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OPTIMIZING SUGARCANE PRODUCTIVITY AND SOIL NUTRIENT UPTAKE WITH SULPHITATED PRESS MUD (SPM), PHOSPHORUS SOLUBILIZING BACTERIA (PSB) AND *TRICHODERMA VIRIDE* INTEGRATION IN CALCAREOUS SOIL

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ABSTRACT

This field experiment, conducted during the January 2020-February 2021 to investigate the impact of Sulphitated press mud cake (SPMC) in combination with *Trichoderma viride*, phosphorus solubilizing bacteria (PSB) and 100 % chemical fertilizer (RDF) on nutrient uptake and the productivity of sugarcane in calcareous soil in randomized block design (RBD). The highest germination (43.5%), number of tiller (170.55 $\times 10^{-1}$ ha^{-1}), plant height (272 cm), number of millable cane (NMC) (125.67 $\times 10^{-1}$ ha^{-1}), cane girth (2.20 cm) and single cane weight (0.831 kg) was observed in the plots receiving SPMC @ 12.5 t/ha along with *T. viride* + PSB. The addition of sulphitated press mud cake either with *T. viride* alone and in combination of PSB resulted in profitable yield of sugarcane crop. However, SPMC treatments (SPMC @ 5 - 12.5 t ha^{-1}) was found at par. The uptake of nutrients by sugarcane plant (NPK and micronutrients) significantly influenced due to application of either SPMC + *T. viride* or SPMC + *T. viride* + PSB. Furthermore, the nutrient uptake by sugarcane plants, including NPK (292.54, 32.64, 278.55 Kg ha^{-1}) and micronutrients *viz.* Fe, Mn, Zn, Cu (530.53, 434.25, 454.12, 109.86 g ha^{-1}) was significantly influenced by the application of SPMC, with the highest levels recorded in plots treated with SPMC at 12.5 t/ha along with *T. viride* and PSB. The integrated approach of SPMC, *T. viride*, and PSB presents a promising strategy for enhancing sugarcane productivity and nutrient uptake in calcareous soil. This research provides valuable insights for sustainable and high-yielding sugarcane cultivation practices.

Key words : Actinomycetes, Calcareous soil, Micronutrients, Sustainable and Yield.

Introduction

Sugarcane (*Saccharum officinarum* L.) crops is the valuable sources of sweetening agent in India and has a prominent position or agricultural map of India as a cash crop. In the Sugar Season of 2021-22 (from October to September), India has established itself as the leading global producer and consumer of sugar, and it's the second-largest sugar exporter in the world, following Brazil (Anonymous, 2022).

The production of sugarcane is round about 1850 mt and is grown around 126 mha worldwide. White, crystal sugar obtained from sugar cane accounts for 80% of the overall quantity of sugar produced annually in the world and 20% comes from beet sugar. The global processing of sugarcane is annually about 177 mt are grown by more than 115 countries (Anonymous, 2022). The sugarcane industry is India second largest Agro-based industry, which help sustain the nation socio-economics growth. It also used as an alternative commodity such as feed, fibre, energy and as bio-fuel for a portion of production. Developing country alone contribute 70% to the world overall production of sugarcane. In India sugarcane crop chiefly grown by farmers as cash crop in an area around 4.95 mha with a total output of 3030 million tonnes and a productivity of 61.3 tha. In Bihar, sugarcane crop grown in an area 0.29 million ha with an overall output of 10.8 million tonnes and an average productivity of 50 t/ha (ISMA, 2018).

Sugarcane is a comprehensive long-standing and highly nutritious crop that absorbs sufficient quantities of nutrients. By performing multi-ratooning of sugarcane is economically more favourable to farmers. Sub-tropical states Uttarakhand, Punjab, Haryana, Uttar Pradesh and Bihar are facing problems such as soil health depletion, productivity through sugar cane cultivation, which in turn reduces the yield, which is clearly visualized from the static average productivity in the last five years hovering close to 60 t/ha compared to its potential yield of 150 t/ha (Srivastava *et al.*, 2014). The imbalance in fertilizer use is the main aim behind the decrease in sugarcane crop productivity. The continuous apply of chemical fertilizers impairs the physical, chemical and biological properties of the soil resulting in low sugarcane yields.

Different problems have been generated and excessive use of chemical fertilizers such as universal secondary and micronutrient deficiencies reduce crop productivity and increased environmental pollution in Pathak and Ghosh (1996).

Sugarcane productivity in Bihar is poor for a several reasons. The long-term sugarcane trial clearly demonstrated that neither chemical fertiliser or organic sources alone can ensure the soil and crop production sustainability (Singh and Biswash, 2000). Organic sources enhance the properties of soil, and thus result in increasing the efficiency of the crop and maintaining soil quality. Organic inputs have the essential nutrients in less quantities in contrast to the chemicals, the growth hormones and enzymes of organic matter, essential for improving fertility, productivity and soil health (Bhuma, 2001).

Calcareous soils, falling within the pH range of 7.5-8.5 are afflicted by alkalinity. These soils typically exhibit 100 percent base saturation, with calcium dominating the exchange complex. This dominance of calcium locks up essential nutrients in the soil, rendering them unavailable for plant uptake. Calcareous soils are prevalent in arid and semi-arid climates and can also be found as inclusions in more tropical regions, where leaching is relatively limited. They cover over 1.5 billion acres of soil worldwide, and in India, they occupy more than 6.5 mha of land. Specifically, Uttar Pradesh and Bihar comprise over 1.3 million hectares of calcareous soils. These soils are widely found in nearly 5 million hectors of land including mostly Punjab, Haryana, Rajasthan, West Bengal and North East states (Basu *et al.*, 2016).

Organic manures play a pivotal role in enhancing the quality of juice and jaggery production by providing a balanced and slow-release supply of all essential nutrients throughout the cropping season (Dotania *et al.*, 2016). This balanced nutrient supply is achieved through various organic sources, including farmyard manure, oil cakes, pressmud cake, vermicompost, green manure, intercropped legumes and sugarcane trash, which have been utilized as nutrient sources for ages (Khandagave, 2023). The incorporation of organic nutrients not only contributes to the improved nutrition of sugarcane but also promotes the maintenance of healthy physical, chemical and biological soil conditions (Chatterjee *et al.*, 2017). By nurturing these aspects, organic manures offer a sustainable approach to sugarcane cultivation, fostering both crop quality and the long-term well-being of the soil (Bhattacharya and Gehlot, 2003). Different organic manure such as Farmyard manure, wastes of sugar industry such as pressmud or pressmud cake, green manure can be used in chemical fertilizer incorporation to improve the yield of sugar cane and preserve fertility of soil (Bokhtiar and Sakurai, 2005).

Press mud is a sugar industry commodity. It's also known as the cake filter. The raw juice contains suspended and dissolved impurities such as dispersed soil particles bagasse, particles wax, fat, proteins, gums, pectin and inorganic salt of Na, K and P etc. Sarangi *et al*. (2008). These impurities have to be separated from the juice. Usually, two kinds of processes are followed to explain the cane juice namely sulphitation and carbonation. An Indian sugar factory, after processing 100 tons of sugarcane, generates the following: 10 tons of sugar, 4 tons of molasses, 3 tons of filter mud, 0.3 tons of furnace ash, 30 tons of bagasse, 30 tons of top leaves and 1500 KWh of surplus power (Yadav and Solomon, 2006).

Press mud is one of the most important organic by-product of the sugar industry, its enable to supplying adequate nutrients plant to the soil because of its beneficial impact on soil texture, soil structure, water holding capacity, soil porosity, soil bulk density, infiltration, hydraulic properties and its generally related to basic soil properties, these are followed by increases in soil aggregate stability and the soil ecological system physical climate is important for soil health and sustainable agricultural (Singh *et al.*, 2023). Pressmud has significantly improved soil bacterial and fungal populations. Improvement in bacterial, fungal and *actinomycetes*. Populations by pressmud application in agricultural soils Label their functions in organic substances to releasing nutrients for the growth and production of plants (Kumar *et al*., 2017).

Biofertilizers are carrier-based preparations containing mainly efficient microorganism strains in sufficient quantities that are useful for plant nitrogen fixation, phosphorus solubilization, uptake and growth synthesis that promote substances *viz*. hormones, vitamins and auxins. Biofertilizers improve the properties of the soil and maintain the fertility of the soil (Yadav and Sarkar, 2019).

When organics were used in conjunction with inorganic fertilisers or trash incorporation with bio-fertilizers, cane and commercial cane sugar yields improved and 25 percent of nitrogen was saved (Virdia and Patel, 2010). Enhancing the decomposition of sugarcane trash can be expedited by the application of *Trichoderma* sp., particularly as these microorganisms are often found in the rhizosphere. In addition to their role in hastening the decomposition of organic matter, they can serve as bio-control agents against soil-borne plant pathogens, a point highlighted by Harman (2000). Furthermore, their presence has been associated with the improvement of soil health (Shukla *et al*., 2008). Bacteria with the beneficial ability to convert inorganic phosphorus from insoluble compounds into soluble forms are referred to as phosphate solubilizing bacteria (PSB). A fundamental aspect of plant phosphate nutrition is the capacity of rhizosphere bacteria to solubilize phosphate (Satyaprakash *et al*., 2017). The mechanism underlying the solubilization of mineral phosphate by PSB strains is believed to be associated with the production of low molecular weight organic acids. These acids contain hydroxyl and carboxyl groups that can chelate the cations bound to phosphate, thereby transforming them into soluble forms.

Materials and Methods

The experimental field was the medium upland, well drained and having uniform located at southern bank of river Burhi Gandak in the Samstipur district of Bihar, India. The different sources *viz*. sulphitated press mud cake (SPMC), *Trichoderma viride* and Phosphorus solubilizing bacteria (PSB) were applied in the sugarcane crop variety (CoP 112). The RDF control (150kg N, 85kg P_2O_5, 60kg K_2O) and press mud, *T. viride*, PSB source were added as per treatment detail given in Table 1.

Various parameters was observed for yield, juice quality, plant analysis for micro and macronutrients. Cane and sugar yield *viz*. Cane yield (t ha^{-1}). Juice quality parameters at harvest stage *viz*. Brix (%) and Sugar (%) was measured with a brix hydrometer, according to Spencer and Meade (1964), Commercial cane sugar (%) estimated using Parthasarathy (1979) and Purity (%). Plant analysis where, nitrogen content (Kjeldahl), Phosphorous content by Jackson (1978), Potassium content by Jackson (1978), sulphur content analyzed in spectrophotometer (Chesnin and Yien, 1950).

Table 1 : Treatment details of the experiment.

T_1	Control RDF (150 Kg N, 85 Kg P_2O_5, 60 Kg K_2O)
T_2	SPMC @ 5.0 t/ha + *T. viride*
T_3	SPMC @ 7.5 t/ha + *T. viride*
T_4	SPMC @ 10 t/ha + *T. viride*
T_5	SPMC @ 5.0 t/ha + *T. viride* + PSB
T_6	SPMC @ 7.5 t/ha + *T. viride* + PSB
T_7	SPMC @ 10 t/ha + *T. viride* + PSB
T_8	SPMC @ 12.5 t/ha + *T. viride* + PSB

Note : RDF (150kg N, 85kg P_2O_5, 60kg K_2O) will be applied (T_1 to T_8), NPK was applied through urea, DAP and MOP, The K_2O and P_2O_5 was applied as basal dose in planting and nitrogen was applied in split dose *i.e*., 50% in planting and 50% at top dressing (25% first irrigation and 75% early stage), *Trichoderma* (*T. viride*) @ 2.5 Kg+ Phosphorus solubilizing bacteria (*Bacillus megaterium*) @ 4 Kg/ha.

Uptake of nutrient for macronutrient content

Total uptake N, P, K and S by sugarcane was estimated by multiplying the N, P, K and S nutrient content by dry matter yield.

Micronutrient content

Amount of Fe, Zn, Cu and Mn was determined using an atomic absorption spectrophotometer (ZEEnit 700 P) as per normal procedure (Lindsay and Norvell, 1978).

The brix percent in cane juice was calculated at the maturity stage of the crop. Brix was used to determine total soluble solids (TSS) in juice and was measured with a brix hydrometer, according to Spencer and Meade (1964). The Commercial cane sugar (CCS %) was estimatedusing formulabased on brix and sucrose data (Parthasarathy, 1979).

$$CCS\ (\%) = [S-0.49\ (B-S)] \times 0.73$$

Where,

S = sucrose percent in juice

B = Brix percent in juice

Sugar yield was estimated CCS % using formula

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

Purity test was estimated using formula

$$Coefficient\ of\ purity\% = \frac{Pol\ per\ cent\ in\ juice}{Corrected\ brix\ reading} \times 100$$

Results and Discussion

Growth and yield characteristics

Yield attributes

The plant growth parameters *viz.* germination, plant height and tillers were recorded during the different plant growth stage. The germination was counted at 45 days after sugarcane planting. The yield attributing characteristics *viz.* number of millable cane, cane girth, and single cane weight were recorded at maturity stage of the crop. The data related to the growth characteristics and yield attributes of sugarcane *viz.* number of tillers, plant height, cane girth, NMC and single cane wt. has been presented in Table 2.

The observation on the germination % showed significant increase in all the SPMC treatments over control. However, the highest germination (43.5%) was recorded in T_8 receiving SPMC along with *T. viride* and PSB. Plant parameter including plant height, no of tiller significantly increased in all the treatments over control. However, the highest germination, plant height (cm) and tillers was recorded in T_8 receiving SPMC along with *T. viride* and PSB. The data indicated that all the SPMC treatments were found at par. The plant height, number of tillers, cane girth, NMC and single cane wt. significantly increased in the SPMC treatments compared to control (T_1). The number of millable cane, cane girth and single cane weight were contributing directly to cane yield. The NMC ranged from (70.73 – 125.17 × 10^3 ha^{-1}) and single cane weight from (0.628 – 0.831 kg). The addition of SPMC along with *T. viride* + PSB produce favourable condition for availability of nutrients and also increased the microbial population result in higher NMC, cane girth, single cane weight and cane yield with the use of press mud along with *T. viride* and PSB. The addition of the SPMC along with *T. viride*+ PSB produces favourable condition for improvement in growth parameter *viz.* plant height and tillers which ultimately resulted in higher cane yield. Singh *et al.* (2007) documented that the application of press mud led to the highest NMC, canes with extended growth and greater thickness, and the highest ratoon cane yield. Sharma *et al.* (2009) also reported the inclusion of pressmud cake along with the recommended amounts of phosphorus, potassium and phosphorus solubilizing bacteria resulted in enhanced plant population and NMC.

Table 2 : Effect of pressmud, *Trichoderma* and Biofertilizers on yield attributes and cane yield soil after harvest of sugarcane crop.

Treatment	Germination (%)	Plant height 180 DAP(cm)	Tillers ($\times 10^{-1}$/ha) 120 DAP	Cane girth (cm)	NMC (x 10^{-1} ha^{-1})	Single cane weight (kg)	Cane yield (t ha^{-1})
T_1: Control RDF	29.9	183.00	104.63	2.00	76.39	0.628	57.83
T_2:SPMC @ 5.0 t/ha + *T. viride*	33.6	231.00	139.13	2.02	103.94	0.710	64.15
T_3:SPMC @ 7.5 t/ha + *T. viride*	36.8	244.89	144.22	2.06	109.64	0.732	65.91
T_4:SPMC @ 10 t/ha + *T. viride*	37.6	258.67	147.88	2.08	113.38	0.756	69.13
T_5:SPMC @ 5.0 t/ha + *T. viride* + PSB	36.4	252.12	142.30	2.10	109.90	0.726	66.96
T_6:SPMC @ 7.5 t/ha + *T. viride* + PSB	38.2	262.26	153.32	2.15	115.73	0.746	67.05
T_7:SPMC @ 10 t/ha + *T. viride* + PSB	40.5	267.33	155.98	2.19	120.03	0.811	69.68
T_8:SPMC @ 12.5 t/ha + *T. viride* + PSB	43.5	272.00	170.55	2.20	125.67	0.831	71.98
SE(m)±	**0.68**	**9.71**	**7.57**	**0.03**	**6.13**	**0.03**	**2.697**
LSD (0.05)	**2.08**	**29.44**	**22.97**	**0.08**	**18.60**	**0.10**	**8.29**

Control: (RDF 150kgm N, 85kg P_2O_5, 60kg K_2O), Bio-fertilizer, phosphorus solubilizing bacteria (PSB).

Table 3 : Effect of pressmud, *Trichoderma* and Biofertilizers on cane juice quality and sugar yield of soil after harvest of sugarcane crop.

Treatment	Juice Quality (%)			CCS (%)	Sugar yield (t ha^{-1})
	Brix	Pol	Purity		
T_1: Control RDF	16.7	15.87	86.1	9.80	5.34
T_2:SPMC @ 5.0 t/ha + *T. viride*	17.1	16.17	86.9	10.43	6.51
T_3:SPMC @ 7.5 t/ha + *T. viride*	17.4	16.55	86.0	10.52	6.82
T_4:SPMC @ 10 t/ha + *T. viride*	17.6	16.61	86.9	11.42	7.61
T_5:SPMC @ 5.0 t/ha + *T. viride* + PSB	17.2	16.29	87.0	11.09	6.82
T_6:SPMC @ 7.5 t/ha + *T. viride* + PSB	17.7	16.74	86.7	11.39	7.32
T_7:SPMC @ 10 t/ha + *T. viride* + PSB	17.8	16.89	86.6	11.55	8.06
T_8:SPMC @ 12.5 t/ha + *T. viride* + PSB	18.2	17.15	88.1	12.47	8.37
SE(m) ±	**0.35**	**0.25**	**0.52**	**0.58**	**0.56**
LSD (0.05)	**NS**	**0.75**	**NS**	**NS**	**1.70**

Control: (RDF 150kgm N, 85kg P_2O_5, 60kg K_2O), Bio-fertilizer, phosphorus solubilizing bacteria (PSB).

Cane yield

The data obtain to the cane yield of crop has been presented in Table 2. The cane yield varied and was significantly higher in the organic treated plots T_2, T_3, T_4, T_5, T_6, T_7, T_8 compared to control (T_1). The cane yield varied from 57.83 – 71.98 t/hain the SPMC treated plots. Treatment T_8 receiving SPMC + *T. viride* + PSB in combination observed the maximum cane yield of 71.98 t/ha. The highest NMC resulted in maximum yield in T_8 treatment. The addition of SPMC either alone or with *T. viride* / in combination of PSB resulted in profitable yield of sugarcane crop. The application of pressmud significantly increased cane yield. In their study, Sharma *et al*. (2003) also noted that augmenting pressmud with phosphorus solubilizing bacteria (PSB) led to improvements in soil organic carbon (OC), available phosphorus and potassium. Bokhtiar *et al*. (2001) found that the significant enhancement in cane yield, by 20-30 percent, was achieved by applying pressmud in conjunction with nitrogen, as compared to plots that did not receive pressmud. Shankaraiah and Kalyanamurthy (2005) noted that cane yield significantly improved when enriched pressmud cake was applied. Saini *et al*. (2006) observed that combining pressmud cake and phosphorus solubilizing bacteria enhanced shoot population and increased sugarcane yield compared to using inorganic fertilizers alone.

Juice quality and sugar yield

The effect of different treatments on cane juice quality *viz*. brix, sucrose, purity and commercial cane sugar (CCS %) has been given in Table 3. The effect of different treatments on juice quality *viz* brix, purity and CCS % in all the treatments were found non-significant. However, pol % was found significant. The pol % was recorded treatment T_8 followed by T_7 & T_6 receiving SPMC along with *T. viride* + PSB. The brix and purity %, CCS % varied numerically. The higher sugar yield was recorded in treatment T_8 receiving SPMC @ 12.5 t/ha along with *T. viride* + PSB. This might be due to addition of SPMC which increase the sulphur content ultimately increase the sucrose of sugar yield. The pol % was recorded treatment T_8 followed by T_7 and T_6 receiving SPMC along with *T. viride* + PSB. Similar results where, Venkatakrishnan and Ravichandran (2007), Shukla and Yadav (2011) also found that the application of PSB + PMC led to the highest ratoon cane yield and commercial cane sugar yield, with a maximum cane yield. Sharma *et al.* (2009) observed that inclusion of pressmud cake, along with the recommended phosphorus, potassium and phosphorus solubilizing bacteria, resulted in increased plant population and NMC. The maximum sugar yield was observed in the treatment T_8 (8.37 t/ha) followed by T_7 (8.06 t/ha), T_6 (7.32 t/ha), T_5 (6.82 t/ha), T_4 (7.61 t/ha) and T_3 (6.82 t/ha). The sugar yield exhibited similar pattern of cane yield. Higher cane yield resulted in high sugar yield.

Uptake of nutrient

NPK and S

NPK and S uptake of (macro nutrient) has been presented in Table 4. The uptake of macro nutrient NPK and S increased significantly in the SPMC treatment as compared to control. The treatment T_8 was significantly superior among other treatment. The N uptake was found at par in treatments T_2, T_3, T_4, T_5, T_6, T_7 and T_8. The phosphorus and potassium and sulphur are significantly increased in all the treatment as compared to control.

Table 4 : Effect of pressmud, *Trichoderma* and Biofertilizers on uptake of nutrients by sugarcane crop plant.

Treatment	Uptake Macro Nutrient(Kg ha^{-1})				Uptake Micro Nutrient(g ha^{-1})			
	N	P	K	S	Fe	Mn	ZN	Cu
T_1: Control RDF	218.74	16.90	198.65	25.37	227.91	174.67	168.90	75.87
T_2:SPMC @ 5.0 t/ha + *T. viride*	229.10	20.25	203.54	31.11	281.96	245.24	267.62	101.27
T_3:SPMC @ 7.5 t/ha + *T. viride*	240.17	20.96	211.92	33.58	367.62	336.54	337.21	102.39
T_4:SPMC @ 10 t/ha + *T. viride*	245.21	22.44	218.65	35.01	419.04	361.03	362.25	104.42
T_5:SPMC @ 5.0 t/ha + *T. viride* + PSB	250.44	23.96	225.39	33.43	399.04	377.08	304.17	106.24
T_6:SPMC @ 7.5 t/ha + *T. viride* + PSB	264.92	25.61	237.11	35.40	467.82	385.24	350.54	106.48
T_7:SPMC @ 10 t/ha + *T. viride* + PSB	275.96	29.41	251.11	36.76	515.39	416.12	382.57	107.48
T_8:SPMC @ 12.5 t/ha + *T. viride* + PSB	292.54	32.64	278.55	38.93	530.53	434.25	454.12	109.86
SE(m)±	**2.61**	**1.24**	**2.31**	**0.73**	**16.70**	**5.73**	**7.66**	**4.19**
LSD (0.05)	**7.99**	**0.41**	**7.08**	**2.25**	**50.66**	**17.38**	**23.24**	**14.90**

Control: (RDF 150kgm N, 85kg P_2O_5, 60kg K_2O), Bio-fertilizer, phosphorus solubilizing bacteria (PSB).

The maximum nutrient uptake was observed in treatment T_8 receiving SPMC along with *T. viride* and phosphate solubilizing bacteria. The higher cane yield resulted in higher uptake of nutrients by plant. Rakkiyappan *et al*. (2001) noted that the incorporation of PMC along with *Pleurotus* sp., in conjunction with 75% of the necessary chemical fertilizers, enhanced cane yields compared to using chemical fertilizers alone. Singh *et al*. (2007) documented that the utilization of 10 t/ha of press mud resulted in the highest NMC, extended cane growth, thicker canes, and a maximum ratoon cane yield. Singh *et al*. (2007), Singh *et al*. (2009a and 2009b) found that the combination of 50% N, P, K, S and Zn with 50% PMC and biofertilizers significantly improved germination percentage, tiller numbers, NMC, yield and commercial cane sugar content.

Fe, Zn, Mn and Cu uptake

The micronutrient (Fe, Zn, Mn and Cu) uptake by sugarcane crop has been presented Table 4. The micronutrients uptakes varied significantly, being the highest in T_8 receiving SPMC + *T. viride*+ PSB in combination. The Fe, Zn, Mn and Cu uptake were found at par with SPMC treatments. The higher cane yield resulted in higher uptake of nutrients by plant. The higher yield resulted in higher uptake of micronutrients in T_8 receiving SPMC @ 12.5 t/ha + *T. viride* + PSB in combination. The significantly increase in nutrient uptake due to addition of organic and biofertilizer. In their study, Singh *et al*. (2010) also examined the impact of a *Trichoderma* multi-culture on the regenerating stubbles. They found that cultivating *T. harzianum* strains on stubbles led to an increase in the availability of nutrients such as nitrogen, phosphorus, and potassium, as well as higher levels of Fe, Zn, Cu and Mn in the soil.

The overall results revealed that application of SPMC along with *T. viride* and PSB significantly increases the organic carbon and availability of nutrients (NPK and micronutrients) in soil with significant reduction in bulk density. The mean cane yield (57.83-71.98 t/ha) and sugar yield (5.34-8.37 t/ha) varied significantly in the SPMC + *T. viride* + PSB treated plots. Juice quality parameters viz. brix and purity percent remain unaffected due to application of SPMC. However, pol percent increased significantly due to combined application of SPMC along with *T. viride*or PSB. Based on above findings it may be concluded that application of SPMC @ 5.0 t/ha + *T. viride* + PSB was found suitable for obtaining higher cane and sugar yield with significant improvement in the physical, chemical and biological properties of calcareous soil. Bairwa *et al*. (2022) also demonstrated that sugarcane

Fig. 1 : Effect of pressmud, *Trichoderma* and Biofertilizers on uptake of macronutrients (NPK &S).

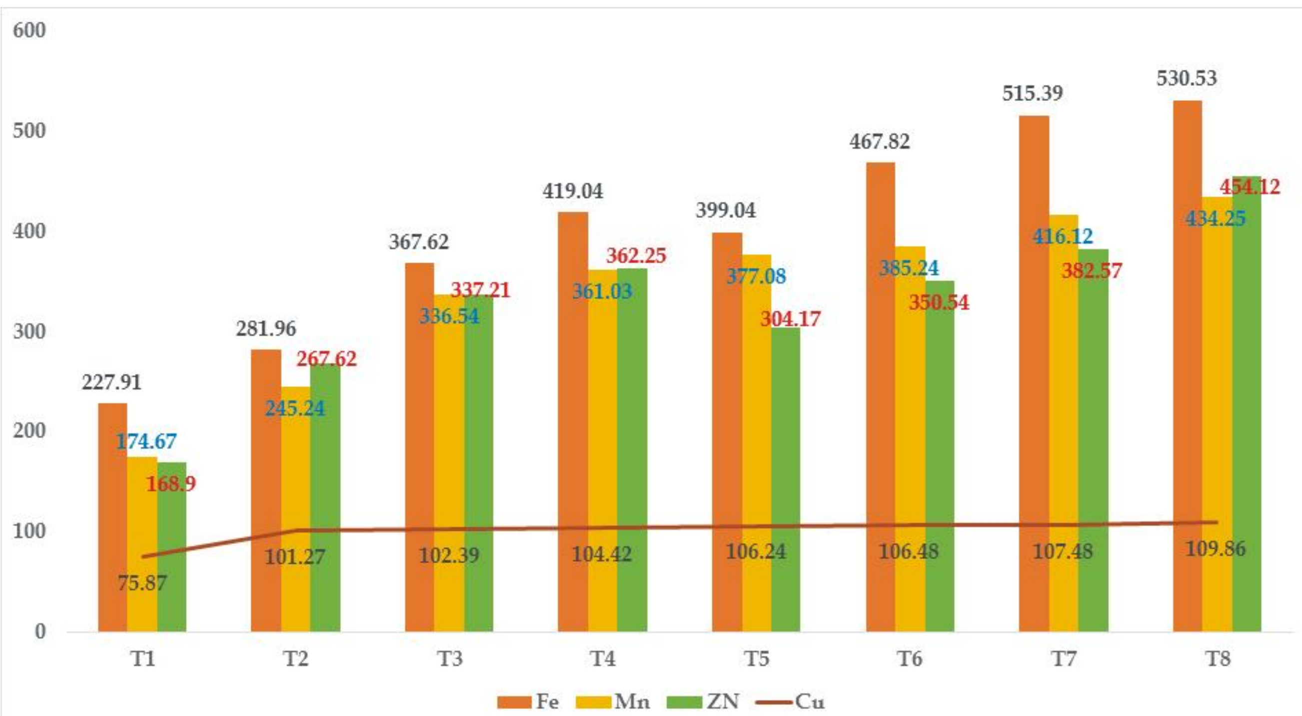

Fig. 2 : Effect of pressmud, *Trichoderma* and Biofertilizers on uptake of micronutrients (Fe, Mn, Zn & Cu).

trash mulching, when treated with inorganic (Urea) or organic sources (Vermicompost/FYM), along with microbial inoculants (*Trichoderma viride* / *Azotobacter* + PSB), significantly enhanced various soil health parameters, encompassing physical, chemical, and biological properties, after the harvest of sugarcane ratoon crop over a two-year period.

Conclusion

The investigation into the integration of sulphitated press mud cake (SPMC), *Trichoderma viride* and phosphorus solubilizing bacteria (PSB) in sugarcane cultivation within calcareous soil has yielded significant insights. The application of these treatments substantially improved various growth and yield attributes of sugarcane. The nutrient uptake in sugarcane plants, both for NPK and micronutrients was notably influenced by the application of either SPMC + *T. viride* or SPMC + *T. viride* + PSB. The addition of organic materials in the form of SPMC led to a substantial increase in the uptake of NPK and sulfur (S) compared to the control plots. Based on the findings presented, it can be concluded that the application of SPMC at a rate of 5.0 t/ha, combined with *T. viride* and PSB, is a favorable approach for achieving increased cane and sugar yields, along with significant enhancements in the physical, chemical and biological properties of calcareous soil. Overall, the application of SPMC at 5.0 t/ha, in combination with *T. viride* and PSB, emerges as a viable strategy to enhance cane and sugar yields while simultaneously improving the physical, chemical and biological properties of calcareous soil. These findings offer valuable insights for sustainable and high-yielding sugarcane cultivation practices.

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