International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 643-646

Received: 19-07-2018
Accepted: 23-08-2018

Sivaranjani C
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

KM Sellamuthu
Assistant Professor, Agricultural Research Station, Bhavanisagar, Tamil Nadu, India

Correspondence
Sivaranjani C
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Impact of graded levels of fertilisers on soil available nutrients in inceptisol by hybrid maize (CO6)

Sivaranjani C and KM Sellamuthu

Abstract
A field experiment was conducted to evaluate graded levels of fertilizers on soil available nutrients and grain and straw yield of hybrid maize on Inceptisol. The experimental soil was sandy clay loam with alkaline pH and non-saline in nature. The soil was low in organic carbon and available N, medium in available P and high in available K. The available Zn, Cu, Fe, and Mn were in sufficient status. Among the STCR - IPNS treatments, the highest and significant grain yield of 12032 kg ha^{-1} was recorded in STCR - IPNS-200% of FD for 5 t ha^{-1} + FYM @ 12.5 t ha^{-1} (T10) followed by STCR - IPNS - 175% of FD for 5 t ha^{-1} + FYM @ 12.5 t ha^{-1} (T9) (11393 kg ha^{-1}). $KMnO_4$ N status ranged from 162 to 166 kg ha^{-1} at 30 DAS, 156 to 166 kg ha^{-1} at 60 DAS, 147 to 158 kg ha^{-1} at 90 DAS, 142 to 152 kg ha^{-1} at harvest stage of maize. Olsen- P values ranged from 13.2 to 17.6 kg ha^{-1} at 30 DAS, 12.7 to 17.1 kg ha^{-1} at 60 DAS, 11.8 to 15.8 kg ha^{-1} at 90 DAS and 11.4 to 13.6 kg ha^{-1} at harvest stage. NH_4OAc-K ranged from 422 to 432 kg ha^{-1} at 30 DAS, 410 to 426 kg ha^{-1} at 60 DAS, 403 to 417 kg ha^{-1} at 90 DAS and 396 to 410 kg ha^{-1} at harvest stage.

Keywords: STCR- IPNS, maize, nitrogen, phosphrous, potassium, grain and straw yield

Introduction
Maize, the queen of cereals, occupies a pride place among the cereal crops in India. Maize also has higher genetic yield potential than any other cereal crops. It has emerged as third most important food crop after rice and wheat. It is one of the most important cereals grown over diverse environment and geographical ranges for human food, fodder for livestock and raw materials for industries. Achieving high maize yield requires adequate and balanced supply of plant nutrients (Barbieri *et al*., 2008) + as declining soil fertility is a prominent constraint for maize production (Okoko and Makworo, 2012) [5]. So, that integrated use of organic manure and chemical fertilizers is beneficial in improving crop yield and uptake by maize hybrid.

Materials and Methods
The experiment was conducted during *Rabi* season in Allapalayam village, Annur block, Coimbatore District, Western Zone of Tamil Nadu, Southern India during in the year 2015 to 2016. The experimental soil was Periyanaickenpalayam soil series -*Vertic Ustropept*) (mixed black calcareous soil). The Maize Hybrid TNAU CO 6 was sown in experimental plot having thirteen treatments with three replications. The experiment was laid out in Randmozied block design with the treatments are T_1-STCR-NPK alone- 100% of FD for 5 t ha^{-1}, T_2-STCR-NPK alone- 125% of FD for 5 t ha^{-1}, T_3-STCR-NPK alone- 150% of FD for 5 t ha^{-1}, T_4-STCR-NPK alone- 175% of FD for 5 t ha^{-1}, T_5-STCR-NPK alone- 200% of FD for 5 t ha^{-1}, T_6-STCR-IPNS - 100% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}, T_7-STCR-IPNS - 125% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}, T_8-STCR-IPNS - 150% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1},T_9 -STCR-IPNS - 175% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}, T_{10}-STCR-IPNS - 200% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}, T_{11}-FYM @ 6.25 t ha^{-1} alone, T_{12}-FYM @ 12.5 t ha^{-1} alone, T_{13}-Absolute control.

Analysis of soil samples
The initial composite soil sample collected before raising the maize crop was analysed for various physical, physico-chemical and chemical properties. The soil samples collected at critical stages of crop growth were analysed for available N (Subbiah and Asija, 1956) [10], (P Olsen *et al.* 1954) [6] and (K Stanford and English, 1949) [9] status.

Result and Discussion

Characteristics of the initial surface soil

The present investigation was carried out on Periyanaickenpalayam soil series, taxonomically Vertic Ustropept which is mixed black calcareous soil in the Western Zone of Tamil Nadu. The soil is sandy clay loam in texture with a bulk density, particle density and porosity of 1.05 Mg m-3, 2.22 Mg m-3 and 52.70 per cent.

The experimental soil was moderately alkaline in reaction (pH of 8.10), non-saline (EC 0.13 dS m^{-1}) with CEC of 32.60 c mol (p^{+}) kg^{-1}. The soil was low in organic carbon (5.25 g kg^{-1}) and available N (162 kg ha^{-1}), medium in available P (16.5 kg ha^{-1}) and high in available K (430 kg ha^{-1}). The available Zn, Cu, Fe, and Mn were in sufficient status (2.19, 2.27, 8.52 and 4.38 mg kg^{-1}, respectively).

Grain and stover yield

Native soil fertility, commercial fertilisers and manures are necessary to maintain global crop productivity of maize. Maize is an exhaustive crop and removes large amounts of plant nutrients and its yield with complementary alliance of inorganic and organic manures treatment in the present study is comparable. The highest mean grain weight (12032 Kg ha^{-1}) (Table 4) was recorded in the plot treated 200% STCR NPK recommended feriliser dose along with 5 t ha^{-1} of FYM. Among the treatments, STCR-IPNS – 200% FD for 5 t ha^{-1} + FYM @ 12.5 t ha^{-1} (T10) recorded significantly higher grain yield. Similar results were also recorded by Endris and David (2015) [2]. Synthetic fertilizers with organic matter recommendation could be helpful for enhancing stagnant wheat grain yield was reported by Tahir *et al.* (2011) [12]. The lowest (5313 Kg ha^{-1}) was recorded in absolute control plot (Table 4.).

Grain yield is determined by the total dry matter production of maize which will reflect the transport of nutrient from the source to sink. The highest and significant stover yield of 13125 kg ha^{-1} was recorded in STCR-IPNS-200% of FD for 5 t ha^{-1} + FYM @ 12.5 t ha^{-1} (T10) (Table 4). Increase in stover yield with balanced nutrition with organic and inorganic treatments could partly be attributed to its direct influence on dry matter production of each vegetative part and indirectly through increased morphological parameters of growth (Kadlag and Godke, 2013) [3].

Available N, P and K status

Available N status showed a progressive reduction from 30 DAS to harvest stage of the crop. At 60 DAS, 125% STCR-NPK alone for 5 t ha^{-1} (T_2) recorded the higher available nitrogen (162, kg ha^{-1}) followed by 100% STCR-NPK alone for 5 t ha^{-1} (T_1) and found to be on par with each other. At 90 DAS and at harvest stages, 100% STCR-NPK alone for 5 t ha^{-1} (T_1) recorded higher available nitrogen (156 kg ha^{-1}) and it was followed by 125% STCR-NPK alone for 5 t ha^{-1} (T_2) (153 kg ha^{-1}) (Table 1), respectively. Among the treatments, STCR-IPNS 100% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1} (T_6) recorded higher available nitrogen during the growth stages of the crop. Irrespective of the stages of crop growth STCR-IPNS treatments found to record higher available N in soil. Absolute control recorded the lowest available N in all the stages. Enhanced available N content in soil due to the application of FYM have been reported by Singh *et al.* (2015) [8]. Higher biomass production and predominance of cereal crops will return lot of roots and stubbles to the soil that leads to the accumulation of slightly higher amounts of N as hydrolysable and non-hydrolysable N in INM treatments (Shilpa shree *et al*., 2013) [7].

Maize is also a demanding crop for P and is quite sensitive to low P availability, especially in the early growth stages. Among the treatments, STCR-IPNS treatments recorded higher available P when compared to STCR-NPK alone treatments or FYM treatments. STCR-IPNS-200% of FD for 5 t ha^{-1} + FYM @ 12.5 t ha^{-1} (T10) (Table 2) recorded higher available phosphorus upto maturity stage of maize. Harvest stage recorded lower values of available P when compared to initial soil test values due to the uptake of maize. Similar findings were reported by Kalhapure *et al.* (2014) [4]. Hence, application of P fertilisers along with FYM can sustain the soil fertility over the period and the residual and cumulative effect of FYM can enhance the productivity of subsequent crop (Swarup, 2010) [11].

Potassium is involved in number of physiological process, protein synthesis and activation of enzymes. Potassium is a major inorganic solute, it plays a key role in the water balance of plants. STCR-IPNS 100% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1} (T_6) recorded the highest available potassium at 60 DAS, 90 DAS and harvest followed by STCR-IPNS 125% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1} (T_7) (Table 3) and found on par with each other. With the advancement of crop growth, available K found to be reduced in all the treatments, due to higher yield and removal of K. Decline in available K due to exclusion of K and maximum mining of the native reserves due to nutrient imbalance in soil was reported by Verma *et al*. (2012) [13].

Table 1: Effect of varying fertiliser doses of NPK and IPNS on available N (kg ha^{-1}) at different growth stages of maize

Treatments		30 DAS	60 DAS	90 DAS	Harvest
T_1	STCR-NPK alone- 100% of FD for 5 t ha^{-1}	163	160	156	150
T_2	STCR-NPK alone-125% of FD for 5 t ha^{-1}	163	162	153	147
T_3	STCR-NPK alone-150% of FD for 5 t ha^{-1}	162	158	151	146
T_4	STCR-NPK alone -175% of FD for 5 t ha^{-1}	163	158	150	145
T_5	STCR-NPK alone- 200% of FD for 5 t ha^{-1}	163	157	148	145
T_6	STCR-IPNS - 100% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	166	165	158	152
T_7	STCR-IPNS -125% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	166	166	155	148
T_8	STCR-IPNS -150% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	165	163	152	148
T_9	STCR-IPNS -175% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	166	162	150	147
T_{10}	STCR-IPNS -200% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	165	159	148	146
T_{11}	FYM @ 6.25 t ha^{-1} alone	163	158	152	148
T_{12}	FYM @ 12.5 t ha^{-1} alone	164	161	147	145
T_{13}	Absolute Control.	162	156	147	142
Mean		164	160	151	146
SEd		1.2	1.2	1.1	1.1
CD (P=0.05)		2.5	2.4	2.3	2.2

Table 2: Effect of varying fertiliser doses of NPK and IPNS on available P (kg ha^{-1}) at different growth stages of maize

Treatments		30 DAS	60 DAS	90 DAS	Harvest
T_1	STCR-NPK alone- 100% of FD for 5 t ha^{-1}	15.1	14.2	13.4	13.1
T_2	STCR-NPK alone-125% of FD for 5 t ha^{-1}	15.6	14.6	13.6	12.7
T_3	STCR-NPK alone-150% of FD for 5 t ha^{-1}	15.9	15.0	13.6	12.5
T_4	STCR-NPK alone -175% of FD for 5 t ha^{-1}	16.4	15.5	14.0	12.5
T_5	STCR-NPK alone- 200% of FD for 5 t ha^{-1}	16.6	16.0	14.0	12.2
T_6	STCR-IPNS - 100% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	15.6	15.0	13.9	13.6
T_7	STCR-IPNS -125% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	16.2	15.6	13.7	13.6
T_8	STCR-IPNS -150% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	16.8	16.2	15.1	13.5
T_9	STCR-IPNS -175% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	17.0	16.6	15.2	13.5
T_{10}	STCR-IPNS -200% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	17.6	17.1	15.8	13.4
T_{11}	FYM @ 6.25 t ha^{-1} alone	14.2	13.8	13.2	12.8
T_{12}	FYM @ 12.5 t ha^{-1} alone	14.8	13.5	12.8	12.2
T_{13}	Absolute Control.	13.2	12.7	11.8	11.4
	Mean	15.8	15.0	13.8	12.9
SEd		0.82	0.81	0.68	0.62
CD (P=0.05)		1.70	1.67	1.41	1.29

Table 3: Effect of varying fertiliser doses of NPK and IPNS on available K (kg ha^{-1}) at different growth stages of maize

Treatments		30 DAS	60 DAS	90 DAS	Harvest
T_1	STCR-NPK alone- 100% of FD for 5 t ha^{-1}	428	420	413	406
T_2	STCR-NPK alone-125% of FD for 5 t ha^{-1}	430	417	409	403
T_3	STCR-NPK alone-150% of FD for 5 t ha^{-1}	427	414	406	400
T_4	STCR-NPK alone -175% of FD for 5 t ha^{-1}	426	413	404	397
T_5	STCR-NPK alone- 200% of FD for 5 t ha^{-1}	423	412	403	396
T_6	STCR-IPNS - 100% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	432	426	417	410
T_7	STCR-IPNS -125% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	432	424	414	406
T_8	STCR-IPNS -150% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	429	423	411	403
T_9	STCR-IPNS -175% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	427	421	408	400
T_{10}	STCR-IPNS -200% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	426	419	406	400
T_{11}	FYM @ 6.25 t ha^{-1} alone	422	415	410	401
T_{12}	FYM @ 12.5 t ha^{-1} alone	429	417	407	399
T_{13}	Absolute Control.	422	410	403	396
Mean		427	418	409	401
SEd		3.6	3.1	3.0	2.9
CD (P=0.05)		7.3	6.3	6.2	6.1

Table 4: Effect of varying fertiliser doses of NPK and IPNS on yield (kg ha^{-1}) of maize

Treatments		Grain yield	Stover yield
T_1	STCR-NPK alone- 100% of FD for 5 t ha^{-1}	8148	9030
T_2	STCR-NPK alone-125% of FD for 5 t ha^{-1}	8704	10137
T_3	STCR-NPK alone-150% of FD for 5 t ha^{-1}	9683	10713
T_4	STCR-NPK alone -175% of FD for 5 t ha^{-1}	10278	11040
T_5	STCR-NPK alone- 200% of FD for 5 t ha^{-1}	10486	11144
T_6	STCR-IPNS - 100% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	9245	10381
T_7	STCR-IPNS -125% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	10203	11377
T_8	STCR-IPNS -150% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	10992	12317
T_9	STCR-IPNS -175% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	11393	12705
T_{10}	STCR-IPNS -200% of FD for 5 t ha^{-1}+ FYM @ 12.5 t ha^{-1}	12032	13125
T_{11}	FYM @ 6.25 t ha^{-1} alone	6234	7193
T_{12}	FYM @ 12.5 t ha^{-1} alone	6625	7525
T_{13}	Absolute Control.	5313	6507
Mean		9180	10245
SEd		174.40	93.57
CD (P=0.05)		359.95	193.13

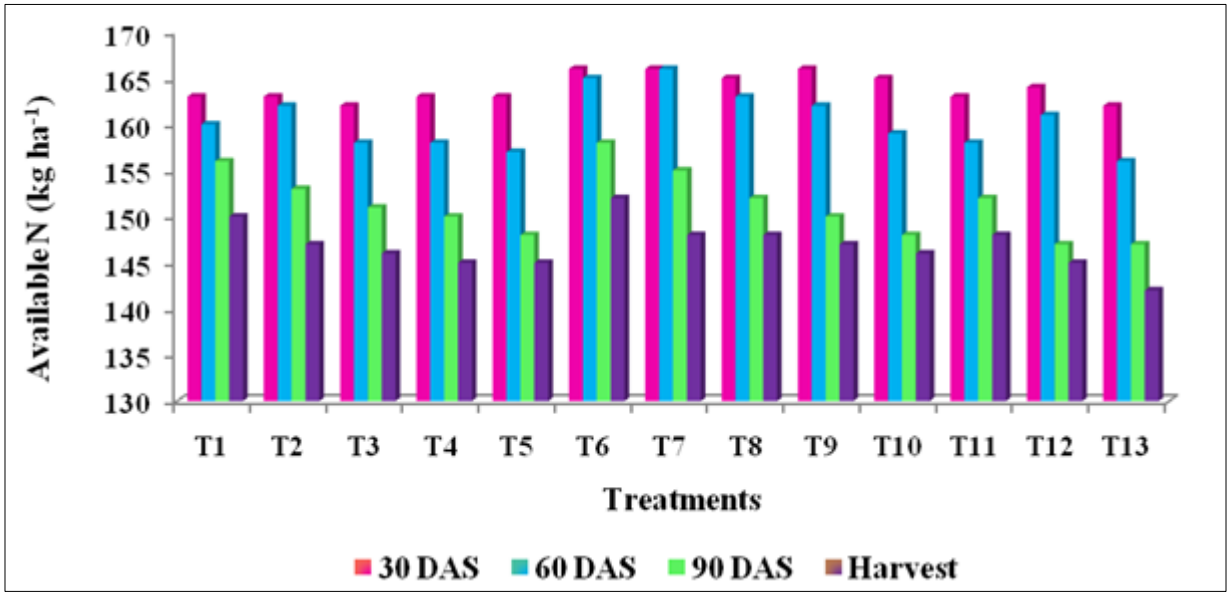

Fig 1: Effect of varying fertiliser doses of NPK and IPNS on available N (kg ha^{-1}) at different growth stages of maize

Conclusion

It was evident from the present study, using the STCR - IPNS Fertiliser Prescription Equations, optimum fertiliser dose for mixed black calcareous soils (Vertic Ustropept) of Tamil Nadu for achieving higher yield target with sustained soil health.

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