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Secondary and micronutrient uptake of ratoon sugarcane as influenced by integrated nutrient management strategy

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Abstract

A field experiment was conducted in Palani Chettipatti (P.C.Patti) village of Theni district, Tamil Nadu with Sugarcane (var. CO 86032) as test crop during 2013-2014 to study the impact of integrated nutrient management on secondary and micronutrient uptake of ratoon sugarcane. The T_9 (RSCL package) significantly recorded the highest total S uptake of 46.4 kg ha^{-1}. The T_{10} (TNAU package) significantly recorded the highest total Ca and Mg uptake of 82.1 and 69.8 kg ha^{-1} respectively. The lowest total secondary and micronutrient uptake was recorded in T_4. Either application of TNAU package (T_{10}) or RSCL package ($T_{9)}$ recorded the highest micronutrient uptake rather than the T_7 (T_1+Zn) or T_8 (T_7+S) where $ZnSO_4$ or S was applied either alone or in combinations. Hence, following fertilisation package of TNAU and RSCL enhanced micronutrients uptake.

Key words: Secondary nutrients, micronutrient uptake, ratoon sugarcane, INM.

Sugarcane is an important agricultural commercial cash crop, grown on 4.5 per cent of the total cropped area of the country. Ratoon is unique in the sense that a number of succeeding sugarcane crops are raised from a single planting which is an integral component of sugarcane production system. Area-wise India is ranked fifth in the world and 12th for the recovery of sugar from the cane. Indian sugar consumption in MY 2016-17 is estimated to increase to 27.2 MMT (Sugar annual report 2016). In India more than 50 to 55 per cent of sugarcane acreage is occupied by ratoons, which are often poor yielders than the plant cane due to non-adoption of improved agricultural technologies. Thus, even a small improvement in ratoon crop would add considerably to overall sugarcane production and ratoon crop often gives better yield, quality and sugar recovery than plant cane (Van Der *et al.* 2013).

Sulphur is recognized as the fourth major nutrient besides N, P, and K. The crops which produce higher biomass with quality remove higher amount of S from the soil which necessitates its replenishment. The sulphur requirement of sugarcane crops is known to be high. Improvements in the yield and quality of sugarcane due to the application of sulphur have been reported by Singh *et al.* (2008). Calcium is essential for the growth and development of the spindle, leaves and roots as it comprises part of the cell walls, thus strengthening the plant and plays an important role in nitrogen metabolism. Magnesium is essential for photosynthesis and sugar production as it is needed for movement of phosphorus in the plant and involved in plant respiration (Thangavelu and Chiranjivi Rao 2002).

Micronutrients play a vital role in the growth and development of sugarcane plant. Though these elements are required in lesser amounts but are as essential as macronutrients. Furthermore deficiency of micronutrient in soil as well as in plants develops symptoms of crop malignancy (Bowen 1975). Micronutrient requirement of sugarcane crop varies with soil type and agro climatic conditions of an area (Li 1985). Zinc is essential for production of growth substances, required for the synthesis of tryptophan responsible for indole acetic acid production, which is essential for the protein metabolism. Iron is the fourth abundant element in the soil, yet its deficiency is frequently noticed in sugarcane crop especially in ratoons of sugarcane (Prasada Rao 1980). Iron is essential for chlorophyll formation. It acts as catalyst in respiration and photosynthesis. It acts as a factor in a few enzyme systems. Though required in small amounts, micronutrients control most of the physiological activities of the crop by interrupting the level of chlorophyll content in the leaves which ultimately influence the photosynthesis activity of the plant.

Studies related to influence of integrated nutrient management (INM) on secondary and micronutrients uptake of ratoon sugarcane are very limited and hence the present study investigation was undertaken to know the effect of INM on secondary and micronutrients uptake of ratoon sugarcane.

Materials and Methods

Study site

A field experiment was conducted in Palani Chettipatti (P.C.Patti) village of Theni district with Sugarcane (*Saccharum officinarum*) (var. CO 86032) as test crop during 2013-2014 to study the impact of integrated nutrient management (INM) on secondary and micronutrients nutrient uptake of ratoon sugarcane. The study site situated in Theni district at 9°28' and 10°12' N and 77°9' and 77°38' E and at 200-400 masl. The soil of the experimental site belonged to Somayanur series and according to USDA soil taxonomy classified as sandy clay loam containing 63.6, 12.8 and 23.6 per cent sand, silt and clay, respectively with pH of 7.7 and moderately fine non arid kaolinitic isomegathermic family of Typic Haplustalf. With regard to the fertility status of the soil it was low in available N, high in available P and K (Table 1).

The field experiment was laid out in a randomised block design (RBD) replicated thrice with following treatments- T_1-Recommended dose of fertilisers N, P_2O_5, K_2O @ 350:150:150 kg ha^{-1}, T_2-125% N+100% P_2O_5+ 100% K2O, T_3- 100% N+75% P_2O_5+ 75% K_2O, T_4-100%N+50% P_2O_5+50% K_2O, T_5-125%N+75% P2O5+100% K_2O, T_6-STCR (Soil Test Crop Response) based fertiliser prescription for an yield target of 200 t ha-1, T_7 -T_1+ Zn (as $ZnSO_4$) @ 25 kg ha^{-1}, T_8 -T_7 + elemental S (as Gromor) @ 25 kg ha^{-1}, T_9-RSCL package T_1+ elemental S (as Gromor) and $ZnSO_4$ each @ 25 kg ha^{-1}, $FeSO_4$ @ 50 kg ha^{-1} and Bio-A (Azospirillum), P (Bacillus subtilis) and K (Frateuria) each @ 2.5 L ha^{-1}, T^{10}-TNAU package (375:100:200:100:37.5 for N, P_2O_5, K_2O, $FeSO_4$, $ZnSO_4$ kg ha^{-1} and Azospirillum and phosphate solubilising bacteria each @ 2 kg ha^{-1}).

The soil samples collected from the experimental field were processed and analyzed for experimental studies. The samples were air dried, powdered and sieved through 2.0 mm sieve for the analysis of basic parameters like pH, electrical conductivity. The available nitrogen was analyzed by alkaline permanganate method (Subbaiah and Asija 1956), available phosphorus by Olsen *et al.* (1954) method and available potassium by ammonium acetate method (Hanway and Heidal 1952). Plant samples were collected at harvest . All the samples were air dried and then oven dried at 60-70 degree celcius for 12 hours. The dried samples were ground and preserved for assessing the nutrient contents and uptake. The data were analyzed by ANOVA using AGRES software.

$$\text{Nutrient uptake} = \frac{\text{Nutrient content (\%) x total dry matter yield (kg ha}^{-1}\text{)}}{100}$$

Table 1. Initial soil characteristics of experimental field

Soil Characteristics	Value
Soil reaction (pH)	7.70
Electrical conductivity (dS m^{-1})	1.28
Organic carbon (g kg^{-1})	6.8
Total N (%)	0.059
Total P (%)	0.066
Total K (%)	0.275
C/N ratio	13.90
CEC (cmol (p+) kg^{-1})	24.8
Available N (kg ha^{-1})	229
Available P (kg ha^{-1})	38.8
Available K (kg ha^{-1})	295
Available S (mg kg^{-1})	12.0
Available Fe (mg kg^{-1})	3.21
Available Mn (mg kg^{-1})	7.34
Available Zn (mg kg^{-1})	1.25
Available Cu (mg kg^{-1})	1.50

Results and Discussion

Total uptake of sulphur

Perusal of data in Table 2 revealed that application of recommended dose of fertilisers along with sulphur and other biofertilisers enhances the uptake of sulphur. The effect of integrated fertilisation on total S uptake of ratoon sugarcane at harvest varied between 27.7 and 46.4 kg ha^{-1}. The T_9 (RSCL package) significantly recorded the highest total S uptake of 46.4 kg ha^{-1}. This might be due to application of sulphur along with the biofertilisers and micronutrients increased the uptake of sulphur. Whereas the lowest total S uptake of 27.7 kg ha^{-1} was recorded in T_4 (100% N+50% P_2O_5& K_2O).

The crops which produce higher biomass with quality remove higher amount of S from the soil which necessitates its replenishment. In the present study, the T_9 (RSCL package) significantly recorded the highest total S uptake of 46.4 kg ha^{-1}. The response of various crops to sulphur application have been reported from different parts of India (Tandon 1991). Sulphur is indispensable element for carbohydrate metabolism and crop production. Ananthanarayanan *et al.* (1986) and Badigar (1985) reported that low content of available sulphur had limited the crop production in red sandy soils. According to Ganeshmurthy and Saha (1999), the sugarcane crop recorded the lower cane yields when the available sulphur is fixed as 20 ppm. Tandon (1995) reported that sulphur uptake generally is 9.15 per cent of the total N uptake though it can range from 5 to 30 per cent. The sulphur requirement of sugarcane crops is known to be high. Improvements in the yield and quality of sugarcane due to the application of sulphur have been reported by Singh *et al.* (2003). Mathew *et al.* (2003) reported that the sulphur application at higher doses exerted positive influence on uptake of plant nutrients there by increasing the cell activities and ultimately contributed for the higher yield attributes and cane yield in sulphur deficit soil.

Total uptake of calcium

The effect of fertilisation on total Ca uptake of ratoon sugarcane at harvest varied between 49 and 82.1 kg ha^{-1}. The T_{10} (TNAU package) significantly recorded the highest total Ca uptake of 82.1 kg ha^{-1}, which was at par with T_6 (STCR based fertiliser application). This might be due to application of balanced amount of potassium had an positive effect on uptake of calcium. Application of balanced amount of fertilisers increases the availability of nutrients to the cane. Cordero *et al.* (1977) also reported that the availability of calcium to cane increased as a function of increasing levels of potassium fertilization. The lowest total Ca uptake of 49 kg ha^{-1} was recorded in T_4 (100% N+50% P_2O_5 & K_2O). Calcium is essential for the growth and development of the spindle, leaves and roots, comprises part of the cell walls, thus strengthening the plant and plays an important role in nitrogen metabolism (Thangavelu and Chiranjivi Rao 2004). Dang *et al.* (1998) reported that a significant positive relationship between relative calcium concentration in sodic versus normal soil indicated the importance of calcium nutrition in sugarcane growth in sodic soil.

Total uptake of Magnesium

Data indicate significant treatment effect on magnesium uptake with balanced integrated fertilisation (Table 2.) The effect of fertilisation on total Mg uptake of ratoon sugarcane at harvest varied between 34.3 and 69.8 kg ha^{-1}. The T_{10} (TNAU package) significantly recorded the highest total Mg uptake of 69.8 kg ha^{-1}. This was followed by T_8 (T_7+S) which recorded the maximum Mg uptake of 65.7 kg ha^{-1}. Application of inorganic fertilisers along with organic manures and biofertilisers enhances the uptake of native soil magnesium. The lowest total Mg uptake of 34.3 kg ha^{-1} was recorded in T_4 (100% N+50% P_2O_5 & K_2O). Magnesium essential for photosynthesis and sugar production, needed for movement of phosphorus in the plant and involved in plant respiration (Thangavelu and Chiranjivi Rao 2004). According to Sachez and Clements (1974), magnesium had an influence on sucrose, dry matter and plant height. Babu (1979) reported that sulphur content increased with increase of nitrogen and magnesium and also it had a significant effect on yield. Paneque and Genzales (1985) reported that magnesium content of the soil did not have any effect on N, P and K concentrations in leaves but leaf magnesium content was related to its content in the soil.

Total uptake of micronutrient

Data reported in the table 3 revealed that application of inorganic nutrients along with organic manure and biofertilisers increases the uptake of micronutrients. The effect of fertilisation on total micronutrients uptake of ratoon sugarcane at harvest ranged from 6.95 to 14.5 kg ha^{-1} of Fe, 1.11 to 2.55 kg ha^{-1} of Mn, 0.52 to 1.00 kg ha^{-1} of Zn and 0.54 to 0.82 kg ha^{-1} of Cu. Either application of TNAU package (T_{10}) or RSCL package (T_9) recorded the highest micronutrient uptake rather than the T_7 (T_1+Zn) or T_8 (T_7+S) where Zn SO_4 or S applied either alone or in combinations. This might be due to application of biofertilisers and organic manures enhances the availability of micronutrient for the growth of sugarcane and

Table 2. Effect of fertilisation on total macro nutrients (S, Ca and Mg kg ha-1) uptake by ratoon sugarcane

Treatment	Total S uptake	Total Ca uptake	Total Mg uptake
T_1	35.4	49.7	47.7
T_2	40.8	72.1	54.3
T_3	30.8	50.0	46.2
T_4	27.7	49.0	34.3
T_5	34.6	65.1	49.5
T_6	42.6	80.6	53.1
T_7	37.8	58.1	52.4
T_8	43.3	62.4	65.7
T_9	46.4	67.8	58.5
T_{10}	36.6	82.1	69.8
Mean	37.6	63.7	53.1
SEd	4.5	3.8	3.5
CD(P=0.05)	9.4	8.0	7.4

Table 3. Effect of fertilisation on total micro nutrients (Fe, Mn, Zn and Cu kg ha^{-1}) uptake by ratoon sugarcane at harvest

Treatment	Total Fe uptake	Total Mn uptake	Total Zn uptake	Total Cu uptake
T_1	7.31	1.49	0.73	0.64
T_2	9.37	1.97	0.82	0.69
T_3	9.65	1.63	0.60	0.63
T_4	6.95	1.11	0.52	0.54
T_5	9.54	2.03	0.87	0.69
T_6	11.3	2.14	0.94	0.77
T_7	10.1	1.68	0.88	0.73
T_8	9.84	2.27	0.95	0.76
T_9	13.3	2.55	0.99	0.82
T_{10}	14.5	2.31	1.0	0.78
Mean	10.2	1.92	0.83	0.70
SEd	0.24	0.03	0.04	0.03
CD(P=0.05)	0.51	0.08	0.09	0.06

increased their uptake. The T_4 (100% N+50% P_2O_5 & K_2O) recorded the lowest total Fe, Mn, Zn and Cu uptake of 6.95, 1.11 0.52 and 0.54 kg ha^{-1}, respectively. The Zn uptake by sugarcane plants were higher in NPK with organic treatment because organic manures are good source of micronutrient and make higher availability in soil complexation and chelate formation with native Zn (Singh *et al.*, 2000; Babu and Rao 2004). Hence following fertilisation package of TNAU and RSCL enhances micronutrients uptake. Patil and Somawanshi (1983) reported that application of $FeSO_4$ increased the leaf Fe uptake of sugarcane due to increase in leaf Fe content and dry matter production of sugarcane. Umesh *et al.* (2013) reported that application of 100 per cent NPK along with biogas slurry significantly recorded the highest Zn uptake of 993 g ha^{-1}.

Conclusion

Efficient application of nutrients is a key to sustainability in agricultural systems and it necessitates balanced fertiliser use and sound management decisions and practices. The results of this present investigation clearly indicated that application of TNAU package or RSCL package recorded the highest micronutrient uptake. Hence, it is concluded that application of fertilisers along with other input like bio-compost and bio-fertilisers for ratoon sugarcane is suggested to enhance the secondary and micronutrient uptake.

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