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EFFECT OF PHOSPHOBACTERIN AND PHOSPHORUS LEVELS ON YIELD AND QUALITY OF SUGARCANE

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Abstract

Two field trials were carried out at Mattana Agricultural Research Station (Qena Governorate) in two growing seasons 1993/1994 and 1994/1995 to study the effect of phosphorus fertilizer and phosphobacterin (biofertilizer) on growth, juice quality and yield of sugar cane. The trial consisted of twenty-four treatments which were the combinations between six levels of phosphorus fertilization (0, 15, 30, 45, 60 and 75 kg P_2O_5/fed.) which were allocated at random in the main plots and four levels of phosphobacterin (0, 250, 500 and 750 g Pb/fed.) which were randomly distributed in the sub plots. A split plot design with four replications was used. The plot size was 35m^2. Variety G. 85/37 was planted.

The obtained results indicated that phosphorus levels had a significant influence on purity percentage while their effect on the length and diameter of stalks, sucrose percentage, cane and sugar yields were insignificant. The best level of phosphorus fertilization was 60 kg P_2O_5/ fed. Phosphobacterin levels significantly affected stalk length, sucrose percentage, cane and sugar yields. Mostly, applying 500 g Pb/fed gave the highest value for the previous characters. The interaction between phosphorus and phosphobacterin levels did not significantly affect all the studied attributes.

INTRODUCTION

Sugarcane is grown in soils vary in texture from light sand to heavy clay. It makes heavy demands on the replaceable soil nutrients and presages a loss in soil fertility due to monocropping, inadequate fertilization and non-recycling of the crop residue.

One of the problems facing phosphorus fertilization is that considerable amounts of the added phosphorus are fixed in the form of tri-calcium phosphate. Several investigators have repeatedly given an impression that the inoculation of such soils with P-dissolver helps in providing the growing plants with available phosphorus. *Bacillus megatherium var. Egyptiacum* is one of the biofertilizers which could supply plants with their needs of phosphorus during their growth, reduce fertilizers. Phosphobacterin; a phosphate solubilizing biofertilizer costs, improve soil structure, balance, and increase soil fertility and crop yields. Rodriguez *et al.* (1982) showed that the application of 40 kg P_2O_5/ha was recommended to give the highest yield and quality of sugarcane. Lakshmikantham (1983) found that the application of phosphate at 112 kg P_2O_5/ha was recommended to give the highest yield and quality of sugarcane. Lakshmikantham (1983) found that the application of phosphate at 112 kg P_2O_5/ha had no effect on cane yield. Pannu *et al.* (1986) noted that P application at the highest rate (75 kg P_2O_5/ha) gave the highest cane yield. This treatment had no significant effect on juice quality. Macalintal and Urgel (1990) indicated that application of 140 kg P_2O_5 per hectare or 50% of this rate gave 104 and 81.3 tons cane/ha, respectively. Sugar concentration in the cane was unaffected by rate or timing of fertilizer application. Devi *et al.* (1992) applied P at 75, 100 and 125 kg/ha to sugercane cv. Co.C 671 and Co. 62175. They found that cane yield was not affected. Patil and Shingte (1992-a) showed that sugar content did not respond to P application at rate of 0-165 P_2O_5/ha. Lestari (1993) noticed that sugar yield increased with increasing P rate up to 30 kg P/ha. Bangar *et al.* (1994) found that application of P showed significantly favorable effect on all growth parameters (tillers, height and diameter), cane yield and sugar production/ha. Sugarcane yield improved significantly by the application of 35.2 kg P/ha (35.7% over the control). Kumaraswamy and Rajasekaran (1994), in india, found that cane yield was highest with the highest P application rate (60 kg P/ha). A combination of Azospirillum + Phosphobacteria gave the highest cane yield. Commercial cane sugar percentage was unaffected by phosphorus or biofertilizers. Muthukumaraswamy *et al.* (1994) stated that biofertilizers (Azospirillum and phosphobacterium) could nearly save 25% chemical nitrogen and phosphate applications when they were used regularly for each crop sugarcane. They found that applying biofertilizer increased crop productivity by 5-7 tons/ac and a marginal increase in sugar recovery. Premono *et al.* (1995) obtained promising phosphate solubilizing microorganizms (PSM) capable of improving the growth and p fertilizer efficiency of sugarcane. The five PSM are capable of increasing available P, improving plant growth and increasing triple super-phosphate fertilizer (TSP) efficiency by 60-135%. The *pseudomonas fluorescens* gave better results than the other isolates. Anderson *et al.* (1995) observed that Phosphorus rates ranging from 0-98 kg/ha gave a positive biomass response for 10% of the plant cane. Similar results were observed for sugar yield. Less than 28% of the juice brix and sucrose concentration declined 0.02% kg/P applied. Phosphorus fertilization generally had little influence on juice quality. Singh *et al.* (1995) found that sugarcane receiving 60 kg P_2O_5/ha recorded significantly better yield attributes (tillers 60%, millable canes

56.1% cane length 57.1%, weight 65.3% and girth 16.9%), giving significantly higher cane yield (84.5 tons/ha) compared with the control. The goal of the present study is to increase sugarcane yield and quality as well as to decrease fertilizer doses used traditionally by sugarcane growers.

MATERIALS AND METHODS

The present study was carried out at Mattana Agricultural Research Station, Qena Governorate, Egypt, during 1993/1994 and 1994/1995 seasons to study the effect of phosphorus levels (0, 15, 30, 45, 60 and 75 kg P_2O_5/fed) and phosphobacterin treatments (0,250, 500 and 750 g Pb/fed) on growth, juice quality and yield of sugarcane. Phosphorus is applied as calcium superphosphate (15.5% P_2O_5). Phosphobacterin (*Bacillus megatherium var. Egyptiacum*) was mixed with appropriate amount of fine sand. Both phosphorus and phosphobacterin treatments were applied at planting. Nitrogen fertilizer as Urea (46% N) at rate of 180 kg N/fed and potassium fertilizer in the form of potassium sulphate (48% K_2O) at rate of 48 kg K_2O/fed were applied in two equal doses after two and four months from planting. Sugarcane variety G. 85-37 was planted during the first week of March in both seasons. Other cultural practices for growing sugarcane were adopted as followed by sugarcane growers in the region. The soil texture of the experimental site was clay loam containing 5.87 and 4.92 ppm of available phosphorus in the first and second season, respectively. A split plot design with four replications was used where phosphorus levels were allocated in the main plots while phosphobacterin treatments were allocated in the sub-plots. The plot area was $35m^2$ (1/120 fed) having 7 meters in length, 5 meters in width and 1 meter apart. The three middle rows in each plot were used for cane growth parameters, juice quality and yield assessment.

Data recorded:

At harvest, a sample of 20 labelled stalks was chosen at random from each plot to determine the following:

1. Stalk length (cm) was measured from the ground level up to the top visible dewlap.

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

3. Sucrose percentage was determined using Saccharameter according to A.O.A.C. (1970).

4. Purity percentage was calculated according to the following equation:

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

5. Cane yield (tons/fed) was determined from the weight of the middle three rows of each plot.

6. Sugar yield (tons/fed) was estimated according to the following equation:

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

The collected data were statistically analyzed according to Snedecor and Cochran (1981). Combined analysis between the two growing seasons was carried out for the collected data.

RESULTS AND DISCUSSION

1. Stalk length :

Data in Table 1 showed that stalk length was not significantly affected by phosphorus levels in 1993/1994 and 1994/1995 seasons while phosphobacterin levels gave a significant increase in stalk length in the first season. The highest average was obtained from 500g Pb./fed. This result is in accordance with that reported by Premono *et al.* (1995).

Table 1. Mean effect of phosphorus and phosphobacterin levels on stalk length and stalk diameter (cm) at harvest in 1993/94 and 1994/95 seasons.

Main effects		Stalk length (cm)*			Stalk diameter (cm)		
		1st season	2nd season	Overall seasons	1st season	2nd season	Overall* seasons
Phosphorus levels Kg P_2O_5/fed.	0	267.80	276.61	272.21	2.90	3.04	2.97
	15	271.69	278.64	275.16	2.84	3.09	2.96
	30	273.24	280.35	276.79	2.81	3.11	2.96
	45	279.59	283.24	281.41	2.85	3.09	2.97
	60	278.30	283.24	281.01	2.86	3.13	2.99
	75	278.26	282.24	280.25	2.93	3.14	3.03
LSD. at 5% level		Ns	Ns	Ns	Ns	Ns	Ns
Phosphobacterin levels g Pb/fed.	0	271.20	275.73	273.47	2.88	3.04	2.96
	250	272.45	280.38	276.42	2.88	3.12	3.00
	500	278.13	284.28	281.20	2.86	3.12	2.99
	750	277.48	282.81	280.14	2.86	3.12	2.98
LSD. at 5% level		6.44	Ns	10.08	Ns	Ns	Ns

* Average of 16 reading for phosphorus levels and of 24 reading for phosphobacterin treatments.

The combined analysis showed that phosphorus levels did not significantly influence stalk length while phosphobacterin levels had a positive effect on this character. The highest value of stalk length was obtained from adding 500 g Pb./fed. This effect may be due to the fact that inoculation of soil with P-dissolver increases P availability and improves element balance and in turn increases stalk length. This result is agreement with that obtained by Premono *et al.* (1995).

2. Stalk diameter:

The results in Table 1 revealed that neither phosphorus nor phosphobacterin levels significantly affected stalk diameter. These results were consistent in both seasons as well as their combined effect.

3. Sucrose percentage:

Data exhibited in Table 2 showed that sucrose percentage was not significantly responded to phosphorus levels in the 1st and 2nd seasons. The effect of phosphorus on sucrose percentage may be had no direct influence on this trait and/or the available amount of P was not enough to appear the fruitful effect of phosphorus on sucrose percentage. These results are in harmony with those reported by Macalintal and Urgel (1990) and Patil and Shingte (1992-a). Phosphobacterin levels significantly improved sucrose percentage in both seasons. The best value of S% was obtained from adding 500g Pb./fed in both seasons which gave S% (1.29, 0.53, 0.47%) in the 1st season and 0.9, 0.25, 0.17% in the 2nd season over 0, 250 and 750 g/fed levels, respectively, in respect to this character. The increment in sucrose percentage may be due to that phosphobacterin could supply plants with their needs of available phosphorus during their growth consequently improved juice quality. These results are in harmony with that reported by Muthukumarasamy *et al.* (1994).

The combined analysis cleared that phosphorus levels did not significantly affect sucrose percentage while phosphobacterin levels significantly influenced this trait. This highest sucrose percentage was obtained from 500 g Pb./fed. These results are in accordance with those reported by Muthukumarasamy *et al.* (1994).

4. Purity percentage :

The results in Table 2 showed that phosphorus levels had a significant effect on purity % in the 1st season. The increase in purity percentage may be due to the relative effect of phosphorus on sucrose percentage in juice. Applying 30 kg P_2O_5/fed surpassed 0, 15, 45, 60 and 75 kg/fed by 3.23, 4.95, 1.24, 1.41 and 1.23%, respectively. This finding is in agreement with those elucidated by Rodriguez *et al.* (1982). Phosphobacterin levels did not significantly affect on purity percentage. This result agrees with that reported by Kumaraswamy and Rajasekaran (1994).

The combined analysis showed that phosphorus levels had a significant influence on purity percentage. The highest purity percentage was obtained from applying 30 kg P_2O_5/fed. These results agree with that obtained by Rodriguez *et al.* (1982). Phosphobacterin levels failed to attain a significant effect on purity percentage. These results are in accordance with that obtained by Kumaraswamy and Rajasekaran (1994).

Table 2. Mean effect of phosphorus and phosphobacterin levels on stalk length and stalk diameter (cm) at harvest in 1993/94 and 1994/95 seasons.

Main effects		Sucrose percentage*			Purity percentage		
		1st season	2nd season	Overall seasons	1st season	2nd season	Overall seasons
Phosphorus levels Kg P_2O_5/fed.	0	18.70	17.23	17.97	86.26	83.08	84.67
	15	18.34	17.76	18.05	84.54	83.34	83.94
	30	19.38	17.42	18.40	89.49	83.45	86.47
	45	19.52	17.47	18.49	88.25	83.18	85.72
	60	19.39	17.83	18.61	88.08	82.70	85.39
	75	19.21	17.60	18.13	88.26	81.12	84.96
LSD. at 5% level		*Ns*	*Ns*	*Ns*	0.66	*Ns*	1.38
Phosphobacterin levels g Pb/fed.	0	18.37	16.89	17.63	87.76	82.48	58.12
	250	19.13	17.54	18.34	87.49	83.00	85.24
	500	19.66	17.79	18.73	86.39	82.88	84.64
	750	19.19	17.62	18.40	88.28	82.89	85.59
LSD. at 5% level		*0.76*	*0.61*	*0.49*	*Ns*	*Ns*	*Ns*

*see Table 1.

5. Cane yield:

Data in Table 3 revealed that phosphorus levels insignificantly increased cane yield in 1993/1994 and 1994/1995 seasons. This effect may be due to that application of phosphorus in elementary form decreased the available phosphorus as a result to P-fixation. These results agree with those elucidated by Lakshmikantham (1983) and Devi *et al.* (1992) who found that cane yield was not affected by adding phosphorus fertilization. Phosphobacterin levels had a significant influence on this trait in both seasons. The highest cane yield was obtained from adding 750 and 500 g Pb./fed in the 1st and 2nd seasons. The increase in cane yield may be due to that phosphobacterin could supply plants with their needs of available phosphorus during their growth, in addition to its role in improving soil structure, balance consequently increasing cane yield. The finding reported by Kumaraswamy and Rajasekaran (1994) agrees with these results.

The combined analysis revealed no significant response of cane yield due to the used phosphorus levels. Phosphobacterin levels gave a significant increase in this trait. Adding 500g Pb./fed increased cane yield by 2.83, 1.24 and 0.1 tons/fed compared to 0,250 and 750 g/fed of phosphobacterin, respectively. These results are in accordance with that reported by Muthukumaraswamy *et al.* (1994).

6. Sugar yield:

Data presented in Table 3 showed that phosphorus levels had insignificant effect on sugar yield in both seasons. This effect may be due to amounts of the phosphorus fixed in the form of insoluble and unavailable to the plant. Sugar yield significantly responded to phosphobacterin levels in the 1st and 2nd seasons. The maximum sugar yield was obtained by adding 750 g Pb./fed in both seasons which attained increases of 12.9, 4.0% and 1.0% in the 1st season and 11.9, 4.7% and 0.7% in the 2nd one over 0, 250 and 500 g Pb./fed, respectively, in respect to this trait. The increase in sugar yield may be attributed with the distinct effect of phosphobacterin on stalk length, sucrose percentage, cane yield and in turn sugar yield. This result is in accordance with that found by Muthukumaraswamy *et al.* (1994).

The combined analysis revealed a significant effect on sugar yield due to the added phosphorus and Phosphobacterin levels. Applying 75kg P2O5/fed and/or 750 g Pb./fed gave the highest sugar yield. This result agrees with those found by Lestari (1993) and Anderson *et al.* (1995).

CONCLUSION

It could be concluded that increasing phosphorus fertilizer up to 75 kg P_2O_5/fed had no significant effect on cane and sugar yields while the application of phosphobacterin at rate of 750 g Pb/fed gave the highest sugar yield.

Table 3. Mean effect of phosphorus and phosphobacterin levels on cane and sugar yields (tons/fed.) at harvest in 1993/94 and 1994/95 seasons.

Main effects		Cane yield (tons/fed)			Sugar yield (tons/fed)		
		1st season	2nd season	Overall seasons	1st season	2nd season	Overall seasons
Phosphorus levels Kg P_2O_5/fed.	0	41.66	46.78	44.22	4.85	4.99	4.92
	15	43.13	47.41	45.27	5.16	5.09	5.13
	30	43.18	48.99	46.08	5.31	5.29	5.30
	45	43.01	49.23	46.12	5.30	5.33	5.32
	60	43.64	50.66	47.15	5.38	5.60	5.49
	75	44.51	50.71	47.61	5.47	5.54	5.51
LSD. at 5% level		*Ns*	*Ns*	*Ns*	*Ns*	*Ns*	*Ns*
Phosphobacterin levels g Pb/fed.	0	41.24	47.34	44.29	4.78	4.89	4.83
	250	43.21	48.54	45.88	5.27	5.29	5.28
	500	43.2	50.32	47.12	5.43	5.51	5.47
	750	44.38	49.65	47.02	5.49	5.55	5.52
LSD. at 5% level		*1.3*	*1.54*	*1.01*	*0.17*	*0.21*	*0.14*

*see Table 1.

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تأثير التسميد الفوسفاتي والفوسفوبكترين علي محصول وجودة قصب السكر

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أقيمت تجربة حقلية بمحطة بحوث المطاعنة (محافظة قنا) خلال موسمي ١٩٩٣ / ١٩٩٤ ، ١٩٩٤ / ١٩٩٥ وذلك لدراسة تأثير مستويات السماد الفوسفاتي والفوسفوبكتيرين علي نمو وجودة ومحصول قصب السكر. وقد إشتملت معاملات هذه التجربة علي ست مستويات من السماد الفوسفاتي (صفر ، ١٥ ، ٣٠ ، ٤٥، ٦٠ ، ٧٥ كجم فو ٢ أ ٥ /فدان) في صورة سوبر فوسفات الكالسيوم ١٥,٥ ٪ أضيفت مع الزراعة، وأربعة مستويات من الفوسفوبكتيرين (صفر ، ٢٥٠ ، ٥٠٠ ، ٧٥٠ جم / فدان) أضيفت مع الزراعة.

وقد إستخدم تصميم القطع المنشقة مرة واحدة في أربع مكررات حيث وزعت مستويات التسميد الفوسفاتي علي القطع الرئيسية ووزعت مستويات الفوسفوبكتيرين عشوائيا علي القطع الشقية، وكانت مساحة القطعة الشقية ٣٥ م٢ (٥ خطوط ، ٧ م طول الخط ، ١م بين الخطوط). الصنف المستخدم في هذه الدراسة هو جيزة ٨٥ / ٣٧ .

أوضحت النتائج أن طول الساق وسمك الساق والنسبة المئوية للسكروز ومحصول القصب ومحصول السكر لم تتأثر معنويا بمستويات التمسيد الفوسفاتي في كلا الموسمين بينما تأثرت نسبة النقاوة إيجابياً بمستويات التسميد الفوسفاتي في موسم ١٩٩٣ / ١٩٩٤ وقد أدي إستخدام ٣٠ كجم فو٢ أ ٥ /فدان إلي الحصول علي أعلي نسبة نقاوة.

أوضحت النتائج تأثير الفوسفوبكتيرين معنوياً علي صفة طول الساق في الموسم الاول فقط بينما أثر علي نسبة السكروز بالعصير ومحصول القصب ومحصول السكر في كلا الموسمين وقد أدي إستخدام ٧٥٠ جم فوسفوبكترين/فدان إلي الحصول علي أعلي كمية سكر (طن /فدان) في الموسمين.

أوضح التحليل التجميعي وجود تأثير معنوي لمستويات التمسيد الفوسفاتي علي النسبة المئوية للنقاوة وكمية السكر حيث زادت هذه الصفة بزيادة مستويات التسميد الفوسفاتي. أما الفوسفوبكتيرين فقد أثر معنويا علي طول الساق والنسبة المئوية للسكروز ومحصول القصب وكمية السكر.