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Balanced Fertilization for Maximizing the Yield And Quality of Sugarcane Crop in Periyar Vaigai Command Area

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A field experiment was conducted in sandy clay loam soils of *Palaviduthi* series of Theni district, Tamil Nadu, India to study the response of sugarcane with respect to N, P, K, Zn and Fe fertilizers. The nutrient status of the experimental soil at the beginning of experiment showed deficiency of N, P, K, Zn and Fe. Sorption study also confirmed that the release of P, K, Zn and Fe was very low when these elements were added to the soil. Similarly sorghum responded well in respect of dry matter yield with respect to N, P, K, Zn and Fe in a greenhouse study. In the field experiment, these elements showed significant effect on germination percentage of sugarcane compared with control. The quality parameters of sugarcane namely brix, pol, purity and CCS were recorded highest in the treatment combination of $N_2P_2K_2$ Zn and Fe each @ 310, 160, 250, 31 and 72 kg ha^{-1} respectively. The results revealed that the optimum dose of N @ 310 kg ha^{-1} in the treatment combination of $N_2P_2K_2$ Zn and Fe has improved the quality of sugarcane. The number of tillers, millable cane and yield of cane (138. 21 t ha^{-1}) and sugar (18.52 t ha^{-1}) increased with the application of $N_3P_2K_2$Zn and Fe each @ 387.5, 160, 250, 31 and 72 kg ha^{-1} respectively.

Key words: Sugarcane, Sorption characteristics, *Palaviduthi* soil series, Birx.

Sugarcane is the major commercial crop cultivated to the extent of 3.50 lakh ha with a total production of 46.7 million tonnes of sugarcane and 16.23 million tonnes of sugar per annum in Tamil Nadu. The sugarcane productivity has increased over the last two decades however, the marginal increase in productivity of sugarcane has to be improved by adopting balanced fertilization. There is an imperative need for balanced fertilization in augmenting soil fertility and sugarcane production. The present investigation on “Evaluation of balanced fertilization for maximising the yield and quality of sugarcane in Theni District” was undertaken with a view to evaluate the fertilizer optima for balanced fertilization enunciated by a systematic approach on soil fertility evaluation proposed by Somportch and Hunter (1988). The present study was carried out in three phases *viz.,* Evaluation of nutrient sorption characteristics of Palaviduthi soil series, to establish the validity of optimum nutrient treatment in greenhouse experiment, to evaluate the various levels of nutrient combinations arrived on the basis of sorption characteristics of soil for maximum and maximum economic yield of sugarcane in Periyar Vaigai Command Area.

Materials and Methods

An incubation experiment was conducted with various levels of P, K, Zn and Fe which were found to be below the critical level in the Palaviduthi soil series collected at Boothipuram Village in Theni district. The initial soil samples collected in the field experiment conducted at P.C. patty, Theni district of Tamil Nadu is neutral in soil reaction and free from salinity and sodicity hazards. The available N, P and K status of the initial soil sample was 178, 8 and 272 kg ha^{-1} respectively. The soil was low with reference to N and P and medium in potassium status as per the soil test fertility classifications. The available Zn, Fe, Cu and Mn were 3.3, 28, 1.32 and 19.12 mg kg^{-1}. The organic carbon content was medium 0.62 per cent. The CEC of soil was 10.2 c mol (p+) kg^{-1}. The textural class of soil was sandy clay loam and the soil fall under the taxonomical classification of Palaviduthi soil series (Typic Haptulastalf).

The quantum of nutrient fixed was determined based on the difference between the concentration of nutrient added and extracted with appropriate extractant. The nutrient fixation curve was used to calculate the amount of plant nutrient needed to be added to the soil to arrive at optimum level for growth and yield of crops followed by the procedure described by systematic approach soil fertility evaluation (Samportch and Hunter, 1988)

The optimum nitrogen requirement of sugarcane CO 86032 in Palaviduthi soil series was evaluated by imposing different levels of N @ 250, 275, 300, 325, 350 and 375 kg ha^{-1} keeping P and K at recommended dose @ 65 and 110 kg ha^{-1}, respectively in 12 progressive farmer field of P.C. Patty Rajashree sugarcane area of Theni district. The average amount of nitrogen @ 310 kg ha^{-1} required on yield of 111.69 kg ha^{-1} was reckoned as optimum nitrogen level in Palaviduthi soil series of Theni district. The validity of the optimum nutrient treatment (ONT) was evaluated in a green house experiment by imposing different nutrient combination in the form of nutrient

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stock solutions to a known weight of soil sample of Palaviduthi soil series of PC Patty. Six out of twelve CO 27 sorghum seedlings grown upto the age of 25 days after sowing were collected and dry matter production was estimated to evaluate the efficacy of ONT as compared to other treatments combinations.

Table 1. Details of treatments combination with various levels of fertilizer nutrients

Treatment Number	Treatment	N kg ha^{-1}	P kg ha^{-1}	K kg ha^{-1}	Zn kg ha^{-1}	Fe kg ha^{-1}
T_1	N_0 P_2 K_2 ZnFe	0	160	250	31	72
T_2	N_1 P_2 K_2 ZnFe	232.5	160	250	31	72
T_3	N_2 P_2 K_2 ZnFe	310	160	250	31	72
T_4	N_3 P_2 K_2 ZnFe	387.5	160	250	31	72
T_5	N_2 P_0 K_2 ZnFe	310	0	250	31	72
T_6	N_2 P_1 K_2 ZnFe	310	120	250	31	72
T_7	N_2 P_3 K_2 ZnFe	310	200	250	31	72
T_8	N_2 P_2 K_0 ZnFe	310	160	0	31	72
T_9	N_2 P_2 K_1 ZnFe	310	160	187.5	31	72
T_{10}	N_2 P_2 K_3 ZnFe	310	160	312.5	31	72
T_{11}	N_2 P_2 K_2 Fe -Zn	310	160	250	0	72
T_{12}	N_2 P_2 K_2 Zn -Fe	310	160	250	31	0
T_{13}	Blanket	275	65	110	37.5	100

Field experiment was conducted in the experimental soil of Palaviduthi series at PC Patty area of Theni district in order to evaluate fertilizer optima for sugarcane CO 86032 during the mid late season of March – January, 2004-2005. The field experiment consists of thirteen treatment combinations. The optimum nutrient treatment formed the central treatment. In each case of N, P and K there were three more levels, *viz.,* a zero level, one below and another above the ONT level. Except the variable nutrient, other nutrients were kept equal to that of ONT. All the ten treatments received Zn and Fe as in ONT. Besides there was one treatment which was ONT minus Zn and another treatment with ONT minus Fe. A blanket fertilizer treatment was included for comparison. The treatments were replicated three times in a Randomized block design (RBD). The details of the treatments are given in Table 1.

Results and Discussion

Phosphorus sorption characteristics revealed that the original soil sample contained 4 mg kg^{-1} of available phosphorus and therefore, the difference of 56 mg kg^{-1} of phosphorus need to be added to the soil to bring it to the level of 60 mg kg^{-1}, which can be attained by adding 80 mg kg^{-1} of P with reference to the P sorption curve as per the methods and procedure described in a systematic approach to soil fertility evaluation for optimum nutrient requirement (Hunter, 1988). Potassium sorption characteristics revealed that the original soil sample contain 136 mg kg^{-1} of available potassium, which is less than 196 mg kg^{-1} of potassium received for optimum nutrient treatment. Therefore the difference of 60 mg kg^{-1} of potassium need to be added to the soil to arrive at optimum nutrient treatment of 196 mg kg^{-1} which can be attained by adding 125 mg kg^{-1} of K to the soil with reference to the K sorption curve.

Zinc sorption characteristics revealed that the original soil sample contained 3.3 mg kg^{-1} of available DTPA-Zn. The optimum Zn nutrient requirement was 6.0 mg kg^{-1} (Hunter, 1988). Therefore the difference of 2.7 mg kg^{-1} of Zn need to be added to the soil to arrive at optimum nutrient requirement of 6.0 mg kg^{-1} which cane be attained by adding 15.5 mg kg^{-1} of Zn with reference to the Zn sorption curve. Iron sorption characteristics revealed that the original soil sample contained 12 mg kg^{-1} of available DTPA Fe, which was less than 46 mg kg^{-1} of Fe required for optimum nutrient treatment. Therefore, the difference of 28 mg kg^{-1} of Fe need to be added to the soil to arrive at optimum nutrient requirement of 40 mg kg^{-1}, which can be attained by addition of Fe@ 36 mg kg^{-1}, with reference to iron sorption curve. The average amount of nitrogen @ 310 kg ha^{-1} required on yield of 111.69 kg ha^{-1} was reckoned as optimum nitrogen level in Palaviduthi soil series of Theni district. The sorption study revealed that the quantum of P, K, Zn and Fe required to be added to meet optimum nutrient requirement was 80 mg kg^{-1}, 125 mg kg^{-1}, 15.5 mg

kg^{-1} and 36 mg kg^{-1} respectively. Since N is universally limiting the crop yield, N was also included along with P, K, Zn and Fe at 100 mg N kg^{-1} level.

Table 2. Drymatter yield of sorghum CO- 27 on 30th day as influenced by different nutrient combinations in Greenhouse experiment

Treatment Number	Optimum Nutrient Treatment (ONT)	Dry matter yield (g / six plants)	Relative yield (per cent)
T_1	ONT	2.02	100
T_2	ONT- N	1.25	62
T_3	ONT- P	1.33	66
T_4	ONT-K	1.57	78
T_5	ONT- Zn	1.69	84
T_6	ONT- Fe	1.60	80
T_7	ONT + $CaCO_3$	1.94	96
T_8	ONT + Ca	2.08	103
T_9	ONT + Mg	2.11	104
T_{10}	ONT + S	1.89	94
T_{11}	ONT + Cu	1.92	95
T_{12}	ONT + Mn	2.14	106
T_{13}	ONT + B	1.88	91
T_{14}	ONT + Mo	2.10	104
T_{15}	Control	0.59	29
	SE_d	**0.065**	-
	CD (P = 0.05)	**0.13**	-

The dry matter yield of CO 27 sorghum was significantly influenced by optimum nutrient treatment (Table 2). The dry matter yield was significantly reduced in the treatments in which N, P, K, Zn and Fe were excluded from the ONT in Palaviduthi soil series with test crop of CO 27 sorghum. The yield reduction was 38 per cent when N was excluded and 34 per cent when P was excluded from the optimum nutrient treatment. The yield reductions were 22, 16 and 20 per cent respectively for K, Zn and Fe exclusion from the optimum nutrient treatment. The addition of other nutrients *viz.,* Ca, Mg, S, Cu, Mn, Mo, which were not part of ONT, did not significantly influenced the dry matter yield. Thus, the green house experiment confirmed that N, P, K, Zn and Fe were deficient nutrient in Palavidhuthi soil series. Similar results were also reported by Latha and Murugappan (1999) and Rahman *et al.* (1992).

The brix per cent of sugarcane juice was significantly influenced by various levels of NPK Zn and Fe and mean value ranged from 18.56 to 20.92 per cent at post harvest stage. The highest brix per cent was recorded in optimum nutrient treatment that received $N_2P_2K_2$ Zn and Fe each @ 310, 160, 250, 31 and 72 kg ha^{-1} whereas the lowest value was recorded in treatment that received $N_0P_2K_2$ Zn and Fe each @ 0, 160, 250, 31 and 72 kg ha^{-1} (Table 3).

The higher level of N application @ 387.5 kg ha^{-1} in the treatment combination of $N_3P_2K_2$ Zn and Fe recorded 20.76 per cent at post harvest stage, whereas the blanket fertilizer recommendation consisting of NPK Zn and Fe each @ 275, 65, 110, 37.5 and 100 kg ha^{-1} recorded 19.62 per cent at post harvest stage.

The mean pol per cent of sugarcane juice as influenced by various levels of fertilizer nutrients ranged from 18.88 to 16.22 per cent at harvest stage. The highest pol content in sugarcane juice was recorded in optimum nutrient treatment with $N_2P_2K_2$ Zn and Fe each @ 310, 160, 250, 31 and 72 kg ha^{-1} whereas the lowest value was recorded in treatment that received $N_0P_2K_2$ Zn and Fe each @ 0,160, 250, 31 and 72 kg ha^{-1} respectively. The results also revealed that the fertilizer optima which offered balanced plant nutrient supply to the sugarcane resulting higher pol percentage and synthesis of sucrose in sugarcane. The higher level of N application @ 387.5 kg ha^{-1} along with combination of $N_3P_2K_2$ Zn and Fe each @ 387.5, 160, 250, 31 and 72 kg ha^{-1} recorded 18.88 pol per cent at post harvest stage whereas, the blanket fertilizer recommendation consisting of NPK Zn and Fe each @ 275, 65, 110, 37.5 and 100 kg ha^{-1} recorded 17.53 at post harvest stage, respectively.

The purity per cent of sugarcane juice as influenced by different fertilizer nutrient treatment was found to be significant and the mean value of purity per cent of sugarcane juice ranged from 87.39 to 90.25 per cent at post harvest stage. The highest purity per cent of sugarcane juice was recorded in optimum nutrient treatment that received $N_2P_2K_2$ Zn and Fe each @ 310, 160, 250, 31 and 72 kg ha^{-1} whereas, the lowest value was recorded in treatment that received $N_0P_2K_2$ Zn and Fe each @ 0, 160, 250, 31 and 72 kg ha^{-1}. The higher level of N application @ 387.5 kg ha^{-1} in the combination of $N_3P_2K_2$ Zn and Fe each @ 387.5, 160, 250, 31 and 72 kg ha^{-1} recorded 90.03 per cent at post harvest stage whereas, the blanket fertilizer recommendation consisting of NPK Zn and Fe each @ 275, 65, 110, 37.5 and 100 kg ha^{-1} recorded 89.35 per cent at post harvest stage.

The highest CCS per cent of sugarcane juice was recorded in the optimum nutrient treatment that received $N_2P_2K_2$ Zn and Fe whereas the lowest value was recorded in treatment that received $N_0P_2K_2$ Zn and Fe each @ 0, 160, 250, 31 and 72 kg ha^{-1} respectively. The results revealed that balanced supply of plant nutrient element *viz.,* nitrogen @ 310 kg ha^{-1} in the optimum nutrient treatment combination with $N_2P_2K_2$ Zn and Fe effected the highest commercial sugar percentage as compared to no N addition. The higher level of N application @

387.5 kg ha^{-1} in the combination of $N_3P_2K_2$ Zn and Fe recorded 13.40 per cent of CCS whereas the blanket fertilizer recommendation consisting of NPK Zn and Fe each @ 275, 65, 110, 37.5 and 100 kg ha^{-1} recorded 12.52 per cent of CCS at post harvest stage. The highest cane yield of sugarcane was recorded in treatment that received $N_3P_2K_2$ Zn and Fe each at the rate of 387.5, 160, 250, 31 and 72 kg ha^{-1} whereas, the lowest yield was recorded in treatment that received $N_0P_2K_2$ Zn and Fe each @ 0, 160, 250, 31 and 71 kg ha^{-1}, respectively.

Table 3. Quality parameters of Sugarcane CO 86032 as influenced by various levels of fertilizer nutrient at harvest stage

Treatment Number	Treatment	Brix corrected (per cent)	Pol (per cent)	Purity (per cent)	CCS (per cent)
T_1	$N_0 P_2 K_2$ ZnFe	18.56	16.22	87.39	11.46
T_2	$N_1 P_2 K_2$ ZnFe	19.78	17.69	89.43	12.64
T_3	$N_2 P_2 K_2$ ZnFe	20.92	18.88	90.25	13.55
T_4	$N_3 P_2 K_2$ ZnFe	20.76	18.69	90.03	13.40
T_5	$N_2 P_0 K_2$ ZnFe	20.34	18.25	89.72	13.06
T_6	$N_2 P_1 K_2$ ZnFe	20.52	18.46	89.96	13.23
T_7	$N_2 P_3 K_2$ ZnFe	20.85	18.81	90.22	13.50
T_8	$N_2 P_2 K_0$ ZnFe	20.42	18.83	89.77	13.12
T_9	$N_2 P_2 K_1$ ZnFe	20.47	18.39	89.84	13.16
T_{10}	$N_2 P_2 K_3$ ZnFe	20.81	18.76	90.15	13.46
T_{11}	$N_2 P_2 K_2$ Fe - Zn	19.96	17.88	89.58	12.79
T_{12}	$N_2 P_2 K_2$ Zn - Fe	19.89	17.80	89.49	12.72
T_{13}	Blanket	19.62	17.53	89.35	12.52
	SEd	0.0134	0.0946	0.0190	0.0063
	CD(0.05)	0.0277	0.1953	0.0392	0.0129

The results revealed that the treatment combinations consisting of higher dose N @ 387.5 kg ha^{-1} in combination of $N_3P_2K_2$ Zn and Fe each arrived on the basis of sorption studies recorded (138.12 t ha^{-1}) higher cane yield whereas the lowest cane yield was recorded (85.59 t ha^{-1}) in treatment that received no nitrogen along with P_2K_2 Zn and Fe each at the level arrived on the basis of sorption characteristics of soil. The yield of sugarcane totally depend on vegetable growth and the increase in yield could be attributed to more cane yield in much aged crop as revealed by Durai *et al.* (1989) and Daniel (1984). Natarajan (1998) reported that higher level of N application @ 375 kg ha^{-1} recorded higher cane yield over recommended level (275 kg ha^{-1}). The present study also revealed that higher level of N application @ 375 kg ha^{-1} recorded (138.12 t ha^{-1}) higher cane yield over the blanket recommended level (275 kg ha^{-1}) (Table 4). These results confirm the findings of long term experiments conducted with different crop sequences at various locations in India (Singh *et al*,2008). The sugar yield of sugarcane CO 86032 as influenced by various levels of fertilizer nutrients in Palaviduthi soil series was found to be significant and mean value ranged from 9.81 to 18.5 t ha^{-1}. The highest sugar yield was recorded in treatment that received $N_3P_2K_2$ Zn and Fe each @ 387.5, 160, 250, 31 and 72 kg ha^{-1} recording an increase in 8.82 per cent of sugar yield as compared to optimum nutrient treatment (17.01 t ha^{-1}) whereas, lower value was recorded in treatment that received $N_0P_2K_2$ Zn and Fe each @ 0, 160, 250, 31 and 72 kg ha^{-1}, respectively. Similar results were recorded by Sharma *et.al* 2002.

The results revealed that the response of sugarcane CO 86032 was found to be the highest in brix, pol, purity and CCS per cent were recorded in the optimum nutrient treatment in the combination of $N_2P_2K_2$ Zn and Fe each @ 310, 160, 250, 31 and 72 kg ha^{-1} recording a mean value of 20.92, 18.88, 90.25 and 13.55 per cent at harvest stage. The results revealed that the optimum dose of N @ 310 kg ha^{-1} in the treatment combination of $N_2P_2K_2$ Zn and Fe has improved the quality of sugarcane. The

results revealed that the highest sugarcane yield was recorded in the treatment combination of $N_3P_2K_2$ Zn and Fe (138.12 t ha^{-1}) each @ 387.5, 160, 250, 31 and 72 kg ha^{-1} whereas, the optimum nutrient treatment involving $N_2P_2K_2$ Zn and Fe each @ 310, 160, 250, 31 and 72 kg ha^{-1} recorded 125.52 t ha^{-1}.

Table 4. Yield parameters of Sugarcane CO 86032 influenced by various levels of fertilizer nutrients

Treatment Number	Treatment	Cane yield (t ha^{-1})	Sugar yield (t ha^{-1})
T_1	N_0 P_2 K_2 ZnFe	85.59	9.81
T_2	N_1 P_2 K_2 ZnFe	94.47	11.94
T_3	N_2 P_2 K_2 ZnFe	125.52	17.01
T_4	N_3 P_2 K_2 ZnFe	138.12	18.51
T_5	N_2 P_0 K_2 ZnFe	87.58	11.44
T_6	N_2 P_1 K_2 ZnFe	106.66	14.11
T_7	N_2 P_3 K_2 ZnFe	110.80	14.96
T_8	N_2 P_2 K_0 ZnFe	90.78	11.91
T_9	N_2 P_2 K_1 ZnFe	106.59	14.03
T_{10}	N_2 P_2 K_3 ZnFe	118.77	15.99
T_{11}	N_2 P_2 K_2 Fe - Zn	104.22	13.33
T_{12}	N_2 P_2 K_2 Zn - Fe	101.21	12.87
T_{13}	Blanket	100.43	12.57
	SEd	1.229	0.0070
	CD(0.05)	2.536	0.0144

The blanket recommendation consisting of NPK Zn and Fe each @ 275, 65, 110, 37.5 and 100 kg ha^{-1} recorded 100.48 t ha^{-1} whereas, the lower yield of 85.59 t ha^{-1} was recorded (85.59 t ha^{-1}) in treatment combination of $N_0P_2K_2$Zn and Fe each @ 0, 160, 250, 31 and 72 kg ha^{-1}, respectively. The highest sugar yield (18.51 t ha^{-1}) was recorded in the treatment combination of $N_3P_2K_2$ Zn and Fe as compared to the optimum nutrient treatment in the combination of $N_2P_2K_2$ Zn and Fe 17.01 t ha^{-1} whereas, the blanket fertilizer recommendation consisting of NPK, Zn and Fe recorded 12.57 t ha^{-1}. The results of the salient findings revealed that the optimum nutrient treatment in the combination of $N_2P_2K_2$ Zn and Fe recorded the maximum economic yield of sugarcane in Palaviduthi soil series of Theni district whereas, the maximum yield was attained in higher level of N application @ 387.5 kg ha^{-1} in the combination of $N_3P_2K_2$ Zn and Fe each @ 387.5, 160, 250, 31 and 72 kg ha^{-1}, respectively.

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