with that reported by El-Sayed (1996).

Data in Table (2) illustrated that stalk diameter was not significantly affected by P and *phosphobacterin*. These results are in harmony with those reported by Ismail *et al* (2000) and Shankaraiah *et al* (2000).

The results in Table (2) indicate that DxN, DxP, NxP and DxNxP interaction significantly affected stalk diameter in the 1st season. The results show that the thickest stalk diameter were 2.87, 2.89, 2.88 and 2.92 cm which were recorded by (double drills and 180 kg N/fed), (double drills and zero P application), (180 kg N/fed and 200 kg superphosphate) and (double drills and 180 kg N/fed and zero application P)., respectively.

3. Leaf area (cm^2/plant):

Table (3) clears that leaf area was not significantly affected by plant density in both seasons.

Data given in Table (3) cleared that N and *Azospirillum* had a marked effect on leaf area, the results indicated that 180 kg N/fed increased the leaf area compared with *Azospirillum* only and *Azospirillum* + 90 kg N/fed. This increse reached the level of significant. This result is in harmony with that reported by Osman (2000).

Table (2) Effect of planting density, mineral and biofertilizers of nitrogen and phosphours on stalk length and diameter (cm) of sugar cane at harvest in 2001/2002 and 2002/2003 seasons.

Planting density	Nitrogen	stalk length (cm)								stalk diameter (cm)							
		2001/2002			Mean	2002/2003			Mean	2001/2002			Mean	2002/2003			Mean
		P1	P2	P3		P1	P2	P3		P1	P2	P3		P1	P2	P3	
1.5 drills	N1	314.0	318.3	316.3	316.2	310.3	311.3	312.3	311.3	2.22	2.30	2.38	2.30	2.48	2.57	2.60	2.55
	N2	336.0	341.7	335.0	337.6	318.3	321.0	322.3	320.6	2.80	2.86	2.85	2.84	2.63	2.68	2.73	2.68
	N3	321.3	337.3	337.3	332.0	321.7	317.0	317.0	318.6	2.82	2.86	2.75	2.81	2.70	2.73	2.63	2.69
Average		323.8	332.4	329.6	328.6	316.8	316.4	317.2	316.8	2.61	2.67	2.66	2.65	2.61	2.66	2.66	2.64
Double drills	N1	317.0	314.7	327.7	319.8	319.7	322.0	317.0	319.6	2.87	2.81	2.84	2.84	2.72	2.73	2.72	2.72
	N2	316.0	325.0	343.0	328.0	321.3	325.7	318.0	321.7	2.92	2.77	2.90	2.87	2.73	2.67	2.70	2.70
	N3	324.0	338.3	349.0	337.1	325.7	327.7	313.7	322.3	2.88	2.87	2.87	2.87	2.70	2.68	2.63	2.67
Average		319.0	326.0	339.9	328.3	322.2	325.1	316.2	321.2	2.89	2.82	2.87	2.86	2.72	2.69	2.68	2.70
NxP	N1	315.5	316.5	322.0	318.0	315.0	316.7	314.7	315.4	2.55	2.56	2.61	2.57	2.60	2.65	2.66	2.64
	N2	326.0	333.3	339.0	332.8	319.8	323.3	320.2	321.1	2.86	2.82	2.88	2.85	2.68	2.68	2.72	2.69
	N3	322.7	337.8	343.2	334.6	323.7	322.3	315.3	320.4	2.85	2.87	2.81	2.84	2.70	2.71	2.63	2.68
Total average		321.4	329.2	334.7	328.4	319.5	320.8	316.7	319.0	2.75	2.75	2.77	2.76	2.66	2.68	2.67	2.67
L.S.D. at 5% level of significant																	
plant density (D)					N.S				N.S				0.128				N.S
Nitrogen and bio fertilizer (N)					8.79				N.S				0.097				N.S
phosphours and Phosphobacterine (P)					7.86				2.90				N.S				N.S
D x N					N.S				N.S				0.137				N.S
D x P					N.S				4.11				0.036				N.S
N x P					N.S				N.S				0.044				N.S
D x N x P					N.S				N.S				0.062				N.S

N1 = Azospirillum only (24 unit/fed - unit weight 400 g), N2 = 180 kg N/fed, N3 = Azospirillum + 90 kg N/fed.
P1 = Zero application, P2 = 200 kg superphosphate calcium (15.5 % P_2O_5/fed), P3 = Phosphobacterin (24 unit/fed - unit weight 400 g).

Table (3) Effect of planting density, mineral and biofertilizers of nitrogen and phosphours on Leaf area cm^2/plant and brix percentage of sugar cane at harvest in 2001/2002 and 2002/2003 seasons.

Planting density	Nitrogen	Leaf area (cm^2/plant)								Brix percentage							
		2001/2002			Mean	2002/2003			Mean	2001/2002			Mean	2002/2003			Mean
		P1	P2	P3		P1	P2	P3		P1	P2	P3		P1	P2	P3	
1.5 drills	N1	430.4	443.9	448.7	441.0	460.5	470.6	480.5	470.5	18.57	19.25	20.41	19.41	21.20	21.67	21.43	21.43
	N2	506.8	520.6	493.4	506.9	485.9	507.1	486.3	493.1	20.51	20.45	20.16	20.37	20.77	20.62	19.83	20.40
	N3	447.0	457.4	467.2	457.2	506.2	484.0	486.0	492.0	20.03	20.89	20.85	20.59	19.63	19.73	20.00	19.79
Average		461.4	473.9	469.8	468.4	484.2	487.2	484.2	485.2	19.70	20.20	20.48	20.13	20.53	20.67	20.42	20.54
Double drills	N1	509.3	500.0	473.6	494.3	505.0	513.3	503.3	507.0	20.98	20.73	20.16	20.62	20.47	19.97	20.12	20.19
	N2	496.8	501.5	507.8	502.0	520.6	510.0	523.0	517.8	20.43	20.67	20.54	20.55	20.30	20.33	20.67	20.43
	N3	499.7	493.8	503.7	499.1	496.0	507.0	504.1	502.3	20.82	20.44	20.59	20.62	19.97	19.40	20.43	19.93
Average		502.0	498.4	495.0	498.5	507.0	510.1	510.1	509.1	20.74	20.61	20.43	20.60	20.24	19.90	20.41	20.19
NxP	N1	469.9	472.0	461.1	467.7	482.5	492.0	491.9	488.8	19.78	19.99	20.29	20.02	20.83	20.82	20.78	20.81
	N2	501.8	511.0	500.6	504.5	503.3	508.6	504.6	505.5	20.47	20.56	20.35	20.46	20.53	20.48	20.25	20.42
	N3	473.4	475.6	485.5	478.1	501.1	495.5	495.0	497.2	20.43	20.67	20.72	20.60	19.80	19.57	20.22	19.86
Total average		481.7	486.2	482.4	483.4	495.6	498.7	497.2	497.1	20.22	20.41	20.45	20.36	20.39	20.29	20.41	20.36
L.S.D. at 5% level of significant																	
plant density (D)					N.S				N.S				N.S				N.S
Nitrogen and bio fertilizer (N)					23.49				N.S				0.369				0.533
					9												
phosphours and Phosphobacterine (P)					N.S				N.S				N.S				N.S
D x N					33.23				N.S				0.522				0.754
					3												
D x P					N.S				N.S				0.423				N.S
N x P					N.S				N.S				N.S				N.S
D x N x P					N.S				N.S				0.733				N.S

N1 = Azospirillum only (24 unit/fed - unit weight 400 g), N2 = 180 kg N/fed, N3 = Azospirillum + 90 kg N/fed.
P1 = Zero application, P2 = 200 kg superphosphate calcium (15.5 % P_2O_5/fed), P3 = Phosphobacterin (24 unit/fed - unit weight 400 g).

The effect of P on leaf area was not significant in both seasons. This result is in harmony with that reported by Shankaraiah *et al* (2000).

The results in Table (3) indicates that DxN interaction significantly affected leaf area in the 1st season. The results showed that the greatest leaf area was 506.0 cm^2, which was recorded from (1.5 drills and 180 kg N/fed) treatment.

III. Juice quality at harvest:

1. Brix percentage %

The data illustrated in Table (3) clear that brix % was not significantly affected by plant density in both seasons. This result is in harmony with that reported by El-Sayed (1996).

The effect of N fertilizer treatments on brix % was significant in both seasons. The results showed that (*Azospirillum* + 90 kg N/fed) treatment produced higher brix % in the 1st season compared with *Azospirillum* only and/or 180 kg N/fed treatment, the increase in brix % was 0.58 and 0.14 %, while only *Azospirillum* treatment produced higher brix % in the 2nd season compared with 180 kg N/fed and (*Azospirillum* + 90 kg N/fed) treatment. The increase in brix % was 0.39 and 0.95 %., respectively. These results are in line with those reported by Osman (2000) and Ahmed (2003).

Phosphours fertilizer treatments insignificantly affected brix % in both seasons. This result is in harmony with that reported by Muthukumaraswamy *et al* (1994).

Results given in Table (3) indicate that DxN, DxP and DxNxP interactions significantly affected brix % in the 1st season. The results show that the highest brix % were 20.62, 20.74 and 20.98 % which were recorded by (double drills and *Azospirillum* + 90 kg N/fed), (double drills and zero P application) and (double drills, *Azospirillum* only and zero P application)., respectively.

2. Reducing sugar percentage (RS%):

The results in Table (4) reveale that plant density significantly increased reducing saugar (RS %) in the 2nd season only. However, the highest value of RS % was recorded in both seasons with double drills planting. This result is in harmony with that reported by El-Sayed (1996).

Data presented in Table (4) clear that nitrogen fertilization treatments had a marked effect on RS %. The results indicated that *Azospirillum* + 90 kg N/fed

Table (4) Effect of planting density, mineral and biofertilizers of nitrogen and phosphours on reducing sugar percentage (RS %) and purity percentages of sugar cane at harvest in 2001/2002 and 2002/2003 seasons.

Planting density	Nitrogen	Reducing sugar percentage (RS %)								Purity percentage							
		2001/2002			Mean	2002/2003			Mean	2001/2002			Mean	2002/2003			Mean
		P1	P2	P3		P1	P2	P3		P1	P2	P3		P1	P2	P3	
1.5 drills	N1	0.227	0.237	0.250	0.238	0.240	0.253	0.272	0.250	77.98	80.79	82.01	80.26	82.84	83.05	82.54	82.81
	N2	0.330	0.350	0.332	0.337	0.386	0.419	0.388	0.398	85.38	85.71	86.49	85.86	86.41	85.70	87.67	86.59
	N3	0.317	0.319	0.272	0.303	0.375	0.457	0.402	0.411	87.16	88.26	85.28	86.90	86.20	85.94	84.83	85.66
Average		0.291	0.302	0.285	0.293	0.334	0.376	0.354	0.355	83.50	84.92	84.59	84.34	85.15	84.89	85.01	85.02
Double drills	N1	0.362	0.365	0.349	0.359	0.386	0.391	0.418	0.399	85.17	87.25	85.48	85.96	86.19	87.88	86.09	86.72
	N2	0.408	0.409	0.432	0.416	0.459	0.431	0.516	0.468	87.02	86.71	83.29	85.67	87.83	86.62	84.90	86.45
	N3	0.401	0.383	0.411	0.398	0.524	0.448	0.506	0.493	88.40	85.36	87.31	87.02	87.24	85.61	85.25	86.03
Average		0.390	0.386	0.397	0.391	0.456	0.423	0.480	0.453	86.86	86.44	85.36	86.22	87.09	86.70	85.41	86.40
NxP	N1	0.294	0.301	0.300	0.298	0.313	0.322	0.345	0.327	81.57	84.02	83.74	83.11	84.51	85.46	84.32	84.76
	N2	0.369	0.379	0.382	0.377	0.423	0.425	0.452	0.433	86.20	86.21	84.89	85.77	87.12	86.16	86.28	86.52
	N3	0.359	0.351	0.341	0.350	0.449	0.452	0.454	0.452	87.78	86.81	86.29	86.96	86.72	85.77	85.04	85.84
Total average		0.341	0.344	0.341	0.342	0.395	0.400	0.417	0.404	85.18	85.68	84.98	85.28	86.12	85.80	85.21	85.71
L.S.D. at 5% level of significant																	
plant density (D)					N.S				0.083				2.02				0.806
Nitrogen and bio fertilizer (N)					N.S				0.048				1.17				N.S
phosphours and Phosphobacterine (P)					N.S				N.S				N.S				N.S
D x N					N.S				N.S				1.66				N.S
D x P					N.S				N.S				N.S				N.S
N x P					N.S				N.S				N.S				N.S
D x N x P					N.S				N.S				N.S				N.S

N1 = Azospirillum only (24 unit/fed - unit weight 400 g), N2 = 180 kg N/fed, N3 = Azospirillum + 90 kg N/fed.
P1 = Zero application, P2 = 200 kg superphosphate calcium (15.5 % P_2O_5/fed), P3 = Phosphobacterin (24 unit/fed - unit weight 400 g).

increased RS% by 0.32 and 0.42 in the 2nd season, compared with *Azospirillum* only and/or 180 kg N/fed. This result is in harmony with that reported by Osman (2000).

Neither, the phosphours element nor the biofertilizer phosphours had a significant effect on RS % in both seasons. These results are in harmony with those reported by Ismail *et al* (2000) and Shankaraiah *et al* (2000).

Data in Table (4) indicate that no significant was shown due to the interactions between the experimental factors on RS % in both seasons.

3. Juice purity percentage.

The results in Table (4) show that purity % was significantly affected by plant density in both seasons. The highest purity % were recorded with double drills in both seasons, the increase in purity % were 1.88 and 1.38 %., respectively. This result is in harmony with that reported by El-Sayed (1996).

The effect of N fertilizer treatments on purity % was significant in the 1st season; *Azospirillum* + 90 kg N//fed treatment surpassed that of adding *Azospirillum* only and also 180 kg N/fed. This result is in agreement with that reported by Osman (2000).

The results obtained in Table (4) indicate that purity% was not significantly affected by P fertilizer treatments in both seasons. These results are in line with those reported by Ismail *et al* (2000) and Shankaraiah *et al* (2000).

The results in Table (4) show that DxN interaction significantly affected purity % in the 1st season only. The results showed that the highest purity % was 87.02 % which was recorded by double drills and *Azospirillum* + 90 kg N/fed.

4. Sugar recovery percentage (SR%):

Data in Table (5) show that sugar recovery% (SR%) was significantly affected by plant density in the 1st season, the increase in SR % recorded was by double drills being 0.54 %. This result is in harmony with that reported by El-Sayed (1996).

Concerning the effect of N fertilizer treatments, the results in Table (5) show that using 180 kg N/fed produced higher SR % in the 1st season compared with *Azospirillum* only and *Azospirillum* + 90 kg N/fed, the increase in SR % were 0.83 and 0.34, while using *Azospirillum* + 90 kg N/fed produced higher SR % in the 2nd season compared with *Azospirillum* only and 180 kg N/fed, the increase in SR % were 0.91

Table (5) Effect of planting density, mineral and biofertilizers of nitrogen and phosphours on sugar recovery (SR %) and number of millable cane (thousand/fed) of sugar cane at harvest in 2001/2002 and 2002/2003 seasons.

Planting density	Nitrogen	Sugar recovery (SR%)								Number of millable cane (thousand/fed)							
		2001/2002			Mean	2002/2003			Mean	2001/2002			Mean	2002/2003			Mean
		P1	P2	P3		P1	P2	P3		P1	P2	P3		P1	P2	P3	
1.5 drills	N1	10.62	11.57	12.66	11.61	10.57	11.63	12.58	11.59	39.28	41.33	39.80	40.14	41.37	42.98	38.23	40.86
	N2	13.32	12.72	13.65	13.23	13.16	12.79	13.42	13.12	39.58	41.49	42.35	41.14	36.56	36.99	38.10	37.21
	N3	12.48	13.66	12.57	12.90	12.86	12.50	12.68	12.68	41.46	41.90	40.84	41.40	39.04	38.97	41.64	39.88
Average		12.14	12.65	12.96	12.58	12.20	12.31	12.89	12.47	40.10	41.58	41.00	40.89	38.99	39.65	39.32	39.32
Double drills	N1	13.74	12.64	13.22	13.20	11.90	12.90	13.35	12.71	34.00	41.57	38.14	37.90	41.51	37.52	37.05	38.69
	N2	13.37	12.82	13.55	13.25	12.97	12.86	13.08	12.97	37.24	38.60	42.26	39.37	40.53	38.47	36.70	38.57
	N3	12.87	13.30	12.55	12.91	13.60	12.66	14.04	13.43	42.07	42.56	44.50	43.04	42.72	40.37	37.98	40.36
Average		13.33	12.92	13.11	13.12	12.83	12.80	13.49	13.04	37.77	40.91	41.63	40.10	41.59	38.78	37.24	39.20
NxP	N1	12.18	12.11	12.94	12.41	11.23	12.27	12.96	12.15	36.64	41.45	38.97	39.02	41.44	40.25	37.64	39.78
	N2	13.35	12.77	13.60	13.24	13.07	12.82	13.25	13.05	38.41	40.05	42.31	40.25	38.55	37.73	37.40	37.89
	N3	12.68	13.48	12.56	12.90	13.23	12.58	13.36	13.06	41.76	42.23	42.67	42.22	40.88	39.67	39.81	40.12
Total average		12.73	12.79	13.03	12.85	12.51	12.56	13.19	12.75	38.94	41.24	41.32	40.50	40.29	39.22	38.28	39.26
L.S.D. at 5% level of significant																	
plant density (D)					0.264				N.S				N.S				N.S
Nitrogen and bio fertilizer (N)					0.190				0.726				1521.1				1882.7
phosphours and Phosphobacterine (P)					N.S				N.S				1320.1				N.S
D x N					0.269				N.S				2151.3				N.S
D x P					N.S				N.S				N.S				2384.2
N x P					0.901				N.S				2286.4				N.S
D x N x P					N.S				N.S				N.S				N.S

N1 = Azospirillum only (24 unit/fed - unit weight 400 g), N2 = 180 kg N/fed, N3 = Azospirillum + 90 kg N/fed.
P1 = Zero application, P2 = 200 kg superphosphate calcium (15.5 % P_2O_5/fed), P3 = Phosphobacterin (24 unit/fed - unit weight 400 g).

and 0.01, respectively. These results are in agreement with those reported by Osman (2000) and Ahmed (2003).

The effect of P on SR % was not significant in both seasons. This result is in line with that reported by Ismail *et al* (2000).

The results in Table (5) indicate that DxN and NxP interaction significantly increased SR% in the 1st season. The results show that the highest SR% were 13.25 and 13.6%, which were recorded by (double drills and 180 kg N/fed) and (180 kg N/fed and 200 kg superphosphate., respectively.

IV. Yield and its attributes at harvest:

1. Number of millable cane (thousand/fed).

Results obtained in Table (5) pointed out that planting seed setts by 1.5 drills produced higher number of millable cane plants compared with double drills in both seasons but these increases were insignificant. This result is in accordance with those reported by El-Sayed (1996).

Regarding the effect of nitrogen fertilizer treatments adding, the results in Table (5) indicate that *Azospirillum* + 90 kg N/fed significantly increased number of millable cane compared with *Azospirillum* only or 180 kg N/fed. The results indicated that *Azospirillum* + 90 kg N/fed increased number of millable cane by 3.200 and 1.970 thousand in the 1st season, 0.340 and 2.230 thousand in the 2nd season., respectively. These results are in harmony with those reported by Osman (2000) and El-Geddawy *et al* (2003 a,b).

The results showed that 200 kg superphosphate produced higher number of millable cane in the 1st season compared with zero application or *phosphobacterine*. This result is in line with that reported by Shankaraiah *et al* (2000).

The results in Table (5) indicate that DxN interaction significantly affected number of millable cane in the 1st season. While, the DxP interaction significantly affected number of millable cane in the 2nd season and the NxP interaction significantly affected number of millable cane in the 1st season. The results showed that the highest number of millable cane were 43.040, 41.590 and 42.670 which were recorded by (double drills and *Azospirillum* and 90 kg N/fed), (double drills + zero application P/fed) and (*Azospirillum* + 90 kg N/fed and 200 kg superphosphate., respectively.

2. Cane yield (tons/fed)

Data illustrated in Table (6) clear that cane yield was not significantly affected by plant density in both seasons. This result is in harmony with that reported by El-Sayed (1996).

Data given in Table (6) indicate that cane yield was significantly affected by N fertilizer treatments in the 1st season, the results indicated that *Azospirillum* + 90 kg N/fed increased cane yield by 2.64 and 1.83 tons/fed, compared with *Azospirillum* only and 180 kg N/fed, respectively. These results are in agreement with those reported by Osman (2000), Ahmed (2003) and El-Geddawy *et al* (2003 a,b).

Regard to the effect of P fertilizer treatments, the results in Table (6) show that application of 200 kg superphosphate produced higher cane yield (tons/fed) in the 1st season compared with zero application and *phosbacterine*, the increase in cane yield were 1.88 and 0.22 tons/fed., respectively. This increase was significant in the 1st season only. These results are in line with those reported by Ismail *et al* (2000) and Shankaraiah *et al* (2000).

Data presented in Table (6) indicate that DxN and NxP interaction significantly affected cane yield in the 1st season. The results show that the highest cane yield were 60.77 and 60.24 tons/fed, which were recorded by (double drills and *Azospirillum* + 90 kg N/fed) and (*Azospirillum* + 90 kg N/fed and 200 kg superphosphate., respectively. While, the results in Table (6) show that DxP interaction significantly affected cane yield in the 2nd season. The results show that the highest cane yield was 57.34 tons/fed, which was recorded by 1.5 drills and *phosphobacterine*.

3. Sugar yield (tons/fed)

Data obtained in Table (6) show that planting sugar cane seed setts by using double drills produced higher sugar yield tons/fed in both seasons compared with 1.5 drills, the increase in sugar yield were 0.26 and 0.32 tons/fed., respectively. These increase were insignificant in both seasons. This result is in harmony with that reported by El-Sayed (1996).

The effect of N fertilizer treatments on sugar yield was significant in the 1st season. Application of *Azospirillum* + 90 kg N/fed treatment produced higher sugar

yield in the 1st season, compared with *Azospirillum* only and 180 kg N/fed, the increase in sugar yield was 0.64 and 0.05 t/fed. These results are in line with those reported by Osman (2000), Ahmed (2003) and El-Geddawy *et al* (2003 a,b).

The results show that adding 200 kg superphosphate produced higher sugar yield tons/fed in the 1st season, compared with zero application or *phosphobacterine,* the increase in sugar yield was 0.42 and 0.18%. These results are in harmony with those reported by Ismail *et al* (2000) and Shankaraiah *et al* (2000).

The results in Table (6) indicate that DxN and NxP interaction significantly affected sugar yield tons/fed in the 1st season. The results show that the highest sugar yield were 7.84 and 8.16 tons/fed which were recorded by (double drills and *Azospirillum* and 90 kg N/fed) and (180 kg N/fed and 200 kg superphosphate., respectively.

Table (6) Effect of planting density, mnieral and biofertilizers of nitrogen and phosphours on cane yield and sugar yield (tons/fed) of sugar cane at harvest in 2001/2002 and 2002/2003 seasons.

Planting density	Nitrogen	Cane yield (tons/fed)								Sugar yield (tons/fed)							
		2001/2002			Mean	2002/2003			Mean	2001/2002			Mean	2002/2003			Mean
		P1	P2	P3		P1	P2	P3		P1	P2	P3		P1	P2	P3	
1.5 drills	N1	56.82	59.22	57.66	57.90	58.63	60.80	56.32	58.58	6.04	6.85	7.30	6.73	6.20	7.07	7.09	6.79
	N2	57.10	59.27	60.26	58.88	54.19	54.73	55.76	54.89	7.58	7.54	8.23	7.78	7.12	6.99	7.50	7.20
	N3	59.11	59.75	58.43	59.10	56.51	56.50	59.41	57.48	7.38	8.16	7.34	7.63	7.29	7.10	7.52	7.30
Average		57.67	59.41	58.78	58.62	56.44	57.34	57.16	56.98	7.00	7.52	7.62	7.38	6.87	7.06	7.37	7.10
Double drills	N1	54.44	59.04	56.57	56.68	59.12	55.24	54.92	56.43	7.49	7.45	7.48	7.47	7.03	7.15	7.32	7.17
	N2	56.11	55.99	59.86	57.32	58.66	56.27	54.14	56.36	7.50	7.17	8.10	7.59	7.60	7.22	7.07	7.30
	N3	60.00	60.26	62.06	60.77	60.65	58.26	55.51	58.14	7.72	8.02	7.79	7.84	8.25	7.38	7.79	7.81
Average		56.85	58.43	59.49	58.26	59.48	56.59	54.86	56.97	7.57	7.55	7.79	7.64	7.63	7.25	7.39	7.42
NxP	N1	55.63	59.13	57.11	57.29	58.87	58.02	55.62	57.50	6.76	7.15	7.39	7.10	6.62	7.11	7.21	6.98
	N2	56.60	57.63	60.06	58.10	56.42	55.50	54.95	55.62	7.54	7.35	8.16	7.69	7.36	7.10	7.29	7.25
	N3	59.55	60.01	60.24	59.93	58.58	57.38	57.46	57.81	7.55	8.09	7.56	7.74	7.77	7.24	7.65	7.55
Total average		57.26	58.92	59.14	58.44	57.96	56.97	56.01	56.98	7.29	7.53	7.71	7.51	7.25	7.15	7.38	7.26

L.S.D. at 5% level of significant						
plant density (D)	N.S	N.S	N.S			N.S
Nitrogen and bio fertilizer (N)	1.38	N.S	0.253			N.S
phosphours and Phosphobacterine (P)	0.994	N.S	0.279			N.S
D x N	1.95	N.S	0.357			N.S
D x P	N.S	2.39	N.S			N.S
N x P	1.72	N.S	0.482			N.S
D x N x P	N.S	N.S	N.S			N.S

N1 = Azospirillum only (24 unit/fed - unit weight 400 g), N2 = 180 kg N/fed, N3 = Azospirillum + 90 kg N/fed.
P1 = Zero application, P2 = 200 kg superphosphate calcium (15.5 % P_2O_5/fed), P3 = Phosphobacterin (24 unit/fed - unit weight 400 g).

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تأثير الكثافة النباتية والتسميد المعدنى والحيوى لكلا من النيتروجين والفوسفور على انتاجية قصب السكر

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أقيمت تجربتان حقليتان بمحطه البحوث الزراعيه بشندويل بمحافظه سوهاج لدراسه تأثير الكثافة النباتية والتسميد المعدنى والحيوى على انتاجية قصب السكر. أشتملت الدراسة على ١٨ معاملة تمثل التفاعل بين: الكثافة النباتية وهى الزراعة على صفين وصف ونصف وتسعة معاملات تسميد وهى: التوافق بين ثلاثة معاملات تسميد ازوتى: التلقيح بالازوسبيرليم منفرد والمعدل الموصى به من السماد الازوتى وهو ١٨٠ وحدة ازوت للفدان والتلقيح بالازوسبيرليم + ٩٠ كجم نيتروجين/فدان وثلاثة معاملات من السماد الفوسفاتى (بدون سماد والمعدل الموصى به ٢٠٠ كجم سوبر فوسفات كالسيوم ١٥,٥% فو٢أه والتلقيح بالفوسفوبكترين). وزعت المعاملات فى تصميم قطع منشقه مرتين حيث وضعت الكثافات النباتية فى القطع الرئيسية ومستويات التسميد الازوتى فى القطع الفرعية ومستويات التسميد الفوسفاتى فى القطع تحت الفرعية وكانت مساحة القطعة التجريبية ٣٥ متر مربع اشملت على ٥ خطوط بطول ٧ متر وعرض ١ متر وتمت الزراعة خلال الاسبوع الثالث من مارس فى كلا الموسمين.

أوضحت النتائج المتحصل عليها:

– تفوقت الكثافة النباتية صفين من العقل فى كلا من الصفات التالية عدد النباتات فى المتر المربع ومعدل الاستطالة وسمك الساق والنسبة المئوية للسكريات المختزلة والنقاوة وناتج السكر مقارنة بالصف والنصف صف.

– تفوق خليط السماد الازوتى والحيوى على الحيوى منفرد أوالازوتى منفرد فى صف عدد النباتات فى المتر المربع ومعدل الاستطالة وطول الساق والنسبة المئوية للسكريات المختزلة والبركس والنقاوة وعدد العيدان القابلة للعصير (١٠٠٠/فدان) ومحصول العيدان والسكر (طن/فدان). بينما تفوق ١٨٠ كجم نيتروجين/فدان فى صفة سمك الساق ومساحة الاوراق والنسبة المئوية لناتج السكر.

– تفوق التسميد بالمعدل الموصى به من السماد الفوسفاتى ٢٠٠ كجم سوبر فوسفات كالسيوم (١٥,٥ % فو٢أه) فى صفات عدد النباتات فى المتر المربع وطول الساق فى الموسم الاول وعدد النباتات القابلة للعصير (١٠٠٠/فدان) ومحصول العيدان والسكر (طن/فدان). بينما تفوق التلقيح بالفوسفوبكترين فى صفات معدل الاستطالة وطول الساق فى الموسم الثانى.

– اوضحت النتائج ان احسن محصول من عيدان القصب نتج من التفاعل بين الزراعة فى صفين و التلقيح بالازوسبيرليم + ٩٠ كجم نيتروجين/فدان والموصى به من الفوسفات ٢٠٠ كجم سوبر فوسفات كالسيوم (١٥,٥% فو٢أه) فى الموسم الاول وكانت القيمة ٦٢,٠٦ طن/فدان بينما فى الموسم الثانى نتج من التفاعل بين الزراعة فى صف ونصف من العقل والتلقيح بالازوسبيرليم منفرد والتلقيح بالفوسفوبكترين وكانت القيمة ٦٠,٨ طن/فدان.

– – اوضحت النتائج ان احسن محصول سكر نتج من التفاعل بين صف ونصف عقل و(التلقيح بالازوسبيرليم + ٩٠ كجم نيتروجين/فدان) والتلقيح بالفوسفوبكترين فى الموسم الاول وكانت القيمة ٨,١٦ طن/فدان بينما فى الموسم الثانى نتج من التفاعل بين صفين من العقل و(التلقيح بالازوسبيرليم + ٩٠ كجم نيتروجين/فدان) وبدون فوسفات فكانت القيمة ٨,٢٥ طن/فدان.