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Changes in leaf macronutrient concentration under different micronutrient fertilization practices in sugarcane

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ABSTRACT

Field experiments were conducted at three locations with the objectives to evaluate new micronutrient fertilizer mixture formulations aiming at balanced fertilization of sugarcane. The experiments were conducted in Tamil Nadu sugarcane growing tract at different locations at Cuddalore, Sirugamani and Melalathur during 2012-13 in randomized block design with eight treatments replicated thrice. The treatments included the application of N, P and K alone (check) (T_1), 190 kg mineral nutrient (MN) mixture as straight chemical fertilizer as per crop production guide blanket recommendation (T_2), 120 kg MN mixture formulation-I as enriched vermicompost (EVC) (T_3) as well as enriched farm yard manure (EFYM) (T_4), 92.5 kg MN mixture formulation-II as EFYM (T_5) as well as EVC (T_6) and as straight chemical fertilizer (T_7) and MN mixture of the State Department of Agriculture at 25 kg/ha as straight chemical fertilizer (T_8). The application of 120 kg micronutrient mixture formulation-I as enriched vermicompost as well as enriched farm yard manure and the application of 92.5 kg micronutrient mixture formulation-II as enriched farm yard manure being on par recorded steady decline in the N, P and K content of the leaves from tillering to harvest and markedly higher cane yield over control.

Keywords: Micronutrient mixture; mineral nutrients; sugarcane; leaf nutrient concentration

INTRODUCTION

India is one of the largest producers of sugar and has a neck to neck race with Brazil for the first position. India shares about 13.25 per cent of world's and 41.11 per cent of Asia's sugar production. In Tamil Nadu sugarcane is cultivated in an area of 3.35 lakh hectares producing 3.5 million tonnes with an average productivity of 105 t/ha (Anon 2007).

Mineral nutrition is one of the potential means of improving cane yield. The yield and quality of cane could be maximized only if all the essential nutrients are supplied to the crop in adequate quantities and desired proportions. Micronutrients though required in very small quantities by crops are equally essential as that of major and secondary nutrients for the normal growth and yield of crops. The delineation of the soils of Tamil Nadu for their micronutrient availability indicated that the overall per cent deficiency was 58, 17, 6 and 6 for Zn, Fe, Mn and Cu respectively while it was 70.4, 12.4, 4.0 and 13.8 respectively during the same period in the soils of sugar belts (Velu et al 2008) indicating a higher magnitude of Zn and Cu deficiency in the sugarcane soils in Tamil Nadu.

MATERIAL and METHODS

Field experiments were laid out during 2012-13 in randomized block design with eight treatments in plot size of 40 m^2 replicated thrice at sugarcane research stations of TNAU at Cuddalore, Sirugamani and Melalathur. The details of treatments are given in Table 1.

The index leaf (3rd-4th fully opened leaf from top) was taken from five randomly selected plants per plot and the middle portion of the leaf removing the midrib was taken and analyzed for leaf nutrient contents viz N, P and K. The index leaves were collected at 60th (S1), 120th (S2), 180th (S3), 240th (S4) and at harvest (S5) stages of crop as per the crop logging procedure described by Lakmikantham et al (1970).

RESULTS

Physico-chemical properties of the soil

The soils of the experimental sites were near netural in reaction, non-saline, low in organic carbon and available nitrogen and medium in available P and K. The soils were deficient in zinc at all the locations except Cuddalore and iron deficiency was recorded in Melalathur centre. The details of the physico-chemical properties of initial soils are given in Table 2.

Nutrient content of index leaves

The nitrogen content of the leaves monitored at different stages of crop growth ranged from 1.13 to 2.69 per cent at Cuddalore, 0.97 to 2.19 per cent at Sirugamani and 0.63 to 1.77 per cent at Melalathur with an overall mean value of 2.03, 1.62 and 1.21 per cent respectively. The phosphorus content of the leaves at different stages of crop growth at three locations varied from 0.139 to 0.341 per cent at Cuddalore, 0.209 to 0.323 per cent at Sirugamani and 0.144 to 0.340 per cent at Melalathur with an overall mean value of 0.210, 0.255 and 0.236 per cent respectively. The potassium content of leaves monitored at different stages of crop growth at all locations varied from 1.09 to 1.90 per cent at Cuddalore, 0.80 to 1.51 per cent at Sirugamani and 0.84 to 1.72 per cent at Melalathur with an overall mean value of 1.48, 1.16, 1.29, 1.98 and 1.59 per cent respectively. Among the stages in general a gradual and steady decline in the nitrogen content of the leaves up to harvest was noted irrespective of the locations tested. From the Tables 3, 4 and 5 among the treatments all the treatments involving the application of micronutrient mixtures irrespective of the doses recorded higher N content in index leaves over check at all locations tested. Among the treatments the

Table 1. Details of the treatments

Treatment	Basal dose of mineral nutrients (kg/ha)						
	$FeSO_4$	$MnSO_4$	$ZnSO_4$	$CuSO_4$	Borax	Total	Mode/form of application
Control (N, P and K alone)	-	-	-	-	-	-	control
CPG blanket recommendation	100	25	37.5	7.5	20	190 kg	as straight chemical fertilizers
Formulation-I	75	10	30	5.0	10.0	120 kg	as EFYM
Formulation-I	75	10	30	5.0	10.0	120 kg	as EVC
Formulation-II	50	5.0	30	2.5	5.0	92.5 kg	as EFYM
Formulation-II	50	5.0	30	2.5	5.0	92.5 kg	as EVC
Formulation-II	50	5.0	30	2.5	5.0	92.5 kg	as straight chemical fertilizers
MN mixture of Dept of Agric @ 25 kg/ha	6.25	0.35 $MgSO_4$: 1.56 kg + Filler : 9.04 kg	7.14	0.20	0.46	25 kg	as straight chemical fertilizers

Note: The enriched farm yard manure or vermicompost was made by physical mixing of the micronutrient fertilizer mixture with the organic manure at friable moisture in 1/10 ratio and incubation for one month and then used for field application

Table 2. Physico-chemical properties of initial soil samples at different locations

Characteristics	Cuddalore	Sirugamani	Melalathur
Mechanical analysis			
Coarse sand (%)	29.14	23.64	26.90
Fine sand (%)	21.84	49.82	12.84
Silt (%)	16.20	11.32	28.90
Clay (%)	32.42	15.21	30.45
Textural class	Clay loam	Sandy loam	Sandy clay loam
Chemical analysis			
pH	7.3	8.13	7.50
EC (dS/m)	0.36	0.39	0.24
Alkaline $KMnO_4$ - N (kg/ha)	221	200	212
Olsen - P (kg/ha)	16	17	14
NH_4OAc-K (kg/ha)	172	169	194
DTPA -Zn (kg/ha)	1.91	1.10	0.51
DTPA -Fe (kg/ha)	5.93	6.13	3.27
DTPA -Mn (kg/ha)	16.0	13.7	9.65
DTPA -Cu (kg/ha)	3.01	2.16	1.82
HWS -B (kg/ha)	1.79	1.58	1.50
Organic carbon (%)	0.46	0.43	0.44
CEC (c mol (p+)/kg)	28.4	15.1	24.9

application of 120 kg mineral nutrient (MN) mixture formulation I as EVC (T_4) being comparable with the same quantity of MN mixture as EFYM (T_3) had recorded the highest macronutrient content in leaves at all the locations. The N content of the leaves recorded in control was the lowest at all the locations. The interaction of the treatments with stages was found significantly influenced by different doses and forms of micronutrient applications. The N, P and K content of the index leaves at 60th (S1), 120th (S2), 180th (S3), 240th (S4) and at harvest (S5) stages the initial stages S_1, S_2 and S_3 were found comparable with almost all the treatments; later stage S_4 was found comparable with treatments T_2, T_3, T_4, T_5 and T_6.

Cane yield (Table 6)

The mean cane yield of sugarcane ranged from 104 to 148 t/ha at different locations. Among the locations tested the cane yield at Cuddalore was highest followed by Sirugamani and Melalathur. Among the treatments application of 120 kg MN mixture formulation-I as EVC (T_4) as well as EFYM (T_3) being on a par recorded 20 to 21 per cent higher cane yield over check at all locations. The above

Table 3. Effect of micronutrient mixtures on N content (%) of the index leaf at different stages of crop growth at different locations

Treatment	Cuddalore						Sirugamani						Melalathur\					
	S_1	S_2	S_3	S_4	S_5	M	S_1	S_2	S_3	S_4	S_5	M	S_1	S_2	S_3	S_4	S_5	M
T_1	1.58	1.45	1.40	1.38	1.13	1.39	1.37	1.32	1.27	1.11	0.97	1.21	1.26	1.12	1.01	0.99	0.63	1.00
T_2	2.25	2.30	2.24	2.20	1.75	2.15	2.12	2.01	1.98	1.81	1.47	1.88	1.49	1.31	1.28	1.28	1.03	1.28
T_3	2.27	2.31	2.29	2.34	1.88	2.22	2.16	2.02	1.99	1.91	1.56	1.93	1.50	1.32	1.37	1.29	1.09	1.31
T_4	2.35	2.69	2.59	2.58	2.08	2.46	2.19	2.15	2.06	1.98	1.63	2.00	1.59	1.50	1.38	1.77	1.52	1.55
T_5	2.24	2.25	2.22	2.11	1.71	2.11	2.01	1.98	1.71	1.62	1.39	1.74	1.41	1.29	1.22	1.21	0.98	1.22
T_6	2.23	2.21	2.15	2.10	1.68	2.07	1.90	1.72	1.70	1.61	1.34	1.65	1.39	1.22	1.19	1.18	0.91	1.18
T_7	2.21	2.12	2.11	1.91	1.53	1.98	1.56	1.42	1.32	1.22	1.18	1.34	1.31	1.20	1.18	1.12	0.84	1.13
T_8	2.20	2.02	2.00	1.82	1.48	1.90	1.50	1.35	1.31	1.18	1.01	1.27	1.29	1.15	1.17	1.02	0.75	1.07
Mean	2.17	2.17	2.13	2.05	1.66	2.03	1.85	1.75	1.67	1.56	1.32	1.62	1.41	1.26	1.22	1.23	0.97	1.21
		S		T		SxT		S		T		SxT		S		T		SxT
SEd		0.02		0.03		0.06		0.02		0.02		0.05		0.01		0.02		0.04
$CD_{0.05}$		0.04		0.06		0.13		0.04		0.05		0.10		0.03		0.03		0.08

Table 4. Effect of micronutrient mixtures on P content (%) of the index leaf at different stages of crop growth at different locations

Treatment	Cuddalore						Sirugamani						Melalathur					
	S_1	S_2	S_3	S_4	S_5	M	S_1	S_2	S_3	S_4	S_5	M	S_1	S_2	S_3	S_4	S_5	M
T_1	0.147	0.141	0.139	0.091	0.141	0.119	0.228	0.227	0.210	0.209	0.227	0.210	0.168	0.162	0.159	0.144	0.162	0.148
T_2	0.242	0.240	0.239	0.227	0.240	0.247	0.301	0.300	0.289	0.277	0.300	0.280	0.290	0.281	0.280	0.271	0.281	0.273
T_3	0.308	0.301	0.297	0.287	0.301	0.297	0.312	0.309	0.297	0.287	0.309	0.289	0.329	0.328	0.310	0.278	0.328	0.299
T_4	0.341	0.340	0.339	0.324	0.340	0.328	0.323	0.318	0.298	0.288	0.318	0.295	0.340	0.333	0.320	0.317	0.333	0.321
T_5	0.217	0.210	0.209	0.198	0.210	0.199	0.297	0.287	0.278	0.257	0.287	0.266	0.276	0.267	0.234	0.233	0.267	0.245
T_6	0.205	0.199	0.190	0.187	0.199	0.187	0.266	0.264	0.241	0.230	0.264	0.241	0.241	0.240	0.228	0.221	0.240	0.225
T_7	0.192	0.181	0.180	0.170	0.181	0.172	0.257	0.255	0.240	0.227	0.255	0.235	0.221	0.220	0.219	0.210	0.220	0.211
T_8	0.170	0.168	0.108	0.105	0.168	0.129	0.254	0.250	0.230	0.220	0.250	0.228	0.181	0.180	0.177	0.160	0.180	0.169
Mean	0.228	0.226	0.213	0.199	0.222	0.210	0.279	0.276	0.261	0.249	0.276	0.255	0.256	0.251	0.241	0.229	0.251	0.236
		S		T		SxT		S		T		SxT		S		T		SxT
SEd		0.002		0.003		0.007		0.003		0.004		0.008		0.003		0.003		0.008
$CD_{0.05}$		0.005		0.006		0.014		0.006		0.007		NS		0.005		0.007		0.015

Table 5. Effect of micronutrient mixtures on K content (%) of the index leaf at different stages of crop growth at different locations

Treatment	Cuddalore						Sirugamani						Melalathur					
	S_1	S_2	S_3	S_4	S_5	M	S_1	S_2	S_3	S_4	S_5	M	S_1	S_2	S_3	S_4	S_5	M
T_1	1.47	1.40	1.38	1.30	1.09	1.33	1.16	1.09	0.99	0.96	0.8	1.00	1.18	1.08	1.01	0.99	0.84	1.02
T_2	1.75	1.69	1.58	1.43	1.27	1.54	1.34	1.29	1.21	1.19	1.08	1.22	1.55	1.50	1.41	1.28	1.19	1.39
T_3	1.76	1.74	1.63	1.44	1.33	1.58	1.38	1.31	1.29	1.26	1.18	1.28	1.59	1.58	1.49	1.39	1.28	1.47
T_4	1.90	1.83	1.69	1.50	1.38	1.66	1.51	1.49	1.38	1.37	1.29	1.40	1.72	1.68	1.57	1.48	1.35	1.56
T_5	1.68	1.61	1.51	1.41	1.24	1.49	1.29	1.20	1.19	1.09	1.03	1.16	1.47	1.41	1.39	1.28	1.17	1.34
T_6	1.66	1.59	1.45	1.39	1.2	1.46	1.25	1.15	1.13	1.04	0.97	1.10	1.47	1.32	1.20	1.14	1.01	1.23
T_7	1.55	1.50	1.43	1.37	1.17	1.40	1.21	1.14	1.09	1.01	0.92	1.07	1.31	1.28	1.19	1.09	0.95	1.16
T_8	1.54	1.49	1.41	1.35	1.15	1.39	1.19	1.12	1.01	0.99	0.89	1.04	1.29	1.22	1.14	1.07	0.91	1.13
Mean	1.66	1.61	1.51	1.39	1.23	1.48	1.29	1.22	1.16	1.11	1.02	1.16	1.45	1.38	1.30	1.22	1.09	1.29
		S		T		SxT		S		T		SxT		S		T		SxT
SEd		0.02		0.02		0.05		0.01		0.02		0.04		0.01		0.01		0.04
$CD_{0.05}$		0.03		0.04		NS		0.02		0.03		NS		0.03		0.04		NS

Table 6. Effect of micronutrient mixtures on cane yield (t/ha) at different locations

Treatment	Cuddalore			Sirugamani			Melalathur			Overall increase (%)
	yield (t/ha)	% increase over control	b:c ratio	yield (t/ha)	% increase over control	b:c ratio	yield (t/ha)	% increase over control	b:c ratio	
T_1	124	--	1.91	104	-	1.60	106	-	1.63	-
T_2	143	15	2.04	122	17	1.74	117	10	1.67	13
T_3	148	19	2.15	124	19	1.80	127	19	1.84	19.2
T_4	146	17	2.04	124	19	1.73	130	22	1.81	20.4
T_5	134	08	1.98	120	15	1.77	123	16	1.81	15.2
T_6	137	10	1.96	122	17	1.75	121	14	1.73	14.2
T_7	134	08	2.00	120	15	1.79	116	9	1.73	10.8
T_8	128	03	1.93	115	10	1.74	114	7	1.72	6.4
Mean	137	-	-	119	-	-	119	-	-	-
SEd	4.02	-	-	3.87	-	-	3.83	-	-	-
$CD_{0.05}$	8.57	-	-	8.30	-	-	8.21	-	-	-

two treatments were found comparable with 92.5 kg MN mixture formulation-II as-EFYM (T_5) as well as EVC (T_6) at 3 locations recording 15 to 16 per cent increase over check and 190 kg MN mixture as straight chemical fertilizer (T_2) at two locations recording 14 per cent increase over check. The MN mixture of the Department of Agriculture applied at 25 kg/ha also proved better than the check at all locations recording on an average 7 per cent increased cane yield over check.

DISCUSSION

Application of increasing doses of fertilizers as EVC or EFYM resulted in higher availability of macronutrients to the crops which in turn resulted in higher content and their uptake in sugarcane. Among the different locations the quantum of nutrient availability was higher at Cuddalore (variety CO86032) which resulted in higher content of major nutrients in sugarcane compared to other locations.

The nutrient elements are absorbed by plants in amounts whose magnitude depends on the plant's need and soils ability to supply them. Uptake of the nutrients by plants needs not be in the same ratio as they occur in soil. Consumption of the harvested produce by domesticated animals and human beings results in the continuous removal of nutrients from the soil. Result of the exploitative intensive agriculture has been the progressive occurrence of nutrient deficiencies in soils and crops. For efficient nutrient management complete knowledge on the nutrient uptake by the crops is necessary (Rattan and Goswami 2002).

Nitrogen is the most important plant nutrient and a plant contains 1-5 per cent by weight of this nutrient. Nitrogen is an integrated part of the chlorophyll the primary absorber of light energy needed for photosynthesis. It imparts vigorous vegetative growth and dark green colour to plants. There exists a close relationship between the nitrogen content and photosynthetic rates of leaves. Thus leaf greenness indicates the leaf N content. The higher leaf nitrogen concentration observed during early growth phase was linearly related to yield and quality of sugarcane. The highest leaf N content was observed for the application of 120 kg MN mixture as EVC followed by the application of same quantity of MN mixture as EFYM and 92.5 kg MN mixture applied as EFYM. Application of vermicompost as well as FYM enhanced the leaf N content due to increased and sustained availability of N in the soil. Similar findings were observed by Kanjana (2006).

The leaf P content of sugarcane was significantly higher for the application of 120 kg MN mixture as EVC or EFYM as well as 92.5 kg MN mixture as EFYM. The leaf P content got increased with increasing P availability by the application of enriched vermicompost or FYM. Application of enriched vermicompost or enriched FYM might have favored the solubility and availability of the soil native P thereby increasing the leaf P index.

The leaf P index got progressively decreased from tillering to post harvest stage of sugarcane where the available P content was reduced in amount in the present investigations. Sellamuthu (2002) reported that the P content of the leaf was found to decrease with upward trend of growth stages. The integration of chemical fertilizers with vermicompost or FYM favoured higher P uptake in sugarcane. This might be due to the increased availability of applied as well as the fixed phosphorus by P solubilizing microorganism through secretion of organic acids. Similar finding were reported by Jayaraman and Alagudurai (2003).

Micronutrient mixture application produced notable variation in K content in the index leaves and its uptake in sugarcane. The increase in the content of K was almost equal when the plant parts (tops and cane) were compared. Application of 120 kg MN mixtures as EVC as well as EFYM followed by 92.5 kg MN mixture as EFYM were found to significantly increase the K content in sugarcane.

Perumal (1981) reported that during early stages of crop growth K index was higher in young leaves due to the nature of its mobility and with moisture content of leaf. The results revealed that leaf K content decreased from tillering to postharvest stage of sugarcane. This is in line with the findings of Balaji (2005). Increase in K content due to application of B was reported by Yadav and Manchanda (1982). Potatueva et al (1975) found B application to enhance K uptake. The results have also revealed that the application of 120 kg MN mixtures as EVC or EFYM followed by 92.5 kg MN mixture as EFYM or EVC recorded the highest K uptake in both leaf and cane biomass of sugarcane as compared to control. It might be due to the highest supply and release of K in soil.

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