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Growth, quality and economics of plant and ratoon sugarcane (*Saccharum* spp. hybrid complex) as influenced by doses and sources of sulphur

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ABSTRACT

A field-experiment was conducted during 2001–02 and 2002–03 at Lucknow with 3 S doses (40, 60 and 80 kg S/ha) and 3 sources (elemental S, gypsum and single superphosphate) for improving yield and quality of sugarcane. Significant improvement in cane diameter (2.51 cm) and individual cane weight (1,100 g) was observed at 60 kg S/ha. This registered an increase of 9.87% in cane yield and 8.77% in commercial cane sugar over 40 kg S/ha. Pol % in juice increased significantly when S dose increased from 40 to 60 kg/ha. Application of elemental sulphur resulted in significantly higher cane yield (83.5 t/ha) as well as commercial cane sugar (CCS 9.96 t/ha) over other sources. In plant-ratoon system, by taking 1 plant and 1 ratoon crop in account, maximum net return (Rs 111,032/ha) and benefit : cost ratio (3.18) were obtained at 80 kg S/ha.

Key words : Cane yield, Economics, Juice quality, Sugarcane, Sulphur dose

Decreased use of low-analysis fertilizers like ammonium sulphate and single superphosphate, and organic manures have rendered the Indian soils deficient in sulphur. Yield improvement with sulphur application has been attributed to enhanced nitrogen use efficiency (Ghosh *et al.,* 1990), possibly by increasing nitrate reductase activity. At Mandya, use of ammonium sulphate improved juice quality in S-deficient soil (Rabindra and Swamy Gawda, 1989). A dose of 30–40 kg S/ha was found optimum for improvement in plant cane yield at Lucknow (IISR, 1999–2000; Shukla and Lal, 2001). Ghosh *et al.,* (1990) observed in increase in cane yields up to 80 kg S/ha. Large increase with soil application of elemental S has been reported from alkaline-calcareous soils of Rajasthan (Hunsigi, 2001). It was also observed that yield of sugarcane was positively correlated with the sulphur content of cane leaves. Thus keeping these points in view, a study was undertaken to optimize the dose and sources of sulphur for a plant-ratoon system, to find the optimum dose and source of sulphur fertilizer in relation to cane yield and juice quality in sugarcane plant and ratoon crops.

MATERIALS AND METHODS

The field experiment was initiated on research farm of Indian Institute of Sugarcane Research, Lucknow. The climate of the experimental site was semi-arid subtropical with hot dry summer and cold winter. The average annual rainfall is 976 mm, and nearly 80% of the total rainfall received is through south-west monsoon (July–September). The average monthly minimum temperature fluctuates from 6.9 to 8 °C in January (the coldest month) and from 25.9 to 28 °C in May (the hottest month). The respective maximum temperature ranges from 21.2 to 23 °C in January and 39.0 to 40.6 °C in May.

The experiment was conducted during 2001–02 and 2002–03 with 3 doses (40, 60 and 80 kg S/ha) and 3 sources (elemental sulphur 41% S, gypsum 18.6% S and single superphosphate 16% P_2O_5 and 12% S) of sulphur. Nine treatment combinations were replicated thrice in randomized block design. Total amount of sulphur as per the treatments was supplied as basal dose in furrow. Recommended doses of N (150 kg/ha) and K (50 kg/ha) were applied to sugarcane plant crop. Out of the total recommended dose of N and K, one-third dose of N and full dose of K were applied at the time of planting and remaining two-thirds N was top dressed in 2 instalments during tillering stage from April to June. The amount of phosphorus was balanced keeping all the sources of sulphur in view with reference to single superphosphate. Among various levels, D_1 (23.29 kg P/ha), D_2 (34.9 kg P/ha) and D_3 (46.6 kg P/ha) were applied. At D_3 there was 46.6 kg P/ha, so D_1 and D_2 were balanced as D_3. Thus extra P required in D_1 and D_2 were 23.29 and 11.66 kg/ha, respectively, which was applied through diammonium phosphate. Thus requirement of diammonium phosphate in D_1

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was 15.97 kg/ha and in D_2 58.04 kg/ha. N added through diammonium phosphate was 20.87 kg/ha and 10.44 kg/ha, in D_1 and D_2 respectively. This amount of N was deducted from basal N applied through urea, i.e. 50 kg/ha, so the required amount of N from urea would be 29.13 kg/ha in D_1, 39.56 kg/ha in D_2 and 50 kg N/ha in D_3. Initial soil physical and chemical parameters for both the seasons indicated that soil had 1.40 and 1.37 g/cc bulk density during first and second cropping seasons respectively. Soil had 60.9, 23.7 and 15.4% sand, silt and clay respectively during first season, and 62.4, 21.6 and 16% during second season. Experimental soil was sandy loam, analysed low organic carbon (0.45 and 0.42%, during both the years, respectively), low available N (210 and 220 kg/ha), medium available P (14.6 and 16.2 kg P/ha), medium K (210 and 195 kg N/ha) and low available S (24.5 and 27.2 kg S/ha) at moderately neutal pH (7.6 and 7.4). Carry-over effect of different treatments was observed on ratoon cane. Sugarcane juice of plant and ratoon crops was analysed at the time of harvesting.

Sugarcane was planted on 12 March 2001 and 16 March 2002 in 75 cm row spacing with a seed rate of 45,000 three-budded cane setts/ha. From the main sugarcane crop of both years, ratoon was raised during 2002 and 2004. The harvesting of sugarcane plant and ratoon crops was done manually (11 March 2002 and 10 March 2003 for plant cane; 16 December 2003 and 10 January 2004 for ratoon cane) in various years. After harvesting of crops, trash and dry leaves were burnt in the field, stubbles were shaved to the ground level and field was irrigated for raising ratoon crop. Fertilizers were applied at first inter culture operation. Nitrogen was applied in 2 splits as per standard practice. Transplanting of clumps in gaps was done to have a uniform plant population. Inter-culture operations and plant-protection measures were adopted as per requirement. All the agronomic and plant-protection operations were carried out uniformly as and when required. Available sulphur in soil was also determined in 0.15% $CaCl_2$ extract turbidimetrically. The incidence of diseases and pests was below economic threshold and plant-protection measures were applied irrespective of the treatments in plant and ratoon crops.

RESULTS AND DISCUSSION

Sulphur in plant cane

The mean data from two cropping seasons indicated that various doses of sulphur significantly increased number of millable canes at 60 kg/ha (Table 1). Sulphur-mediated nitrogen metabolism might have increased the nitrate reductase and sulphate reductase activities, thereby improving chlorophyll formation, which contributed greatly to increased number of millable canes and greater cane diameter (Jamal *et al.*, 2003). Highest cane diameter was recorded at 60 kg S/ha, but it did not differ significantly from that recorded at 80 kg S/ha. The highest individual cane weight was recorded at 80 kg S/ha. This might be due to the role of sulphur in carbohydrate metabolism. Since cane weight is a function of cane length and diameter, these contributed positively (Verma *et al.*, 1996). Increasing levels of sulphur increased S uptake at harvest. Different sources could not influence millable canes significantly. Application of elemental S improved the individual cane length (244.8 cm), diameter (2.53 cm) and cane weight (1,139 g) significantly over gypsum. Elemental S improved 12.5% individual cane weight over gypsum.

Significantly higher cane yield and commercial cane sugar (CCS) were obtained at 60 kg S/ha (Table 1). The increase was 9.87% in cane yield and 8.77% in CCS with 60 kg S/ha over 40 kg S/ha. The differences between 60 and 80 kg S/ha were however not significant. Significantly higher cane yield and sulphur uptake were obtained with elemental S over other sources that increased commercial

Table 1. Influence of different treatments on growth, yield and quality of plant cane (mean data of 2 cropping seasons)

Treatment	Millable canes ('000/ha)	Cane length (cm)	Cane diameter (cm)	Cane weight (g)	Cane yield (t/ha)	S uptake at harvest (kg/ha)	°Brix	Pol % juice	Purity (%)	CCS (t/ha)
Sulphur dose (kg/ha)										
40	99	231.6	2.26	1,001	71.87	28.07	20.21	17.49	86.53	8.66
60	101	236.7	2.51	1,100	78.97	31.59	20.00	17.80	88.82	9.42
80	104	242.4	2.42	1,127	78.48	32.30	20.70	17.84	88.32	9.67
SEm±	1.2	2.4	0.04	33	1.80	0.48	0.43	0.16	0.65	0.18
CD (P=0.05)	3.6	6.7	0.13	96	5.30	1.42	NS	0.45	1.80	0.50
S sources										
Element at S	102	244.8	2.53	1,139	83.50	33.40	20.08	17.37	86.49	9.96
Single super phosphate	102	241.4	2.47	1,077	74.33	29.73	20.17	17.63	87.41	9.02
Gypsum	101	231.5	2.29	1,012	71.48	28.59	20.05	17.46	87.04	8.57
SEm±	1.2	2.4	0.04	33	1.80	0.48	0.43	0.16	0.65	0.18
CD (P=0.05)	NS	6.7	0.13	96	5.30	1.42	NS	NS	1.80	0.50

cane sugar (9.96 t/ha) as well. Higher number of millable canes and improved individual cane weight also contributed to the increased cane yield with elemental S. Pol % improved when sulphur dose increased from 40 to 60 kg/ha. Further increase in S dose to 80 kg/ha, however, did not improve juice quality significantly. These results are in conformity with the findings of Amodkar and Joshi (2002). Various sources of sulphur could not influence juice quality parameters significantly.

Sulphur in ratoon cane

Number of millable canes in ratoon was not significantly influenced by S doses applied in plant cane. However, individual cane weight in ratoon significantly improved up to 80 kg S/ha (Table 2). This was due to residual effect of sulphur obtained at 80 kg S/ha applied in plant cane. These results confirm the findings of Ghosh *et al.* (1990) and Shukla and Lal (2004) in alluvial soils. Ratoon yield and commercial cane sugar increased up to 80 kg S/ha, indicating that residual effect of sulphur was highly pronounced in ratoon when 80 kg S/ha was applied to the plant crop. Higher commercial cane sugar was owing to increase in ratoon yield despite optimum cane quality. However, various sources of sulphur applied in plant cane could not influence ratoon growth and yield significantly during both the seasons.

Economics of sugarcane (plant)-ratoon system

The highest gross returns were obtained with 60 kg S/ha in plant cane. Net returns and benefit : cost ratio were also maximum with this dose (Table 3). In sugarcane ratoon, improvement in gross returns, net returns and benefit : cost ratio were obtained owing to reduced cost of production. Maximum gross return, net return and benefit : cost ratio (4.15) were obtained at 80 kg S/ha, indicating that a dose of 80 kg S/ha in plant cane improved net profit from ratoon cane. However, in plant cane application of 60 kg S/ha maximized benefit. In plant-ratoon system, by taking plant and ratoon crop in consideration, maximum net return and benefit : cost ratio were obtained at 80 kg S/ha. It showed that sugarcane production in north India responds to sulphur applicaton and higher production from plant as

Table 2. Influence of different treatments on growth, yield and quality of plant cane (mean data of 2 cropping seasons)

Treatment	Millable canes ('000/ha)	Cane length (cm)	Cane diameter (cm)	Cane weight (g)	Cane yield (tonnes/ha)	S uptake at harvest (kg/ha)	Brix	Pol % juice	Purity (%)	CCS (t/ha)
Sulphur dose (kg/ha)										
40	117.8	229.7	2.31	997	80.80	30.86	18.71	16.76	91.18	9.42
60	117.9	228.2	2.47	1,072	82.91	32.14	18.89	16.75	90.43	9.66
80	122.4	233.4	2.47	1,127	91.93	36.19	19.12	16.99	89.98	10.82
SEm±	2.5	3.6	0.04	19	1.52	0.45	0.42	0.39	1.42	0.25
CD (P=0.05)	NS	NS	0.11	53	4.51	1.31	NS	NS	NS	0.72
S sources										
Elemental S	124.4	234.8	2.42	1,087	86.39	33.48	18.62	16.53	90.07	9.89
Single superphosphate	115.4	232.3	2.40	1,078	86.22	33.42	18.99	16.92	90.45	10.15
Gypsum	118.3	223.7	2.37	1,034	83.10	32.21	19.16	17.05	90.88	9.83
SEm±	2.5	3.6	0.04	19	1.52	0.45	0.42	0.39	1.42	0.25
CD (P=0.05)	7.3	10.6	0.11	53	NS	1.31	NS	NS	NS	NS

Table 3. Influence of different treatments on economics of sugarcane (plant)-ratoon system (mean data of 2 cropping seasons)

Treatment	Plant cane			Ratoon cane			Plant-ratoon system		
	Cost of production (Rs/ha)	Net returns (Rs/ha)	Benefit : cost ratio (Rs/ha)	Cost of production (Rs/ha)	Net returns (Rs/ha)	Benefit : cost ratio (Rs/ha)	Cost of production (Rs/ha)	Net returns (Rs/ha)	Benefit : ratio ratio
Sulphur dose (kg/ha)									
40	28,788	39,489	2.37	21,022	55,795	3.65	49,810	95,284	2.91
60	29,299	45,743	2.56	21,022	57,743	3.75	50,321	1,03,485	3.06
80	29,835	44,721	2.50	21,022	66,312	4.15	50,857	1,11,032	3.18
S source									
Elemental S	30,101	49,224	2.63	21,022	61,049	3.90	51,123	1,10,272	3.16
Single super-phosphate	29,501	41,113	2.39	21,022	60,887	3.89	50,523	1,02,161	3.02
Gypsum	28,300	39,606	2.40	21,022	57,923	3.75	49,322	97,529	2.98

well as ratoon cane may be obtained by supplementing sulphur fertilizer.

The elemental S resulted in highest net returns and benefit : cost ratio (2.63) in plant cane. A similar trend was observed for ratoon and plant-ratoon system. Higher mean benefit : cost ratio in ratoon cane as compared to plant cane was due to lower cost of production of ratoon that maximized profit. Correlation among various growth characters indicated that in ratoon crop, millable canes had greater contribution to yield (r=-0.98) as compared to plant cane (r=0.84). However, contribution of individual cane weight in plant and ratoon to cane yields was 0.96 and 0.90. It showed the importance of number of millable canes in ratoon and cane weight in plant crop. Degree of correlation between cane yield and CCS was 0.95 and 0.98 in plant and ratoon crops, indicating the importance of cane yield as compared to quality.

Thus, it could be concluded that application of 80 kg S/ha improved the yied and quality of sugarcane. Elemental sulphur appeared to be better than others.

REFERENCES

Amodkar, V.T. and Joshi S.S. 2002. Effect of sulphur application on sucrose synthesizing enzyme activities. *Sugarcane International* **20**: 27–32.

Ghosh, A.K., Rai, R.K., Saxena, Y.R. and Shrivastava, A.K. 1990. Effect of sulphur application on the nutritional status, yield and quality of sugarcane. *Journal of Indian Society of Soil Science* **38**: 73–76.

Hunsigi, G. 2001. *Sugarcane in Agriculture and Industry*, pp. 169–70. Prism Books Pvt Ltd, Bangalore.

IISR. 2000. *Annual Report, 1999–2000, Indian Institute of Sugarcane Research*, Lucknow, pp. 37–38.

Jamal, A., Ahmad, S., Kumari, S., Fazli, I.S., Rahman, R.U. and Adiu, M.Z. 2003. Nitrogen and sulphur nutrition enhances seed and oil yield of groundnut (*Arachis hypogaea*). Paper presented at 2nd International Congress of Plant Physiology, 8–12 January, New Delhi, India, 395 pp.

Rabindra, B. and Swamy Gawda, S.N. 1989. Long term effect of continuous application of sulphur containing fertilizers on soil properties: yield and quality of sugarcane. *Procedings of UAS FACT Seminar on Sulphur*, held at Bangalore, pp. 224–225.

Shukla, S.K. and Lal, Menhi. 2004. Effect of sulphur on productivity and quality of sugarcane plant and ratoon crops grown in sugarcane (plant)–ratoon – wheat system on IGP alluvial soils. *Indian Journal of Agronomy* **49**(1): 26–27.

Verma, R.S., Shukla, S.K., Singh, G.B. and Verma, Lal Ji. 1996. Agro-techniques to enhance sugar production of midlate varieties for early crushing. *Indian Journal of Sugarcane Technology* **11**(1): 38–41.