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INTEGRATED NUTRIENT MANAGEMENT (INM) FOR HYBRID MAIZE GROWN IN CALCAREOUS SOIL

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ABSTRACT

Field experiments were conducted at Research Farm of Tamil Nadu Agricultural University, Coimbatore, India for a period of three years (2007-2009) to find out the effect of integrated nutrient management on productivity of hybrid maize. Conjunctive use of 100% NPK + 5 t ha^{-1} poultry manure recorded significantly highest grain and stover yields. Integration of 100% NPK with FYM and micronutrients *viz.*, zinc and iron recorded higher yield than the treatment that received 100% NPK + poultry manure + $ZnSO_4$ + $FeSO_4$. The lowest yield of 5637 kg ha^{-1} was recorded in the treatment that received 100% NPK. The uptake of macronutrients by hybrid maize increased with increase in NPK levels. The organic carbon, available N and K status of soil improved due to the application of 100% NPK + 5 t ha^{-1} poultry manure while the available P status was increased with 75% NPK + 5 t ha^{-1} poultry manure. The highest benefit : cost ratio (2.52) was obtained with the application of 100% NPK + FYM + $ZnSO_4$ + $FeSO_4$.

Keywords: Integrated nutrient management (INM), NPK, Micronutrient, Organic manures, Maize, Calcareous soil.

INTRODUCTION

Integrated use of organics and inorganics improve the soil and crop productivity. The continuous use of micronutrient free high analysis NPK fertilizers in the intensive cropping system with reduced use of organic manures have resulted in the depletion of soil micronutrients (Singh 2007). Application of chemical fertilizers even in balanced amount does not sustain the soil health under continuous cropping where as inclusion of organic manures regulates the removal of nutrients, improve the physico-chemical properties of soil (Satish Chander and Tripathi, 2006).

Maize (*Zea mays* L.) is a nutrient exhaustive crop and hybrids varied in nutrient uptake indicating their nutrient use efficiency due to higher biomass production. Moreover, continuous cropping of hybrid maize might lead to the rapid depletion of mineral nutrients from soil unless appropriate nutrient inputs are supplied. Crop response to nutrition depends on balanced use of fertilizers. The decline in soil fertility due to imbalanced fertilizer use has been recognized as one of the most important factors limiting crop yields (Nambiar and Abrol, 1989). Hence, the present investigation was carried out to study the effect of integrated nutrient management (INM) on yield and nutrient uptake by hybrid maize in a calcareous soil.

MATERIALS AND METHODS

Field experiments were carried out at the Research Farm of Tamil Nadu Agricultural University, Coimbatore (11° 0′ N, 77° 0′ E) in winter seasons (October - December) for a period of three years (2007-2009) using hybrid maize (COH (M) 4) as test crop. The mean maximum and minimum temperature of this area varies between 35°C to 18°C with an average rainfall of 700 mm. The initial soil sample from the experimental plot was analyzed for soil texture, bulk density, particle density, electrical conductivity and cation exchange capacity following standard procedures (Jackson, 1973). The soil of the experimental field was well drained, sandy clay loam, alkaline in reaction (pH 8.17), EC (0.54 dS m^{-1}), organic carbon (7.70 g kg^{-1} soil), Bulk density (1.25 Mg m^{-3}), available nitrogen 182 kg ha^{-1}, available phosphorus 21.5 kg ha^{-1} and available potassium 650 kg ha^{-1} (Table 1). Ten treatments consisted of two levels of NPK (75% and 100%) in combination with farmyard manure, poultry manure; zinc and iron were laid out in randomized block design with three replications as follows:

T_1 : 100% NPK
T_2 : 100% NPK + $ZnSO_4$ + $FeSO_4$
T_3 : 100% NPK + 12.5 t ha^{-1} FYM
T_4 : 100% NPK + 12.5 t ha^{-1} FYM + $ZnSO_4$ + $FeSO_4$
T_5 : 100% NPK + 5 t ha^{-1} poultry manure
T_6 : 100% NPK + 5 t ha^{-1} poultry manure + $ZnSO_4$ + $FeSO_4$
T_7 : 75% NPK + 12.5 t ha^{-1} FYM
T_8 : 75% NPK + 12.5 t ha^{-1} FYM + $ZnSO_4$ + $FeSO_4$
T_9 : 75% NPK + 5 t ha^{-1} poultry manure
T_{10} : 75% NPK + 5 t ha^{-1} poultry manure + $ZnSO_4$ + $FeSO_4$

Table 1: Initial Soil characteristics of the experimental plot

Parameters		Value
Soil texture		Sandy clay loam
Soil taxonomy		Vertic Ustropept
Bulk density	(Mg M^{-3})	1.25
Particle density	(Mg M^{-3})	1.43
Pore space	(%)	40.0
pH*		8.17
Electrical conductivity**	(dS m^{-1})	0.54
Cation exchange capacity	(cmol (p^+) kg^{-1})	22.5
Available N	(kg ha^{-1})	182
Available P	(kg ha^{-1})	21.5
Available K	(kg ha^{-1})	650
Organic carbon	(g kg^{-1})	7.70
$CaCO_3$	(%)	10.0

* pH was determined in 1:2 soil-water suspension.
** EC was determined in 1:2 soil-water extract.

The N content in the manure samples was determined by micro kjeldahl method. Total P and K contents were extracted by digestion with diacid (H_2SO_4:$HClO_4$, 5:2), the available P was estimated colorimetrically as vanado-molybophosphate yellow colour complex and available K was determined by flame photometer. Micronutrients in the diacid extract was analyzed (Table 2) by Atomic Absorption Spectrophotometer (Jackson, 1973). Nitrogen, phosphorus, potassium, Zn and Fe were applied in the form of urea, single super phosphate, muriate of potash, zinc sulphate and ferrous sulphate at 250, 75, 75, 25 and 50 kg ha^{-1}, respectively as per the blanket recommendation of Department of Agriculture, Government of Tamil Nadu. Organic manures were applied as basal dressing. The whole amount of phosphorus, potassium, Zn, Fe and half quantity of N were applied as per treatment schedule at the time of sowing as basal and rest half of N was applied at the tasselling stage. Surface irrigation was given and other intercultural operations were carried out as given in Crop Production Guide (2005). At harvest stage, the grain and stover yield were recorded and samples were taken for N, P and K analysis (Piper, 1942). Also, the nutrient uptake by grain and stover were estimated. The post harvest soil samples were analyzed for soil pH, electrical conductivity (Richards, 1954), organic carbon (Walkley and Black, 1934), available N (Subbiah and Asija, 1956), available P (Olsen *et al.*, 1954), available K (Stanford and English, 1949) and DTPA extractable Zn and Fe (Lindsay and Norvell, 1978).

Table 2: Nutrient content of the organic manures used for the study.

Parameters		Farmyard manure	Poultry manure
Total N	(%)	0.14	1.96
Total P	(%)	0.19	0.29
Total K	(%)	0.10	0.10
Total Fe	(mg kg^{-1})	20.5	629
Total Zn	(mg kg^{-1})	23.2	58.0
Total Mn	(mg kg^{-1})	7.70	40.4
Total Cu	(mg kg^{-1})	12.9	22.7
Organic Carbon	(%)	6.60	12.3
C:N ratio		47:1	6:3

RESULTS AND DISCUSSION

a. Gain and stover yields of hybrid maize

The pooled data of three years trials presented in Table 3, revealed that the application of 100% NPK + 5 t ha^{-1} poultry manure recorded significantly highest grain and stover yields. This could be due to the balanced nutrition of crops supplied through inorganic fertilizers and poultry manure. Maize being nutrient exhaustive crop responds well to the balanced fertilization. The beneficial effect of poultry manure would be due to adequate nutrient supply during the decomposition of organic manure, enhanced mobilization of nutrients from the soil and soil microbial activities through the production of organic acids and improved soil physical conditions consequently led to the increased crop productivity. Similar results were also observed by Singh and Pathak (2003), Datt *et al.*, (2003) and Jaggi (2007). It could also be attributed to the fact that, after decomposition and mineralization, the manures supplied available nutrients directly to plants and also had solubilizing effect on fixed form of nutrients (Sinha *et al.*,1981).

Table 3: Grain and stover yields of hybrid maize.

Treatments	Yield* (kg ha^{-1})		B:C ratio
	Grain	Stover	
T_1	5637	8347	1.17
T_2	6283	9337	2.14
T_3	5784	8638	2.39
T_4	6679	9996	2.52
T_5	6985	10431	1.38
T_6	6281	9158	2.12
T_7	6506	9585	2.05
T_8	6325	9390	2.34
T_9	5749	8584	1.99
T_{10}	6223	9207	2.11
SEd	166	236	-
CD (P = 0.05)	350	497	-

*** Pooled mean of three years.**

The increase in grain yield treatment T_5 was on par with the yield obtained in treatment T_4. The integration of 100% NPK with FYM and micronutrients resulted in increase in grain yield. The experimental soil was calcareous and hence the yield response to the micronutrient fertilization was also observed. Stover yield also followed the same trend.

The lowest yield of 5637 kg ha^{-1} was recorded in the treatment that received 100% NPK. Integration of 100% NPK with FYM and micronutrients *viz.*, Zn and Fe recorded higher yield than the treatment T_6. This could be due to the presence of $CaCO_3$ content (10%) of poultry manure which neutralizes the organic acids produced during decomposition thereby limiting the availability of organic acids for dissolution of micronutrients (Mahimairaja *et al.*, 1995 and Kaleeswari, 2009). Hence the yield response to micronutrients when applied with FYM was greater.

b. Benefit : cost ratio

For economic analysis, the benefit cost ratio (B:C) was calculated by dividing the gross income by total expenditure (Rs. ha^{-1}). The highest B:C ratio was recorded in the treatment T_4 (2.52) followed by 100% NPK + FYM (2.39). Though poultry manure application increased the grain and stover yields, due to the high cost of poultry manure as compared with FYM, B:C ratios were lower in the poultry manure treated plots (Table 3).

c. Nutrient uptake

The pooled data pertaining to N, P and K uptake by grain and stover revealed that nutrient uptake in the treatments T_5 and T_4 were on par. This could be due to the increase of nutrient availability as well as higher dry matter production. The nutrients uptake was increased with increased of NPK levels (Fig. 1 & 2). These results are in concurrence with those reported by Adeli and Varco (2002) and Pervez *et al.*, (2004) in cotton.

d. Changes in soil nutrient status

The electrical conductivity and pH were the highest in the treatment T_{10}. This increase might be attributed to the addition of salts through application of increased doses of inorganics. These results are in accordance with the findings of Santhy *et al.*, (1999). The highest organic carbon content was recorded in the treatment that received T_5. The increase in organic carbon content may be attributed to addition of organic materials and better root growth. These observations are in agreement with the findings of Sharma *et al.*, (2005). The organic carbon contents were lower in the treatment that received only inorganic fertilizers. This could be due to the low organic carbon status of the experimental soil (Table 4).

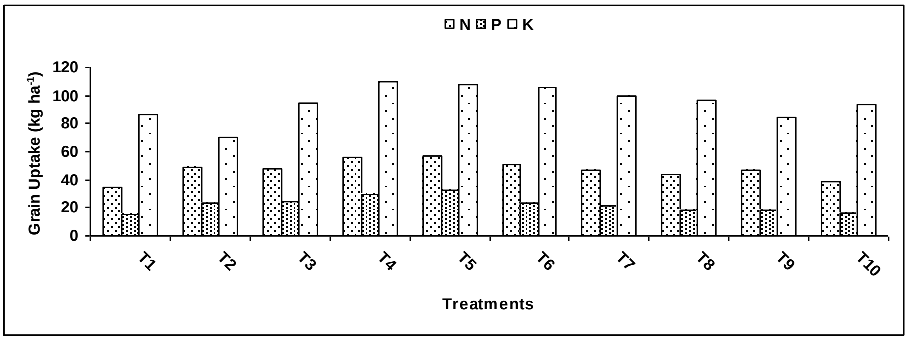

Fig. 1. Uptake of N, P and K by grain yield of hybrid maize.

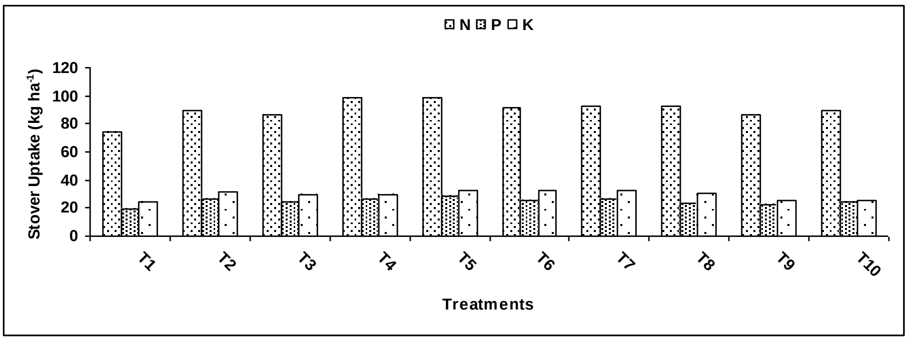

Fig. 2. Uptake of N, P and K by stover yield of hybrid maize.

Table 4: Changes in pH, EC and organic carbon of the post harvest soil.

Treatments	pH*	EC (dS m^{-1})*	Organic carbon (%)*
T_1	7.82	0.54	0.51
T_2	7.81	0.78	0.57
T_3	7.86	0.70	0.79
T_4	8.06	0.25	0.69
T_5	8.02	0.66	1.30
T_6	8.08	0.53	1.01
T_7	7.90	0.81	0.95
T_8	7.98	0.63	1.00
T_9	7.90	0.73	1.28
T_{10}	8.13	1.16	1.00
SEd	0.26	0.03	0.03
CD (P = 0.05)	0.53	0.05	0.07

* Pooled mean of three years.

The available N content was the highest in treatment T_9, due to the application of 100% NPK + 5 t ha^{-1} poultry manure followed by T_5. This could be due to the addition of N from both inorganic fertilizer and poultry manure which supplied excess N as compared to FYM (Table 5). These findings are in accordance with the findings of Yadav *et al.*, (2010).

Highest available P was recorded in the treatment T_9, which was on par with the treatment T_{10}. The increase in available P content of soil due to the incorporation of organic manures may be attributed to the direct addition of P as well as solubilization of native P through release of various organic acids. Similar improvement in available P status due to the integrated use of manures and fertilizers has been reported by Sharma *et al.*, (2009).

Table 5: Soil nutrient status of the post harvest soil (kg ha^{-1}).

Treatments	N*	P*	K*
T_1	378	41.6	327
T_2	378	37.3	310
T_3	401	59.6	348
T_4	350	39.6	341
T_5	425	42.3	385
T_6	359	40.0	380
T_7	341	66.7	326
T_8	280	70.0	320
T_9	406	79.7	335
T_{10}	350	76.3	294
SEd	4.42	1.75	3.60
CD (P = 0.05)	9.16	3.64	7.48

* Pooled mean of three years.

The available K was the highest in the treatment T_5, which was found to be on a par with T_6. The soil nutrient status was enhanced with the poultry manure application since the nutrient contents of this manure were higher. This beneficial effect of organic manure on available K status was reported by Kumawat and Kumawat (2010).

SUMMERY AND CONCLUSION

The integrated use of organic manures *viz.*, FYM and poultry manure along with chemical fertilizers increased the yield of hybrid maize and uptake of NPK over sole use of chemical fertilizers. Substantial improvement was recorded in residual soil fertility as the contents of organic carbon, available nitrogen, phosphorus and potassium were significantly higher in the plots that received poultry manure in combination with chemical fertilizers than the plots that received chemical fertilizers. From the treatments effects on yield, nutrient uptake and soil fertility status, It could also be concluded that, the application of poultry manure performed better than FYM owing to its higher nutrient contents.

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الاستخدام المتكامل للعناصر الغذائية لهجين الذرة النامي بأرض جيرية

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أجريت تجارب حقلية بالمزرعة البحثية لجامعة تاميل نادو الزراعية، كويمباتور، تاميل نادو، الهند لمدة ٣ سنوات خلال الفترة من ٢٠٠٧-٢٠٠٩ لدراسة تأثير الاستخدام المتكامل للعناصر الغذائية علي إنتاج هجين الذرة. سجلت المعاملة التي اسُتخدام فيها ١٠٠% من النيتروجين والفوسفور والبوتاسيوم مع ٥ طن هكتار$^{-1}$ من سماد الدواجن زيادة معنوية في كل من محصول الحبوب والعلف.

سجلت المعاملة التي اسُتخدم فيها ١٠٠% من النيتروجين والفوسفور والبوتاسيوم مع السماد العضوي والعناصر الصغرى كالحديد والزنك أعلي محصول مقارنة بالمعاملة ١٠٠% من النيتروجين والفوسفور والبوتاسيوم مع سماد الدواجن وكل من كبريتات الحديد والزنك. وجد من نتائج الدراسة أن المعاملة ١٠٠% من النيتروجين والفوسفور والبوتاسيوم كانت أقل المعاملات محصولًا حيث بلغ ٥٦٣٧ كجم هكتار$^{-1}$. أيضًا لوحظ زيادة امتصاص هجين الذرة للعناصر الكبرى بزيادة تركيز كل من النيتروجين والفوسفور والبوتاسيوم.

لوحظ وجود تحسن في محتوي التربة من الكربون العضوي والنتروجين الصالح والبوتاسيوم الصالح نتيجة المعاملة ١٠٠% من النيتروجين والفوسفور والبوتاسيوم + ٥ طن هكتار$^{-1}$ من سماد الدواجن بينما زاد الفوسفور الصالح في المعاملة ٧٥% من النيتروجين والفوسفور والبوتاسيوم + ٥ طن هكتار$^{-1}$ من سماد الدواجن. بلغت أعلي نسبة للعلاقة بين التكلفة والاستفادة ٢.٥٢ للمعاملة ١٠٠% من النيتروجين والفوسفور والبوتاسيوم مع السماد البلدي وكل من كبريتات الزنك والحديد.

قام بتحكيم البحث

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