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EFFECT OF SULPHUR, ZINC AND BORON FERTILIZATION ON SUGARCANE GROWTH, YIELD, SUGAR RECOVERY AND QUALITY OF CANE JUICE AND JAGGERY

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ABSTRACT

Sugarcane in Bihar is mainly grown in the north, where calcareous soils lack zinc (Zn), boron (B) and Sulphur (S). The study tested recommended dose of fertilizer (RDF) (150N-85P_2O_5 -60K_2O/ha) with S (60 & 80 kg/ha), Zn (10 kg/ha), and B (1.5 kg/ha), applied as a basal dose alone or in combination. The application of Sulphur (S), either alone or in combination with zinc (Zn) and boron (B), had no significant effect on sugarcane germination, tiller number, or plant height during the early growth stages. However, as the crop matured, there was a notable improvement in tiller count, plant height, and dry matter accumulation. Among the treatments, the application of the RDF along with S at 60 kg/ha, Zn at 10 kg/ha, and B at 1.5 kg/ha resulted in the highest number of tillers (137.44 × 10^3/ha), tallest plants (266.61 cm), and maximum dry matter production (304.27 g/plant) compared to the control (RDF alone). Yield parameters such as cane length (194.90–228.34 cm) and the number of millable canes (96.09–111.72 × 10^3/ha) varied significantly, though cane girth and weight remained unaffected. A higher Sulphur dose (80 kg/ha) negatively impacted growth and yield. Cane yield ranged from 70.90 to 81.40 t/ha, with a yield increase of 9.68–14.80% over the control. Juice quality parameters like Brix (20.52–22.10%), Pol (17.96–19.38%) and juice recovery (46.82–55.63%) improved significantly. The highest sugar and jaggery yield were observed with S 60 + Zn 10 + B 1.5 kg/ha application.

Key words : Dry matter, Germination, Number of Millable Cane plant height, Tiller number.

Introduction

The cultivation of sugarcane dated back to 8000 BC, in the south east Asia (New Guinea). And it is also believed that centre of origin for the sugarcane is also south east Asia. The cultivation of sugarcane reaches to other part of world *via* trade and crusade. In India sugarcane cultivation reaches *via* colonialism. It is high water intensive and high temperature requirement crop. Thus, it grows mainly in the tropical and subtropical belt of world, where rainfall is adequate and temperature is sufficient. The primary as well as by product of sugarcane is beneficial for the human. It is noted that our country is agriculture dependent, hence sugarcane play a significant role in the primary industry of our country and generate a huge employment (35 million individual directly or indirectly depend on sugarcane cultivation). In recent time we see the decline trend of sugarcane production, due to multiple reasons and among all the reasons the main reason is the climate change and uneven disturbance in the rainfall pattern.

In sub-tropical zone Bihar rank 2nd in the production after the Uttar Pradesh and in term of area under sugarcane cultivation it ranked fourth at national level. It is cultivated in almost every district of Bihar, but West Champaran has above 50% area under sugarcane cultivation. Out of all district just seven districts contribute in more than 85% of the sugarcane cultivation (Directorate of Statistics and evaluation, Bihar).

Sugarcane is a heavy feeder crop which remove huge amount of plant nutrients (205 kg N, 275 kg K, 55 kg P, 30 kg S, 1.2 kg Mn, 0.6 kg Zn, 0.2 kg Cu) from soil for the production of 100 t cane /ha, in addition to the nutrient loss during crop growing period (Kumar and Chand, 2009). There is significant gap in the average productivity (84.44 t/ha) and potential productivity of sugarcane (100 t/ha). Hence, the recommended dose of fertilizer (RDF) in combination with secondary nutrient sulphur and micronutrients (Zn & B) nourishment good for improving cane yield as well as quality related parameters of sugarcane (Singh *et al.*, 2015). The secondary as well as the micronutrient play a very critical role in the sugarcane production and their related quality. Although it requires in less amount but can play a very major role in the enhancement of macronutrient use efficiency (Shukla *et al*., 2009).

At present estimates of the micronutrient consumption indicates that zinc sulphate consumption is highest and about 60% of the total borax goes to the vegetables and fruit crops (Shukla *et al*., 2012). Sulphur application significantly increases SO_4 concentration as a result of the S oxidation. The nutrient requirement of S can generally fully be filled by the soil oxidation. Therefore, high dose of S may risk as loss from the field and low availability of S can affect the development of the sugarcane. Hence, the proper management of S along with micronutrients (Zn & B) required for the cell division, sugar translocation by forming sugar borate complex, proper hydration and metabolism. The brix, pol, cane and sugar yield of plant and ratoon crop of sugarcane improved with Zn fertilization. The maximum cane yields, quality of cane juice, total soluble solids (TSS) as well as availability of Zn in trash were recorded due to application of ZnSO4 applied @ 50 kg/ha. However, the effect of $ZnSO_4$ applied @ 37.50 kg/ha and 510 kg /ha was fond at par. Zn application *via* zinc sulphate @ 37.5 kg/ha were found optimum for significant improvement of sugarcane productivity and cane juice quality traits (Dhaliwal *et al*., 2022). It was also established that the incorporation of boron and zinc in combination led to a raise in sugar yield. They also recorded that boron application alone at a rate of 2 kg/ha also resulted in a higher sugar yield as control plot receiving no B (Quaddus *et al*., 2022).

Materials and Methods

Experimental site

The present investigation was carried out experimental farm of Sugarcane research Institute Pusa (SRI Pusa), Samastipur, Bihar (Latitude 25.58 ^{0}N, Longitude 85.40 ^{0}E, altitude 54 M above mean sea level). The Climate is subtropical, with hot and humid receiving annual rainfall 1090 mm and it is located under the ustic moisture regime. The average monthly maximum temperature was 30.98^{0}C and minimum temperature was 18.68^{0}C. The soil is calcareous in nature and can be describe in calciorthent. The initial soil charactertics of the experimental site are represented in Table 1.

Table 1 : Initial soil property of the experimental form Sugarcane research Institute Pusa (SRI Pusa) Samastipur Bihar.

Initial Soil Properties	Value
Textural class	Sandy loam
Sand (%)	65.40
Silt (%)	21.10
Clay (%)	13.50
Bulk density (Mg m^{-3})	1.44
Porosity (%)	47
pH (1:2)	8.45
EC (dSm^{-1})	0.69
Organic carbon (%)	0.47
Available N (kg ha^{-1})	215.16
Available P (kg ha^{-1})	25.40
Available K (kg ha^{-1})	113.86
DTPA available micronutrient (mg kg^{-1})	
Fe	14.36
Zn	0.68
Cu	1.02
Mn	3.50
Free calcium carbonate (%)	34.12

Treatments and experimental design

The field experiment on sugarcane crop was conducted during the year 2023-24. The variety under experiment was Rajendra Ganna-1. This variety is high yielding, high sucrose content and an early variety suitable for cultivation under Bihar condition. The experiment was formulated with two different doses of S, with recommended dose of Zn and B. The treatment comprises of S @ 60 and 80 kg/ha with or without Zn (10 kg/ha) and B (1.5 kg/ha). The experiment was conducted on an area 0.013 acer following randomized block design (Table 2) with nine treatments and three replications.

Crop sowing and Nutrient management

Select healthy three budded setts of Sugarcane and treated with the 1% solution of Bavistin soaking 20 minutes, which prevent the setts from the fungal disease infection. The thimet was applied in the furrow @ 15 kg/ha as insecticide and finally covered the bud setts using the desi plough. Sugarcane is belonging to the Poaceae family, which are susceptible for the crop weed competition. To supress the crop weed competition the first-hand weeding was done at the 45 DAP. sugarcane

Table 2 : Treatments details.

Treatments	Details
T_1	Control (no S, Zn and B)
T_2	RDF + S @ 60 Kg/ha
T_3	RDF + S @ 80 Kg/ha
T_4	RDF + S @ 60 Kg/ha) + Zn @ 10 Kg/ha
T_5	RDF + S @ 60 Kg/ha) + B @ 1.5 Kg/ha
T_6	RDF + S @ 60 Kg/ha + Zn @ 10 Kg/ha + B @ 1.5 Kg/ha
T_7	RDF + S @ 80 Kg/ha + Zn @ 10 Kg/ha
T_8	RDF + S @ 80 Kg/ha + B @ 1.5 Kg/ha
T_9	RDF + S @ 80 Kg/ha + Zn @ 10 Kg/ha + B @ 1.5 Kg/ha

Note: - RDF (Recommended dose of Fertilizer).

is water intensive crop, the first irrigation at 45 DAP, and further two irrigation was provided in the month of May and June. The application of N, P_2O_5, K_2O, S, Zn and B was applied in the form of Urea, DAP, MOP, bentonite sulphur, Zinc sulphate and borax. 50% of N in the form of urea was applied at the time of planting. Rest 50% N was applied in two equal splits. 25% N was applied just after the first irrigation given and second 25% N was applied at the time of earthing up. For diseases and pest management applied Thimet-10G @15Kg/ha in the furrow during planting of setts to control the pest. Shoot and root borer malathion @1.5 litre/ha was sprayed at two times in standing crop.

Plant parameter

Germination percentage was taken after 45 days after planting (DAP), counting germination percentage by the following formula-

$$\text{Germination (\%)} = \frac{\textit{Number of germination buds/plot}}{\textit{Number of buds planted/plot}} \times 100$$

Tillers population calculated in following time- 120, 150 and 180 DAP from each planting and expressed in ($\times 10^3$/ha). Plant height (cm) were measured for stages *viz.;* 150, 180, 210 DAP and at harvesting stage. Dry matter (g/plant) accumulation of the was calculated at different stages- 90, 120, 150 DAP and at harvesting stage. After harvesting measured the cane diameter by using the Vernier slide callipers. Measure the Brix (%), Sucrose (%), Purity (%) and sugar yield (tone/ha) by the following formula (Parthasarathy, 1979).

Purity Percentage = (Sucrose %/HR Brix)100

Sugar Recovery (%) = [S-0.4(B-S)] × 0.73

Where, S = sucrose % in juice, B = Corrected Brix (%)

CCS (tons/ha) = [Yield (tons/ha) × Sugar Recovery (%)] / 100

$$\textit{Sugar yield}\,(t/ha) = \frac{CCS(\%) \times \textit{Cane yield}\left(\frac{t}{ha}\right)}{100}$$

Results and Discussion

Germination (%) and Number of tillers

Table 3 shows that sugarcane germination percentage was not significantly affected by treatments, though the highest germination rate was recorded in Treatment 6, which included the recommended dose of fertilizer (RDF) with Sulphur, zinc, and boron. Additionally, tiller count remained unaffected at 120 days after planting (DAP) but showed a significant increase at 150 and 180 DAP. Similar trends were reported by Sharma *et. al.*, (2002) and Paul *et al.* (2012), highlighting a notable rise in tiller numbers with the application of sulphur, zinc and boron. The highest tiller count at 150 and 180 DAP was observed in the treatment combining RDF with S, Zn and B. This improvement is likely due to the enhanced metabolic activity in sugarcane when sulphur and micronutrients are applied together, promoting better growth at later stages.

Plant height

From the result presented in the Table 4, the data recorded at 150 DAP, 180 DAP and 210 DAP show that plant height was not significantly influenced by treatments during the early growth phase. However, a significant difference was observed at 210 DAP. This pattern is similar to the increase in tiller count, which became significant at later growth stages. At 210 DAP it was found highest in treatment receiving RDF with S, Zn and B combinedly. The similar effect of S and micronutrients (Zn and B) was observed by the Paul *et al.* (2005), Devi *et al.* (2012) and Mishra *et al.* (2014).

Number of milllable cane (NMC) and cane length

Table 5 illustrates that treatments had a significant effect on both the number of millable canes (NMC) and cane length at harvest. The highest NMC was recorded in the treatment receiving RDF along with Sulphur (S), zinc (Zn) and boron (B), likely due to the same factors influencing tiller count and plant height, as these traits are closely related. Similarly, cane length at harvest was significantly affected by treatments, with the longest canes observed in the RDF + S, Zn and B treatment (Treatment 6). This increase can be attributed to the overall improvement in plant height, tiller count, and NMC. However, same observation had been also observed by

Table 3 : Response of S, Zn and B on germination percentage and number of tillers

Treatments	Germination (%)	Number of tillers ($\times 10^3$/ha)		
	45 DAP	120 DAP	150 DAP	180 DAP
T_1	35.87	73.64	101.43	112.00
T_2	38.90	77.75	104.09	118.08
T_3	38.20	83.67	107.71	119.93
T_4	41.10	86.44	117.39	126.60
T_5	40.70	85.58	115.40	124.85
T_6	43.20	86.92	122.52	137.44
T_7	39.50	84.62	115.03	123.52
T_8	38.83	83.29	114.18	122.39
T_9	39.30	84.24	113.40	124.75

Table 5 : Response of S, Zn and B on NMC, Cane length at harvest, single cane weight and cane yield.

Treatments	NMC ($\times 10^3$ ha^{-1})	Cane length at harvest(cm)	Cane yield (t/ha)
T_1	96.09	207.55	70.90
T_2	102.99	210.10	76.68
T_3	103.88	214.66	77.50
T_4	106.33	213.84	79.32
T_5	104.86	199.46	78.21
T_6	111.72	228.34	81.40
T_7	102.05	218.20	75.69
T_8	100.58	213.14	74.31
T_9	104.94	194.90	78.48

Table 6 : Response of S, Zn and B Juice quality and sugar yield.

Treatments	Juice quality (%)				CCS (%)
	Brix	Pol	Purity coefficient	Juice recovery (%)	
T_1	20.52	17.96	87.52	49.68	12.48
T_2	21.27	18.64	87.63	51.37	13.01
T_3	21.78	19.00	87.23	55.63	13.24
T_4	21.78	18.90	86.77	53.92	13.13
T_5	21.31	18.71	87.79	52.14	13.04
T_6	22.10	19.38	87.69	54.18	13.56
T_7	21.39	18.73	87.56	51.84	13.06
T_8	21.86	18.98	86.82	50.92	13.20
T_9	21.31	18.52	86.90	46.82	12.87

the Davi *et al.* (2012) and Mishra *et al.* (2014) in sugarcane on growth and yield parameters.

Cane yield (t/ha)

Table 5 presents data on cane yield, revealing significant variations among treatments, ranging from 70.90 to 81.40 t/ha. Table 4 highlights the percentage

Table 4 : Response of S, Zn and B on plant height of sugarcane crop.

Treatments	Plant height (cm)		
	150 DAP	180 DAP	210 DAP
T_1	201.67	222.40	233.05
T_2	221.33	243.34	257.87
T_3	218.34	233.89	246.11
T_4	216.11	235.00	251.64
T_5	216.12	237.23	251.90
T_6	228.89	243.89	266.61
T_7	213.34	235.56	252.93
T_8	208.89	228.89	241.55
T_9	216.11	232.23	257.06

increase in cane yield, which varied between 9.68% and 14.80% due to the application of Sulphur (S), either alone or in combination with zinc (Zn) and boron (B). The lowest yield increase (6.37%) was recorded in Treatment T_8, while the highest yield (81.40 t/ha) and maximum increase (14.80%) were observed in Treatment T6 (RDF + S 60 + Zn 10 + B @ 1.5 kg/ha), followed by Treatment T_4 (S 60 kg/ha + Zn 10 kg/ha) with a 13.40% increase. The lowest yield (70.90 t/ha) was found in Treatment T_1 (control with RDF only). The yield ranking followed the order: $T_6 > T_4 > T_9 > T_5 > T_3 > T_2 > T_7 > T_8 > T_1$. The higher yield in T_6 was largely attributed to an increase in the number of millable canes (NMC) and cane length. However, applying a higher Sulphur dose (80 kg/ha) resulted in decline in growth and yield parameters of sugarcane. Similar observations were also recorded by Mellis *et al.* (2016) and Silva *et al.* (2020).

Juice quality (%)

From the result presented in the Table 6 on Brix (%), Pol (%), and purity coefficient in sugarcane juice, showing significant treatment effects. The Brix value, which indicates the total soluble solids (TSS) in juice ranged from 20.52% to 22.10%, with the highest in Treatment T_6 (22.10%) and the lowest in T_1 (20.52%). Higher Sulphur (S) doses especially at 80 kg/ha, decreased Brix due to adverse effects on sucrose synthesis, but combining S with zinc (Zn) and boron (B) in Treatments T_7 and T_8 mitigated this (Pawar *et al.*, 2003). Pol (%) values ranged from 17.96% (T_1) to 19.38% (T_6), with T_6 showing the highest sucrose content due to the optimal combination of nutrients (Franco *et al.*, 2011). The purity coefficient, calculated as the ratio of Pol to Brix, showed minimal variation across treatments, ranging from 86.77% (T_4) to 87.90% (T_5), despite significant differences in Brix and Pol (Sharma *et al.*, 2002). Commercial Cane Sugar (CCS%) and juice recovery (%), highlighting treatment effects. CCS%, representing sugar yield from juice, showed no significant differences across treatments, ranging from 12.48% (T_1) to 13.56% (T_6), with T_6 recording the highest value. Juice recovery (%) varied significantly among treatments, ranging from 46.82% (T_9) to 55.63% (T_3). Treatment T_3 performed best, comparable to T_2, T_4, T_5, T_6 and T_7. The higher juice recovery in these treatments is likely due to the optimal Sulphur dose enhancing extraction efficiency (Umesh *et al*., 2018).

Table 6 indicates a significant impact of treatments on jaggery Brix% (19.11–20.28%), yield (8.24–10.45 t/ha) and recovery (11.63–12.85%), with T_6 showing the highest values due to optimal S, Zn and B application. However, treatments had no significant effect on jaggery texture (161.05–161.60) or colour (71.29–72.24).

Sugar yield (t/ha)

The different treatment showed the significant effect on the sugar yield. The value of sugar yield was ranges from the 8.72 t/ha to 11.24 t/ha in treatment T_1 and treatment T_6, respectively. The highest value of sugar yield was observed in the treatment T_6 might be due to the high Pol % value and also due to the high cane yield. Similar result was also observed by the Mangrio *et al.* (2020) and Dhaliwal *et al.* (2022).

Conclusion

The application of S @ 60 kg/ha, Zn @ 10kg/ha and B @1.5kg/ha along with recommended dose of fertilizers (RDF :150N-85P_2O_5-60K_2O) has been found imperative for improving plant growth, yield attributes and cane yield. Sulphur along with micronutrients (Zn & B) also improved the quality of sugarcane juice (brix and pol). The sugar yield and jaggery yield increased significantly due to application of S either alone or in combination with Sulphur and micronutrients (Zn & B).

References

Abdul, Majeed, Rashid Imran, Niaz Abid Allah Ditta, Sameen Aysha and Manzer H. Siddiqui (2022) *J. Agricult. Sci.*, **25**, 125-135.

Devi, T. Chitkala, Bharthalakshmi M., Kumari M.B.G.S. and Naidu N.V. (2012). Effect of Sources and Levels of Phosphorus with Zinc on Yield and Quality of Sugarcane. *Sugar Tech*., **14 (2)**, 195–198.

Dhaliwal, Singh, Salwinder, Sharma Vivek, Shukla Kumar Arvind, Singh Jadgish, Verma Vibha, Kaur Manmeet and Singha Prabhjot (2022). Assessment of optimum mineral zinc fertilizer rate for quantitative and qualitative production of sugarcane in north-western India. *J. Trace Elements and Minerals*, **2**, 100-102.

Franco, H.C., Mariano E., Vitti A.C., Faroni C.E., Otto R. and Trivelin P.C. (2011). Sugarcane response to boron and zinc in Southeastern Brazil. *Sugar Tech.*, **13**, 86-95.

Hamid, Abdelrahman M., Ahmed Yassin M., Hamid Dagash and Osman A. Ahmed (2014). Impact of Sulphur Fertilizer on Sugarcane Performance under Heavy Clay Soils "Vertisols", Sudan. *J. Agricult. Environ. Sci.*, **3(1)**, 2334-2412.

Ismail Muhammad, Ahmad Tufail, Ali1 Amjad, Nabi Ghulam, Ul Haq Nur and Munsif Fazal (2016). Response of sugarcane to different doses of Zn at various growth stages. *Pure Appl. Biol*., **5(2)**, 311-316.

Jha, C.K., Sinha S.K. and Thakur S.K. (2017). Enhancing soil fertility, nutrient uptake and sugarcane productivity through integrated use of Fe and organics in sub-tropical system. *Indian J. Ecol.*, **44(5)**, 521-525.

Kumar Uttam and Chand Ramesh (2009). Mapping of resistance to spot blotch disease caused by Bipolaris sorokiniana in spring wheat. *Academia*, **118**, 783–792.

Mangrio, N., Kandhro M.N., Soomro A.A., Mari N. and Shah Z.H. (2020). Growth, yield and sucrose percent response of sugarcane to zinc and boron application. *Sarhad J. Agricult.*, **36(2)**, 459-469.

Mari, Ali Hassan, Panhwar Riaz Noor, Kaloi Ghulam Moheyuddin, Chohan Muhammad, Ashfaqe Zai, Ahmed Yousuf, Muhammad Aslam Brohi and Muhammad Abbas Bhutto (2006). Assessing Zinc Status of Sugarcane in Taluka Nawabshah Through Soil and Plant Analysis. *J. Appl. Sci.*, **6(l)**, 206-211.

Mellis, E.V., Quaggio J.A., Becari, Teixeira G.R.G., Cantarella L.A.J.H. and Dias F.L.F. (2016). Effect of micronutrients soil supplementation on sugarcane in different production environments: Cane plant cycle. *Agron. J.*, **108(5)**, 2060-2070.

Mishra, A.K., Shukla S.K., Yadav D.V. and Awasthi S.K. (2014). Iron, Manganese and Sulphur Uptake and Nutrients Availability in Sugarcane Based System in Subtropical India. *Sugar Tech.*, **16(3)**, 300–310.

Parthasarthy, S.V. (1979). *Sugarcane in India*. 634–653 pp. K.C.P. Ltd., Madras

Paul, G.C., Rahman M.H. and Rahman A.B.M.M. (2005). Effects of Boron and Molybdenum on Sugarcane Grown in Old Himalayan Piedmont Plain Soils of Bangladesh. *Korean J. Crop Sci.*, **50(2)**, 105-107.

Quddus, M.A., Siddiky M.A., Ali M.R., Ahmed R., Sarker K.K. and Arfin M.S. (2022). Influence of boron and zinc on yield, nutrient uptake and quality of strawberry. *J. Plant Nutr.*, **45(6)**, 866-882.

Sharma, B.L., Mishra A.K., Singh P.K., Singh R.R. and Singh S.B. (2002). Micronutrient fertilization in sugarcane: Effect of zinc and boron in calcareous soil. *Indian Sugar*, **52(6)**, 439-443.

Shukla, A.K., Dwivedi B.S. and Singh V.K. (2009). Macro role of micronutrients. *Indian J. Fertilizers*, **5 (5)**, 11-30.

Shukla, S.K., Sharma L., Jaiswal V.P., Dwivedi A.P., Yadav S.K. and Pathak A.D. (2011). Diversification Options in Sugarcane-Based Cropping Systems for Doubling Farmers' income in Subtropical India. *Sugar Tech*., **5**, 1-18.

Silva, Marcelo de Almeida, Germino Gabriel Henrique, Holanda Lucas Almeida de, Oliveira Laura Costa, Santos Hariane Luiz and Sartori Maria Márcia Pereira (2022). Sugarcane Productivity as a Function of Zinc Dose and Application Method. *Agriculture*, **12(11)**.

Singh, Aneg, Gupta K Rajesh and Sharma B.L. (2015). Effect of Boron on the yield and quality of sugarcane. *Indianjournal.com* **4(1)**, 20-24.

Umesh, U.N., Prasad R.K. and Kumar Vipin (2018). Integrated effect of organic and inorganic fertilizers on yield, quality parameter and nutrient availability of sugarcane in calcareous soil. *India J. Agricult. Res*., **1**, 556-560.