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Effect of Integrated Nutrient Management Practices on Soil Fertility and Production Potential of Hybrid Maize (*Zea mays* L.)

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ABSTRACT

A field experiment was conducted to evaluate the various organics and inorganic fertilizers on soil fertility and production potential of hybrid maize during *kharif* and *rabi* seasons of 2008 and 2009 at the irrigated upland farm of Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in randomized block design with three replications and ten treatments. The results revealed that significant increase in yield components, grain and stover yield of maize were recorded with the application of 50 per cent RDF through poultry manure + 50 per cent RDF through inorganic fertilizers followed by 50 per cent RDF through vermicompost + 50 per cent RDF through inorganic fertilizers. Among the different organic and inorganic treatments, higher net gain in soil available N and P at the end of two years of cropping sequence was recorded with 100 per cent RDF supplied through poultry manure treatment, while the higher net gain in soil available K was observed with the application of 100 per cent RDF through vermicompost treatment.

Key words : Integrated nutrient management, Maize, Productivity, Soil fertility.

Maize (*Zea mays L.*) is one of the most important cereal crop grown all over the globe as poor man's food and also as cattle and poultry feed. With the intention of achieving evergreen revolution, intensive research in maize has been started anticipating its importance for food and feed. It is well known that maize is an exhaustive crop and responds well to applied fertilizers. Though the continuous use of fertilizers had significantly improved the crop productivity, heavy fertilizer application on the same plot every year in continuous maize system will drain the soil fertility rapidly and result in a plethora of problems *viz*., decline in crop productivity, deficiency of several micro nutrients, environmental pollution etc. The success of future agriculture depends upon sustainability of production systems. This has necessiated research on use of organic manures. It helps farmers to reduce inputs of commercial fertilizers, thereby increasing profit margin. But, the use of organic manure alone, cannot sustain the cropping system due to unavailability of required quantities and their relatively low nutrient content (Palm *et al,* 1997).

Thus, it has been realized that application of chemical fertilizers in conjunction with organic manures and bio fertilizers will sustain and maintain the productivity of soil. Therefore, it is necessary to compare various organic as well as biological sources of nutrients with chemical fertilizers in order to find out the most effective combination.

MATERIAL AND METHODS

Field experiments were conducted during *kharif* and *rabi* seasons of 2008 and 2009 at the irrigated upland farm of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The soil of the experimental field was sandy clay loam in texture, alkaline in reaction (pH 8.5), low in organic carbon (0.39%) and available nitrogen (242.6 kg ha^{-1}), medium in available phosphorus (13.5 kg ha^{-1}) and high in available potassium (552 kg ha^{-1}). The experiment was laid out in randomized block design, replicated thrice and the same layout was maintained during both the years of study. The experiment consisted of ten treatments comprising four treatments of different organic manures and their combinations *viz*.,100 per cent RDF through FYM, vermicompost and poultry manure and all the manures at 1/3, 1/3, 1/3 proportion. Four treatments were integrated i.e., 50 per cent RDF through organic manures and 50 per cent RDF through inorganic fertilizers. The remaining two treatments were 100 per cent RDF through inorganic fertilizers and control (without organics and inorganics).

Based on the equal N basis, required quantities of organic manures were incorporated in to the soil ten days before sowing (Table 1). The applied manures also satisfied the P and K requirement of maize. Seed treatment was done with biofertilizers viz., *azospirillum* and *pseudomonas* to all the treatments except 100 per cent RDF through inorganic fertilizers treatment and control. All the organic and integrated treatments were sprayed with *panchagavya* at regular intervals. The recommended dose of fertilizer for maize is 150-75-75 kg N,P_2O_5,K_2O ha^{-1}. Fertilizer dose was calculated as per the treatment using Urea, Super Phosphate and Muriate of Potash. The treatments were imposed on test cultivar of maize CoH (M) 5. The data recorded on various parameters during the course of investigation and the summed up data were statistically analysed following the analysis of variance for randomized block design as suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

YIELD ATTRIBUTES OF MAIZE

Integrated nutrient supply had continuous favourable effect on yield attributes (Raikar *et al*., 2009). The integrated treatment of 50 per cent RDF through inorganics + 50 per cent RDF through poultry manure (T_9) recorded the highest yield attributes, yield and B:C ratio which was on par with the application of 50 per cent RDF through inorganics + 50 per cent RDF through vermicompost(T_8) and differed significantly with 50 per cent RDF through inorganics + 50 per cent RDF through FYM(T_7) and 100 per cent RDF (T_2).

Increase in cob length (18.6 cm during *kharif* and 18.2 cm during *rabi*) and girth (15.3 cm during *kharif* and 14.8 cm during *rabi*) was recorded with T_9 treatment which is due to the simulation effect of combined application of 50 percent RDF through poultry manure and 50 percent RDF through inorganic fertilizers on cell division and expansion (Mohamed *et al.,* 2008). (Table 2).

Number of grain rows per cob is an important yield determining factor in maize. It affects the number of grains per cob and cob weight. Different nutrient management practices had significant effect on number of grain rows per cob. Maximum number of grain rows per cob (15.2 during *kharif* and 14.0 cm during *rabi*) recorded with T_9 treatment which is mainly due to more availability of nutrients from the application of poultry manure in combination with 50 per cent inorganics throughout the growing season. Zhang *et al*. (1998) reported that precise application of poultry manure and inorganic fertilizer combination to maize crop can be as effective as commercial N fertilizer for yield response.

Number of grains per row is also an important parameter contributing towards the final yield. The increase in number of grains per row(37.9 during *kharif* and 37.4 during *rabi*) in T_9 treatment which is attributed to the availability of nitrogen and other nutrients from poultry manure required for plant development up to cob formation (Shah and Arif, 2001).

Increased cob weight (236 gm during *kharif* and 236.2 gm during *rabi*) with T_9 treatment is due to higher concentration of macro and

Table 1. Nitrogen content of organic manures on dry weight basis.

S.No.	Organic manures	Nitogen (%)		Quantity on fresh weight basis (t ha^{-1}) added to supply recommended Nitrogen for maize (150 kg ha^{-1})	
		2008	2009	2008	2009
1.	FYM	0.60	0.50	25.00	30.00
2.	Vermicompost	1.74	1.81	8.62	8.28
3.	Poultry manure	2.74	2.27	5.47	6.60

Table 2. Effect of integrated nutrient management practices on yield attributes of maize (Pooled mean of 2 years).

Treatments	*Kharif* 2008-2009				*Rabi* 2008- 2009			
	Cob length (cm)	Cob girth (cm)	No of rows cob^{-1}	No. of grains row^{-1}	Cob length (cm)	Cob girth (cm)	No of rows cob^{-1}	No. of grains row^{-1}
T_1 – Control (No manure)	13.6	12.1	12.5	29.8	11.4	10.2	12.9	35.0
T_2 – 100% RDF	18.0	15.1	14.8	36.4	17.3	13.7	13.0	34.0
T_3 –100% RDF through FYM	17.7	13.7	14.1	36.3	16.8	12.8	12.3	34.6
T_4 – 100% RDF through Vermicompost (VC)	17.9	14.8	14.3	36.1	15.5	14.0	12.4	35.5
T_5 – 100% RDF through Poultry manure (PM)	17.8	14.7	14.3	36.8	15.4	14.2	12.4	34.3
T_6 – 100% RDF through 1/3 FYM+1/ 3VC+ 1/3 PM	17.7	14.7	14.5	35.4	16.5	13.7	12.6	33.8
T_7 – 50% RDF + 50% through FYM	18.0	15.0	15.1	37.0	15.9	13.8	13.2	35.8
T_8 – 50% RDF + 50% through VC	18.4	14.9	15.0	37.4	17.9	14.7	13.8	36.5
T_9 – 50% RDF + 50% through PM	18.6	15.3	15.2	37.9	18.2	14.8	14.0	37.4
T_{10} – 50% RDF + 50% through 1/3 FYM+1/3VC+ 1/3 PM	17.9	14.6	14.6	36.8	16.5	14.1	13.4	34.9
SEd	0.2	0.2	0.1	0.4	0.3	0.3	0.2	0.7
CD (P=0.05)	0.5	0.3	0.3	0.8	0.7	0.6	0.3	1.5

Table 3. Effect of integrated nutrient management practices on yield attributes of maize (Pooled mean of 2 years).

Treatments	*Kharif* 2008-2009			*Rabi* 2008- 2009		
	Cob weight (g)	Shelling %	100 grain wt.(g)	Cob weight (g)	Shelling %	100 grain wt.(g)
T_1 – Control (No manure)	162.0	64.8	18.5	159.5	65.0	17.2
T_2 – 100% RDF	221.0	72.2	23.9	216.4	71.8	23.0
T_3 –100% RDF through FYM	212.0	71.8	22.5	210.4	70.4	22.8
T_4 – 100% RDF through Vermicompost (VC)	220.3	72.5	23.0	215.8	72.2	24.5
T_5 – 100% RDF through Poultry manure (PM)	218.2	72.3	24.2	211.1	70.8	23.5
T_6 – 100% RDF through 1/3 FYM+1/ 3VC+ 1/3 PM	222.2	71.7	23.7	220.4	71.9	23.7
T_7 – 50% RDF + 50% through FYM	230.7	73.8	24.2	225.0	72.0	24.0
T_8 – 50% RDF + 50% through VC	234.6	74.1	25.1	231.4	72.5	24.5
T_9 – 50% RDF + 50% through PM	236.0	74.5	25.7	236.2	72.8	25.0
T_{10} – 50% RDF + 50% through 1/3 FYM+1/3VC+ 1/3 PM	228.4	72.6	23.7	223.5	72.1	24.0
SEd	5.7	0.4	0.3	6.1	0.4	0.4
CD (P=0.05)	12.0	0.9	0.7	12.8	0.8	0.8

Table 4. Effect of integrated nutrient management practices on grain, Stover yield and harvest index of maize (Pooled mean of 2 years).

Treatments	*Kharif* 2008-2009			*Rabi* 2008- 2009		
	Grainyield (kg ha^{-1})	Stoveryield (kg ha^{-1})	Harvest index	Grainyield (kg ha^{-1})	Stoveryield (kg ha^{-1})	Harvest index
T_1 – Control (No manure)	2820	7844	0.26	2440	7125	0.25
T_2 – 100% RDF	7069	10672	0.40	6609	10483	0.38
T_3 –100% RDF through FYM	5618	9566	0.38	5210	9011	0.36
T_4 – 100% RDF through Vermicompost (VC)	5890	9915	0.39	5706	9455	0.37
T_5 – 100% RDF through Poultry manure (PM)	5965	9874	0.38	5660	9493	0.36
T_6 – 100% RDF through 1/3 FYM+1/ 3VC+ 1/3 PM	5772	9990	0.37	5362	9570	0.35
T_7 – 50% RDF + 50% through FYM	6950	10873	0.39	6897	11223	0.38
T_8 – 50% RDF + 50% through VC	7192	11016	0.40	6915	11520	0.38
T_9 – 50% RDF + 50% through PM	7360	11274	0.41	7123	11378	0.39
T_{10} – 50% RDF + 50% through 1/3 FYM+1/3VC+ 1/3 PM	6843	10285	0.40	6782	10847	0.38
SEd	81.2	154.9	0.01	73.3	211.6	0.01
CD (P=0.05)	170.5	325.5	NS	153.9	444.6	NS

Table 5. Effect of integrated nutrient management practices on soil available nutrient status (kg ha^{-1}) of maize -2008.

Treatments	*Kharif*			*Rabi*		
	N	P	K	N	P	K
T_1 – Control (No manure)	218.0	11.1	534.7	202.6	10.9	527.5
T_2 – 100% RDF	229.0	13.1	542.0	227.0	12.5	536.0
T_3 –100% RDF through FYM	232.0	12.6	553.6	242.6	13.1	556.8
T_4 – 100% RDF through Vermicompost (VC)	233.1	13.2	562.3	245.7	13.6	574.5
T_5 – 100% RDF through Poultry manure (PM)	240.5	13.4	557.1	248.5	13.8	568.9
T_6 – 100% RDF through 1/3 FYM+1/ 3VC+ 1/3 PM	232.6	12.6	550.5	243.2	13.3	555.2
T_7 – 50% RDF + 50% through FYM	221.5	12.4	545.7	224.8	12.6	549.7
T_8 – 50% RDF + 50% through VC	223.3	12.8	552.9	226.9	13.0	562.3
T_9 – 50% RDF + 50% through PM	230.8	12.9	549.1.	229.3	13.2	557.0
T_{10} – 50% RDF + 50% through 1/3 FYM+1/3VC+ 1/3 PM	231.2	12.7	546.2	226.4	12.9	553.6
SEd	3.7	0.1	5.1	4.3	0.2	5.0
CD (P=0.05)	7.8	0.3	10.7	8.9	0.4	10.4

Table 6. Effect of integrated nutrient management practices on soil available nutrient status (kg ha^{-1}) of maize -2009.

Treatments	*Kharif*			*Rabi*		
	N	P	K	N	P	K
T_1 – Control (No manure)	181.6	10.6	518.6	175.6	10.2	507.0
T_2 – 100% RDF	225.7	12.4	531.2	221.4	12.2	526.0
T_3 –100% RDF through FYM	245.3	13.4	563.7	250.9	13.8	570.0
T_4 – 100% RDF through Vermicompost (VC)	249.5	13.8	579.4	258.6	14.6	585.2
T_5 – 100% RDF through Poultry manure (PM)	253.1	14.1	571.0	262.3	15.2	578.1
T_6 – 100% RDF through 1/3 FYM+1/ 3VC+ 1/3 PM	246.0	13.7	568.3	249.6	14.1	575.8
T_7 – 50% RDF + 50% through FYM	232.6	13.0	557.6	245.1	13.7	566.7
T_8 – 50% RDF + 50% through VC	235.8	13.1	566.8	248.6	14.2	573.5
T_9 – 50% RDF + 50% through PM	241.4	13.6	564.5	250.2	14.9	570.0
T_{10} – 50% RDF + 50% through 1/3 FYM+1/3VC+ 1/3 PM	233.3	13.2	562.2	243.6	14.0	568.4
SEd	3.7	0.2	5.2	4.0	0.3	5.5
CD (P=0.05)	7.7	0.4	10.9	8.5	0.6	11.5

micronutrients, enhanced and steady nutrient release from the application of 50 per cent RDF through inorganics in combination with 50 per cent RDF through poultry manure(T_9) (Table 3) when compared to the application of organic sources alone. The 100 grain weight (25.7 gm during *kharif* and 25.0 gm during *rabi*) is increased in T_9 treatment mainly due to balanced supply of nutrients from poultry manure in combination with inorganic fertilizers (T_9) throughout the grain filling and development period (Ma *et al*., 1999).

GRAIN AND STOVER YIELD

Higher maize yield (7360 kg ha^{-1} and 7123 kg ha^{-1}) was recorded with combined use of NPK fertilizer and poultry manure treatment (T_9) (Table 4) during both the years of *kharif* and *rabi* seasons of 2008 and 2009 which was on par with the application of 50 per cent RDF through inorganic fertilizers + 50 per cent RDF through vermicompost (T_8). The beneficial effect of poultry manure in enhancing the yield of maize in combination with inorganics was also reported earlier by Vasanthi and Kumaraswamy (2000), Adeniyan and Ojeniyi (2005), Agyenim *et al*. (2006) and Ayoola and Makinde (2007).

Application of 50 per cent RDF through inorganic fertilizers + 50 per cent RDF through poultry manure (T_9) enhanced the stover yield (11274 kg ha^{-1} and 11378 kg ha^{-1}) during *kharif* and *rabi* seasons of 2008 and 2009 respectively, which is due to adequate biomass production and better nutrient uptake, which might have resulted in higher stover yield (Yadav and Lourduraj, 2006).

Application of 100 per cent RDF through organic manures recorded lower yield mainly due to manures are known to have the characteristic nature of slow release of nutrients. Even though, it contains both macro and micro nutrients, they are not available to crop and could not meet the NPK requirement of the crop in the first year due to slow decomposing nature of manures. The 100 per cent RDF, integrated and organic treatments did not significantly influence the harvest index during both the years of study

Higher harvest index values (0.41, 0.39) were registered under poultry manure applied plots in combination with 50 per cent RDF during *kharif* and *rabi* seasons of both 2008 and 2009 respectively.

SOIL AVAILABLE NUTRIENT STATUS

The highest status of soil available nitrogen 240.5 and 248.5 kg ha^{-1} during *kharif* and *rabi* seasons of 2008 and 253.1 and 262.3 Kg ha^{-1} during *kharif* and *rabi* seasons of 2009 were recorded with the application of 100 per cent poultry manure (T_5), which was comparable with 100 per cent RDF through vermicompost (T_4). (Table 5&6).

The higher N availability with 100 per cent RDF through poultry manure application is due to higher N content and continuous and slow release of nutrients from poultry manure and increased biomass and accumulated soil organic matter as reported by Amanullah *et al*. (2006) and Prasanthrajan *et al*. (2008).

The highest status of post harvest soil available P was recorded with the application of 100 per cent poultry manure (T_5) and the trend was un altered during both the years. This is due to the fact that during the mineralization of organic manure, a number of organic acids, especially the hydroxyl ions (product of microbial metabolism) are produced, which released P through chelation or by removal of metal ions from the insoluble metal phosphates (Mohandas and Appavu, 2000).

The influence of organic manure in increasing the labile P through complexing of cations like Ca^{2+} and Mg^{2+} responsible for P fixation has been reported by Balaguravaiah *et al*. (2005).

Application of 100 per cent RDF through vermicompost (T_4) surpassed all other treatments and recorded higher value of 574.5 kg ha^{-1} of soil available K during *rabi* 2008, and during *rabi* 2009 also vermicompost (T_4) treatment proved better than all other integrated and organic manure treatments in recording higher soil available potassium (585.2 kg ha^{-1}) which was comparable to 100 percent poultry manure (T_5). The increase in soil available K is ascribed to the reduction in K fixation and release of K due to interaction of organic matter (Agbede *et al*., 2008).

It was concluded that combined application of 50 per cent RDF through inorganic fertilizers + 50 per cent RDF through poultry manure is the most efficient nutrient management practice for better growth, yield and soil fertility for the continuous maize-maize cropping system under irrigated upland condition of western zone of Tamil Nadu.

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