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Response of sugarcane variety COVSI 9805 to site specific nutrient management in Maharashtra

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Abstract

The field experiments were conducted to examine the response of sugarcane variety Co-VSI 9805 to nutrient management including macro, secondary and micro nutrients at four locations in Maharashtra. The sugarcane varieties are different in their production potential therefore the nutrient requirement is also differ with their characteristics. Experiment was designed in split plot with four main treatment of 100%, 125%, 150% and 175% RDF based on soil analysis approach and the sub treatments of S, Fe, Zn, Mn and B. The results showed increased cane yield with increased levels of NPK. However, cane yield obtained under 175% RDF was not economically beneficial due to insignificant increase in benefit cost ratio over 150% RDF. The cane variety CoVSI9805 responded significantly to S @ 60 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹ + Zn SO₄ @ 20 kg ha⁻¹. Therefore, conclusion has been made to increase recommended dose of NPK by 50% coupled with S @ 60 kg ha⁻¹, FeSO₄ @ 25 kg ha⁻¹ and Zn SO₄ @ 20 kg ha⁻¹ for maximum cane yield and economic benefit of CoVSI 9805. The number of milliable canes, height, girth and nutrient contents influenced by higher dose NPK, secondary and micronutrients might be the contributory factors for increased cane and sugar yield.

Keywords: Sugarcane, nutrient management, cane yield, sugar yield

Introduction

Sugarcane is increasing popularity among the farmers due to its higher production potential and energy production in addition to sugar. The area under sugarcane is about one million hectares in Maharashtra State with an average yield of 84 ton ha⁻¹. Nutrient management is an important component of soil and crop management system. The requirement of essential plant nutrients and the ability of soil to supply these nutrients are critical for growth and profitable crop production. Introduction of high yielding varieties and use of high analysis fertilizers under irrigated condition resulted increase in productivity tremendously during green revolution in our country however the sugarcane varieties are different in their production potential therefore the nutrient requirement is also differ with their characteristics. The nutrient requirement also varies in different soil types (Natesan *et al.* 2007) [6] The importance of secondary and micronutrient along with macronutrient in improving sugarcane productivity is well known. Phonde and Zende, (2007) [8] reported higher cane and sugar yield under site specific nutrient management comprising macro nutrients along with Sulphur, Zn and Fe than only recommended NPK nutrients. However, there is no any site specific nutrient management package developed for promising or newly released sugarcane varieties. Recently, VSI has released sugarcane variety CoVSI 9805 having 20% more yield than the existing varieties. Therefore, attempt has been made to develop site specific nutrient management package for cane yield maximization of sugarcane variety CoVSI 9805 in Maharashtra.

Materials and Methods

Field experiments were conducted to study the location specific response of sugarcane variety CoVSI 9805 to nutrient management including macro, secondary and micro nutrients at four locations and this experiment was continued on ratoon crop at two locations during 2009-10 and 2010-11.

The experiments were laid out in split plot design comprising four main treatment viz. 100%, 125%, 150% and 175% of the fertilizer dose based on soil testing approach. The fertilizer dose (RDF) 340:170:170 kg N:P:K ha⁻¹ was considered as basic recommended dose of fertilizer (RDF). Total six sub-treatments of secondary and micronutrients viz. S₁ (Control), S₂ (Sulphur @ 60 kg ha⁻¹), S₃ (Sulphur @ 60 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹), S₄ (Sulphur @ 60 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹ + ZnSO₄ @ 20 kg ha⁻¹), S₅ (Sulphur @ 60 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹ + ZnSO₄ @ 20 kg ha⁻¹ + MnSO₄ @ 10 kg ha⁻¹) and S₆ (Sulphur @ 60 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹ + ZnSO₄ @ 20 kg ha⁻¹ + MnSO₄ @ 10 kg ha⁻¹ + Boric acid @ 5 kg ha⁻¹) were included. The treatment combinations were replicated thrice. The important chemical properties of the soil under experimental locations are reported in Table No.1. Surface soil samples (0-22.5 cm) collected before planting, at earthing up and after harvest analyzed by standard methods described by Jackson (1973) [4]. Sugarcane leaf analysis was done as per standard methods given by Piper (1966) [11]. The field observations of biometric, growth and yield parameters were taken at different stages of the crop and at harvest. Sugarcane juice quality for brix and pol percentage was analyzed by using ICUMSA methods. The field and laboratory analysis data was statistically analyzed by methods of Gomez and Gomez (1984) [2].

Results and Discussion

Cane Yield Response to levels of NPK

At all locations, the results clearly revealed that the productivity of sugarcane increased with increased levels of NPK. At VSI Manjari location the cane yield was significantly increased to 99.44 and 106.89 t ha⁻¹ at 125 and 150% RDF, respectively over the treatment of 100% RDF (92.94 t ha⁻¹). At this location cane yield at 175% RDF did not differ significantly over 150% RDF. Whereas, at TK Warna, Ajinkyatara and VSI Vasantdada locations the significant cane yields response was received under 175% RDF. The soil at VSI Manjari location was well drained, with very high organic carbon and available potash compared to other locations might be the reason for at par results of 150 and 175% RDF. The pooled mean results indicated increase in cane yield with increased levels of NPK. However, the mean cane yield obtained under 175% RDF was not found economical due to insignificant increase in benefit cost ratio over 150% RDF (Fig. 1). Therefore, the data revealed that for maximum and economical cane yield of sugarcane variety CoVSI 9805, the NPK level need to be increased by 50% over recommended dose of fertilizer. Similarly, the pooled mean of cane yield of ratoon crops at VSI Manjari and TK Warna locations showed significant results in increased levels of NPK. The maximum cane yield response of 81.82 t ha⁻¹ obtained at 175% RDF over all the remaining levels of RDF might be due to exhaust of nutrients by plant cane. Rehman and Ullah (2008) [13] also recommended 25 to 30 per cent more fertilizers for ratoon crop than plant cane. Hong Lifang *et al.* (2001) [5] reported variable rate of fertilizer application and site specific management provide opportunities for improving sugarcane yield. Vijaykumar and Varma (2001) [14] also reported similar findings.

Cane Yield Response to Secondary and Micronutrients

Among the secondary and micronutrients S, Fe, Zn, Mn and B have been found more crucial in sugarcane in Maharashtra. Therefore, the response of CoVSI 9805 to these secondary and micronutrients verified at various locations. At VSI Manjari location (Table 1) the combine application S + Fe + Zn gave significantly higher cane yield (103.35 t ha⁻¹) over combination

of S + Fe (99.50 t ha⁻¹) and control (99.04 t ha⁻¹) and found at par even after addition of B and Mn. It indicates that CoVSI 9805 responded to micronutrients mixture having Zn in particular, it might be due to deficiency in soil.

At Warna location CoVSI 9805 cane variety not responded to S, Fe, Zn nutrients, however the combination of S + Fe + Zn + B found significant over control indicating response to boron application. At VSI Vasantdada farm and Ajinkyatara location this variety not responded to any secondary and micronutrients. The pooled results of four locations indicated significant response to combine application of S + Fe + Zn. Similar trend of cane yield as in plant crop was recorded in ratoon crop at VSI Manjari farm and Ajinkyatara locations due to secondary and micronutrients.

Overall, sugarcane variety CoVSI 9805 responded significantly to increased levels of NPK without affecting juice quality, however it was economically profitable at 150% of RDF. CoVSI9805 responded to S @ 60 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹ + Zn SO₄ @ 20 kg ha⁻¹ significantly. Phonde and Deshmukh (2012) [9] reported that most of the soils in Maharashtra are deficient in Zn, Fe and S therefore the sugarcane variety Co-VSI-9805 may be responded.

The interaction effects of levels of NPK and secondary& micronutrients found to be insignificant

Yield contributing parameters

Among the yield contributing characters, significant increase in number of millable canes was noticed in increased levels (Table 4). The plant population increased significantly in increased level of NPK at TK Warna and Ajinkyatara locations and remained more or less same at other locations. The pooled results showed significant increase in millable canes (66.03 thousand ha⁻¹) at 175% RDF over control (61.65 thousand ha⁻¹). In ratoon crop, significant increase in plant population recorded at 175% RDF (52.93 thousand ha⁻¹) followed by 150% RDF (48.75 thousand ha⁻¹). Increased millable cane might be due to increased germination and tillering. Hussain *et al.*, (2005) [3] also reported that higher tillering gave rise to higher number of millable canes in a fertilizer experiment. The millable cane height and girth of cane at VSI, Manjari, TK Warna and Ajinkyatara locations found to significantly influenced by increased levels of NPK. Residual effect of sulphur and micronutrients viz. Fe, Zn, B, Mn did not showed significant response with respect to plant population and millable cane height in ratoon cane at all the locations.

Nutrient Contents in sugarcane leaf

Figure 4 illustrates the relative influence of increased levels of NPK on nutrient contents in 4th leaf of sugarcane at 120 days after planting and at harvest stage. N and K contents in leaf observed to be increased with increased levels of NPK at both the stages, while P content not differed much.

Juice Quality and Sugar Yield

The juice quality indicators including sucrose content and commercial cane sugar (CCS) percentage and CCS yield presented in Table No.6 revealed that the juice quality of CoVSI 9805 was not affected either by increased levels of NPK or application of secondary and micronutrients. However, as result of increased cane yield due to increased levels of NPK, secondary and micronutrients, the CCS yield was increased in respective treatments. Similar results have been reported by Phonde *et al.* (2005) [10], Rahman *et al.* (1992) [12] and Anderson *et al.* (1990) [1]

Economics and profitability

The pooled data of cost of cultivation, gross monetary return, net monetary return and benefit cost ratio depicted in Table 7 showed the relative influence of increased NPK levels and micronutrients on profitability. The highest benefit cost ratio 1.90 obtained at 175% NPK followed by 1.87 at 150% NPK found at par to each other and significantly higher than 100%

NPK level. The benefit cost ratio influenced by S and Fe remained same as in control, however combine effect of S + Fe + Zn + B found profitable compared to control. It revealed that increased level of NPK by 50% and application of Sulphur, Fe, Zn and B were integral part of nutrient management for maximum economic cane and sugar yield of CoVSI 9805.

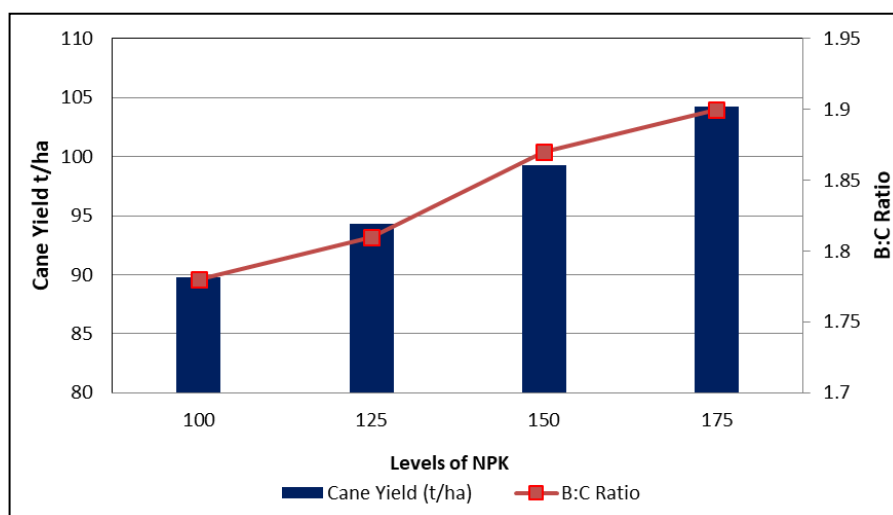


Fig 1: Cane Yield and Benefit Cost Ratio influenced by levels of NPK

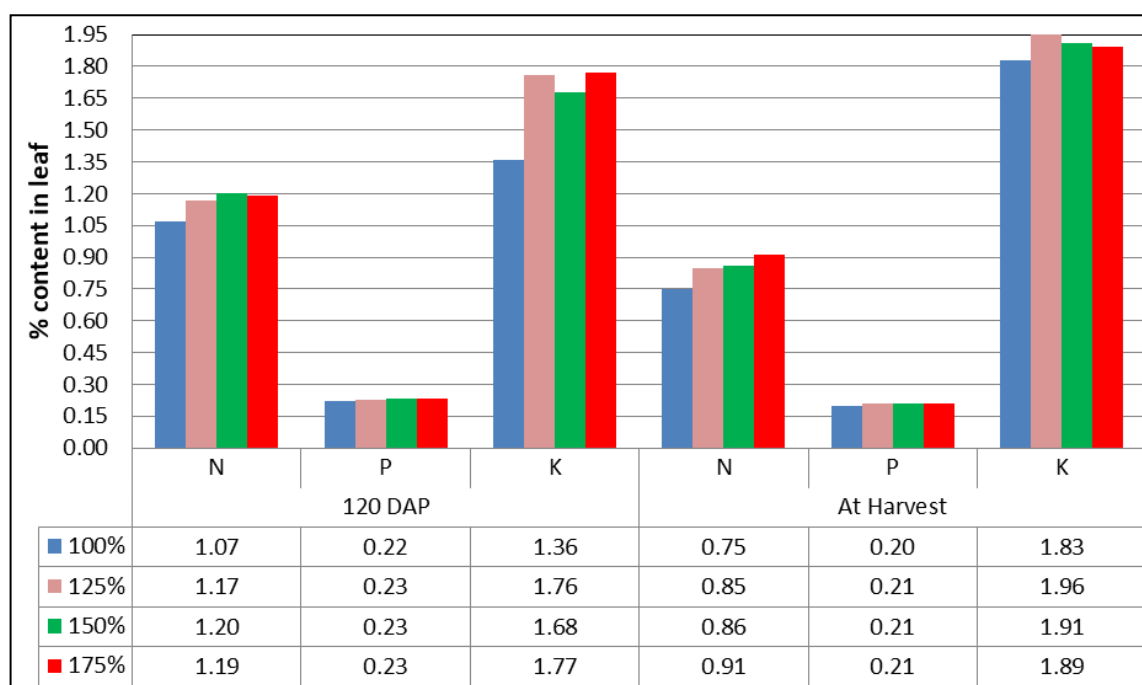


Fig 2: Leaf nutrient contents influenced by levels of NPK at 120 DAP & Harvest

Table 1: Analysis of initial composite samples at all location.

Soil parameters	VSI (M)	TK Warna	VSI (V)	Ajinkyatara, SSK
pH	8.0	7.39	8.14	7.77
EC (dSm ⁻¹)	0.23	0.12	0.51	0.19
Organic carbon (%)	0.91	0.65	0.90	0.60
Available N(kg ha ⁻¹)	175.6	313.6	252.5	132.5
Available P(kg ha ⁻¹)	14.5	17.3	15.8	28.6
Available K(kg ha ⁻¹)	408.2	364.0	350.8	201.0
DTPA extractable Micronutrient (ppm)				
Fe	0.90	3.47	1.72	12.33
Mn	2.09	5.35	3.77	4.37
Zn	0.44	3.12	1.88	0.5
Cu	6.83	6.73	0.26	7.40

Table 2: Response of Sugarcane Var. CoVSI 9805 to levels of NPK, Secondary and Micronutrients on Cane yield of Plant cane and Ratoon

Treatment	Cane yield (t ha ⁻¹)							
	Plant cane					Ratoon		
	VSI (M)	TK Warna	VSI (V)	Ajinkyatara,	PooledMean	VSI (M)	TK Warna	Pooled Mean
Levels of NPK								
M1(100%RDF)	92.94	91.98	90.83	82.94	89.78	70.28	65.96	68.12
M2(125%RDF)	99.44	93.62	99.13	84.44	94.28	74.05	73.51	73.77
M3(150%RDF)	106.89	98.13	104.72	90.03	99.95	77.53	80.15	78.84
M4(175%RDF)	108.35	104.96	110.75	93.06	104.28	80.93	83.33	81.82
S.E.D.	1.51	1.96	1.92	1.03	0.80	2.10	0.98	1.15
CD AT 5%	3.67	4.80	4.71	2.52	1.64	5.14	2.42	2.49
Secondary & Micronutrients								
S1 (Control)	99.04	94.45	98.80	86.65	94.74	74.55	73.57	74.06
S2 (S)	101.45	94.78	101.73	85.48	95.86	74.48	73.99	74.24
S3 (S + Fe)	99.50	96.56	100.54	86.87	95.87	75.38	75.87	75.34
S4 (S + Fe + Zn)	103.35	97.31	100.24	87.85	97.49	75.52	76.74	75.94
S5 (S + Fe + Zn + B)	104.76	99.13	104.52	89.09	99.37	76.65	76.48	76.57
S6 (S + Fe + Zn + B + Mn)	104.12	100.82	102.32	89.31	99.14	77.61	77.75	77.67
S.E.D.	1.87	2.05	2.22	2.77	1.14	1.31	1.05	0.61
CD AT 5%	3.77	4.14	NS	NS	2.23	2.66	2.13	1.71

Table 3: Response of Sugarcane Var. CoVSI 9805 to levels of NPK, Secondary and Micronutrients on CCS yield of Plant cane and Ratoon

Treatment	CCS yield (t ha ⁻¹)							
	Plant cane					Ratoon		
	VSI (M)	TK Warna	VSI (V)	Ajinkyatara	Pooled mean	VSI (M)	TK Warna	Pooled Mean
Levels of NPK								
M1(100%RDF)	12.80	13.96	13.95	10.94	12.91	9.55	7.98	8.76
M2(125%RDF)	11.30	14.82	15.33	11.24	13.31	9.70	8.99	9.35
M3(150%RDF)	11.26	15.40	15.79	11.93	13.88	10.24	9.82	10.02
M4(175%RDF)	13.26	15.60	17.19	11.83	14.61	9.90	10.22	10.06
S.E.D.	1.05	0.74	0.30	0.52	0.39	0.57	0.42	0.30
CD AT 5%	NS	NS	0.74	NS	0.81	NS	0.63	0.66
Secondary & Micronutrients								
S1 (Control)	12.98	14.26	14.86	11.36	13.37	9.94	8.76	9.35
S2 (S)	12.16	14.51	15.74	10.92	13.33	9.61	8.98	9.29
S3 (S + Fe)	11.82	14.35	15.10	11.46	13.39	9.72	9.28	9.5
S4 (S + Fe + Zn)	11.53	16.14	15.81	11.64	13.99	9.79	9.55	9.67
S5 (S + Fe + Zn + B)	12.09	15.66	16.22	11.71	13.92	9.93	9.20	9.57
S6 (S + Fe + Zn + B + Mn)	12.36	14.75	15.67	11.81	14.06	10.11	9.72	9.92
S.E.D.	0.55	0.88	0.50	0.46	0.36	0.28	0.25	0.19
CD AT 5%	NS	NS	NS	NS	NS	NS	0.48	0.37

Table 4: Response of Sugarcane Var. CoVSI 9805 to levels of NPK, Secondary and Micronutrients on plant population of Plant cane and Ratoon

Treatment	Plant population('000 ha ⁻¹)							
	Plant cane					Ratoon		
	VSI (M)	TK Warna	VSI (V)	Ajinkya tara	Pooled mean	VSI (M)	TK Warna	Pooled mean
Levels of NPK								
M1(100%RDF)	71.29	44.02	67.03	61.71	61.65	47.79	42.34	45.06
M2(125%RDF)	65.59	51.30	63.90	63.98	61.20	45.55	48.05	46.80
M3(150%RDF)	68.11	57.35	65.80	65.51	64.11	46.11	51.40	48.75
M4(175%RDF)	73.34	58.63	67.18	64.94	66.03	51.66	54.24	52.93
S.E.D.	3.09	2.49	3.58	1.10	1.27	1.74	1.94	0.95
CD AT 5%	NS	6.11	NS	2.70	2.63	4.26	2.95	2.08
Secondary & Micronutrients								
S1 (Control)	68.90	50.64	66.09	65.45	63.21	48.24	49.8	49.01
S2 (S)	67.59	48.00	65.24	61.42	61.87	46.99	49.24	48.11
S3 (S + Fe)	69.49	53.58	66.03	62.88	62.74	46.82	47.96	47.39
S4 (S + Fe + Zn)	71.79	53.99	65.50	64.44	64.09	48.33	46.71	47.52
S5 (S + Fe + Zn + B)	69.25	55.09	66.62	65.80	64.31	49.91	50.13	50.02
S6 (S + Fe + Zn + B + Mn)	70.50	55.65	66.41	64.22	63.28	46.34	50.22	48.28
S.E.D.	1.67	3.00	1.87	1.98	9.40	1.74	3.39	1.20
CD AT 5%	NS	NS	NS	NS	NS	NS	NS	NS

Table 5: Response of Sugarcane Var. CoVSI 9805 to levels of NPK, Secondary and Micronutrients on growth parameters of Plant cane and Ratoon (Pooled results)

Treatment	Pooled mean of Plant cane			Pooled mean of Ratoon		
	Milliabic cane height (cm)	Internode	Girth (cm)	Milliabic cane height (cm)	Internode	Girth (cm)
Levels of NPK						
M1(100%RDF)	228.18	20.30	10.66	218.9	20.25	10.93
M2(125%RDF)	241.66	20.89	10.68	217.5	19.95	10.91
M3(150%RDF)	239.59	21.07	10.77	219.8	20.80	10.88
M4(175%RDF)	239.24	20.54	11.37	225.4	19.73	11.09
S.E.D.	5.52	0.35	0.07	10.09	0.87	0.1
CD AT 5%	NS	NS	0.15	NS	NS	NS
Secondary & Micronutrients						
S1 (Control)	230.01	21.02	10.37	214.9	19.71	10.90
S2 (S)	239.77	20.52	10.31	217.8	20.10	10.93
S3 (S + Fe)	238.82	20.63	10.42	217.8	19.44	11.13
S4 (S + Fe + Zn)	228.99	20.67	9.95	227.4	20.73	10.87
S5 (S + Fe + Zn + B)	233.13	20.25	10.28	225.4	20.58	10.80
S6 (S + Fe + Zn + B + Mn)	240.30	21.17	10.48	219.4	20.53	11.08
S.E.D.	4.12	0.41	0.25	4.73	0.44	0.14
CD AT 5%	8.15	NS	NS	NS	0.88	NS

Table 6: Response of Sugarcane Var. CoVSI 9805 to levels of NPK, Secondary and Micronutrients on growth parameters of Plant cane and Ratoon (pooled results)

Treatment	Pooled mean of Plant cane			Pooled mean of Ratoon		
	Brix %	Pol %	CCS %	Brix %	Pol %	CCS %
Levels of NPK						
M1(100%RDF)	20.79	20.76	14.01	21.71	19.71	12.85
M2(125%RDF)	20.86	20.86	14.00	21.89	19.69	12.67
M3(150%RDF)	20.70	20.65	13.83	21.73	19.66	12.73
M4(175%RDF)	20.46	20.53	13.79	21.53	19.32	12.29
S.E.D.	0.28	0.32	0.22	0.54	0.59	0.41
CD AT 5%	NS	NS	NS	NS	NS	NS
Secondary & Micronutrients						
S1 (Control)	20.70	20.64	13.83	21.94	19.77	12.64
S2 (S)	20.43	20.65	13.77	21.69	19.52	12.54
S3 (S + Fe)	20.70	20.58	13.83	21.61	19.48	12.61
S4 (S + Fe + Zn)	21.05	21.07	14.21	21.86	19.87	12.73
S5 (S + Fe + Zn + B)	20.88	20.73	14.04	21.12	19.04	12.51
S6 (S + Fe + Zn + B + Mn)	20.45	20.52	13.76	22.09	19.88	12.79
S.E.D.	0.28	0.30	0.22	0.35	0.34	0.22
CD AT 5%	NS	NS	NS	NS	NS	NS

Table 7: Economic evaluation of different levels of NPK, secondary and micronutrients of sugarcane var. Co VSI 9805 for Plantcane

Treatments	Cane Yield (t ha ⁻¹)	Gross Monetary returns (Rs ha ⁻¹)	Cost of Cultivation (Rs ha ⁻¹)	Net Monetary Returns (Rs ha ⁻¹)	B: C Ratio
Levels of NPK					
M1	89.78	161622	90786	70836	1.78
M2	94.28	165613	104846	76418	1.81
M3	99.95	179622	95872	95758	1.87
M4	104.28	187707	98415	101009	1.90
S.E.D.	0.80	2607	93871	12054	0.02
CD at 5%	1.64	5381	95689	24879	0.03
Levels of Secondary and Micronutrients					
S1	94.74	170528	93150	77417	1.82
S2	95.86	169680	94059	78491	1.83
S3	95.87	169280	113121	78172	1.83
S4	97.49	175445	94989	80456	1.84
S5	99.37	178458	93871	99980	1.87
S6	99.14	178454	95689	101515	1.86
S.E.D.	1.14	3116	107774	14807	0.02
CD at 5%	2.23	6153	21277	29243	0.04

Conclusion

The field experiments conducted to examine the response of sugarcane variety CoVSI 9805 to nutrient management including macro, secondary and micro nutrients concluded that

increase in recommended dose of NPK by 50% integrated with S @ 60 kg ha⁻¹, FeSO₄ @ 25 kg ha⁻¹ Zn SO₄ @ 20 kg ha⁻¹ and boric acid 5 kg ha⁻¹ gave maximum cane yield and economic benefit without affecting juice quality.

References

1. Anderson DL, Bowen JE. Sugarcane nutrition. Atlanta: Potash and Phosphate Institute of Canada and Foundation for Agronomic Research; c1990. p. 39.
2. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley & Sons; c1984.
3. Hussain GMA, Barma AC, Mahmud K, Arefin MS, Aslam MS. Nutrient requirement of sugarcane-potato intercropping system in the high Gangas river flood plain soils of Bangladesh. *Pakistan Sugar Journal*. 2005;20(2):2-7.
4. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt. Ltd.; c1973.
5. Lifang H, Fan S, Libo F, Zongesheng Z. Effects of phosphorus, potassium, sulphur, and magnesium on sugarcane yields and quality in Yunnan. *Better Crops International*. 2001;15(1):6-9.
6. Natesan R, Murugesu Boopathi P, Santhi R, Thiyageswari S, Chandra Sekaran N, Paulraj C, *et al*. Technical bulletin on soil test crop response-based fertilizer prescription for different soils and crops in Tamil Nadu. Coimbatore: AICRP-STCR, TNAU; c2007.
7. Paul GC, Bokhtiar SM, Rehman H, Kabiraj RC, Rahman ABMM. Efficacies of some organic fertilizers on sustainable sugarcane production in old Himalayan piedmont plain soil of Bangladesh. *Pakistan Sugar Journal*. 2005;20(1):2-5.
8. Phonde DB, Zende NA. Site-specific nutrient management for maximum yield and quality of sugarcane. In: National seminar on integrated nutrient management in sugarcane cultivation. Pune: VSI; c2007. p. 78-84.
9. Phonde DB, Deshmukh PS. Advances in soil fertility and nutrient management for improving sugarcane productivity. *Bharatiya Sugar*. 2012;13-21.
10. Phonde DB, Nerkar YS, Zende NA, Chavan RV, Tiwari KN. Most profitable sugarcane production in Maharashtra. *Better Crops International*. 2005;89(3):21-3.
11. Piper CS. Soil and plant analysis. Botany: Hans Publisher; c1966.
12. Rahman MH, Pal SK, Alan F. Effect of nitrogen, phosphorus, potassium, sulphur, zinc, and manganese nutrients on yield and sucrose content of sugarcane in flood plain soils of Bangladesh. *Indian Journal of Agricultural Sciences*. 1992;62(7):450-455.
13. Rehman-ur-Atique, Ullah E. Increasing yield of ratoon sugarcane [Internet]; c2008 Jan 7 [cited 2024 Aug 14]. Available from: <http://archives.dawn.com/2008/01/07/abr7.htm>
14. Kumar V, Verma KS. Effect of NPKZn fertilizers and organic manure on plant and ratoon crops of sugarcane and soil fertility under continuous cropping. *Proceedings of the STAI*; c2001;63:135-145.