International Journal of Farm Sciences **6(2)** : 7-12, 2016

Effect of industrial waste with different levels of nitrogen on nutrient uptake and yield of maize, *Zea mays*

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ABSTRACT

A field experiment was conducted to study the nutrient uptake, quality and yield of maize (Co1) under paper mill sludge with inorganic fertilizers at different rates of nitrogen at Agricultural College and Research Institute, Madurai during Rabi 2008. Based on the field experiment it was found that 75 per cent recommended nitrogen and full dose of phosphorus and potassium with paper mill sludge recorded higher nutrient uptake at different growth stages of maize viz knee-high, tasseling and harvest. Nutrient uptake was higher at harvest stage. Application of paper mill sludge with inorganic nitrogen increased the quality of maize grain significantly over absolute control. Higher yield of grain (4.9 tons/ha) and straw (9.0 tons/ha) was received in the treatment T_5 which received 75 per cent inorganic N with paper mill sludge at the rate of 5 tons/ha. The quality characters of the maize grain viz crude protein, total sugars and starch were also increased due to the application of paper mill sludge with inorganic fertilizer.

Keywords: Paper mill sludge; maize; nutrient uptake; yield; nitrogen

INTRODUCTION

Paper mill sludge (PMS) is a source of organic matter and nutrients such as P, K, Ca and Mg and increases the nutrient content in the soil. Although rich in inorganic matter, PMS presented low N levels and high C:N ratios and low decomposition in soil (Fierro et al 2000) which reduced N availability to crops due to N immobilization (Aitken et al 1998). Through the addition of inorganic nitrogen to organic manures it increases the mineralization of organic N and microbial activity. Addition of N along with FYM could lower the C:N ratio and create a conducive medium for better microbial decomposition of organic residues and addition of large amount of microbial protein to the soil (Kamat et al 1982). Maize (*Zea mays* L) is one of the most important economic crop plants and is almost an ideal forage crop because of its quick growth, high yielding, better palatability and nutritious qualities. Organics by virtue of their inherent capability help in augmenting the rate of added fertilizer N addition to complexing or chelating processes that could account

for higher organic N (Prasad and Rokima 2001). Higher responses to PMS have been demonstrated for corn, cabbage and sweet corn and forage (N'Dayegamiye et al 2003, Simard et al 1998).

MATERIAL and METHODS

The field experiment was conducted at the Central Farm, Agricultural College and Research Institute, Madurai to evaluate the performance of maize under combination of industrial waste with different levels of nitrogen. The paper mill sludge (PMS) was collected from Kagithapuram, TNPL of Karur district. It was dried, sieved and used for analysis. The important characteristics of PMS are presented in Table 1.

The experiment was laid out in randomized complete block design with three replications containing seven treatments. Treatments consisted of different doses of inorganic nitrogen with PMS viz T_1 (Absolute control), T_2 (Recommended dose of NPK), T_3 (PMS @ 5 tons/ha), T_4 (100% N + PMS @ 5 tons/ha, T_5 (75% N + PMS @ 5 tons/ha), T_6 (50% N + PMS @ 5 tons/ha) and T_7 (25% N + PMS @ 5 tons/ha). Ridges and furrows were formed in the treatment plot with a spacing of 60 cm between the ridges and calculated quantities of PMS were applied to the treatment plots along with nitrogen in the form of urea by four equal splits viz at basal, 30, 60 and 90 days after sowing as per the treatment. Phosphorus and potassium were applied in full doses in the form of DAP and MOP basally. The plant samples were collected from all the experimental plots at different stages (knee high, tasseling and at harvest stages) and also grain and stover samples were collected at harvest stage, dried in shade and then dried in a hot air oven at 60°C, ground in a Wiley mill using stainless steel blades and used for total N, P and K content analysis as per the method given by Jackson (1973). The dry matter production (DMP) was estimated at harvest stage. The samples were initially air-dried and later oven-dried at 60°C till concurrent weights were recorded and computed to kg/ha. From the DMP and nutrient, content uptake was calculated.

The grain and straw yield was recorded in different plots. The data on various characters studied during the investigation were statistically analysed by the method given by Gomez and Gomez (1984).

RESULTS and DISCUSSION

Characteristics of paper mill sludge

PMS collected from TNPL was dark brown in colour with an unpleasant odour and having a C:N ratio of 40:1. It was neutral (7.10) in reaction with an EC of 3.50 dS/m (Table 1). Among the plant nutrients potassium was found in higher amount (14.7 g/kg) followed by nitrogen (5 g/kg) and phosphorus (1.1 g/kg).

Table 1. Characteristics of paper mill sludge

Property	Value	Property	Value
pH	7.10	Total P (mg/kg)	1100
EC (dS/m)	3.50	Total K (mg/kg)	14700
Organic carbon (g/kg)	19.87	Total Ca (mg/kg)	34.0
Total N (mg/kg)	5000	Total Mg (mg/kg)	21.0

Calcium (34.0 mg/kg) and magnesium (21.0 mg/kg) were also higher in PMS.

Effect of nutrient uptake

Nitrogen uptake: Application of PMS with inorganic nitrogen significantly influenced N uptake by increasing the N content in plant at all three stages. Nitrogen uptake ranged from 19.40 to 188.81 kg/ha at knee-high, tasseling and harvest growth stages (Table 2). Nitrogen uptake was recorded higher in 75 per cent N with PMS (188.8 kg/ha) applied plot than the complete fertilizer N treatment at harvest growth stage. This might be due to the application of PMS with different levels of nitrogen that increased the N content and dry matter which in turn increased the N uptake. This could also be due to the improvement of soil ecosystem, regime and balanced nutrient distribution in the soil that encouraged the proliferation of the roots resulting in absorption of more of water and nutrients to larger area and depth that enhanced the content and uptake. The results are in agreement with the findings of Kumar et al (1996). Significant increase in N uptake in maize was recorded in each successive increase in N level applied to maize. This is supported by the work of Shivay et al (1999) and N'Dayegamiye (2003). A progressive increase in the N uptake with the advancement of crop growth registered during the investigation is quite explainable due to higher dry matter production.

Phosphorus uptake: Phosphorus uptake was significantly influenced by the application of PMS with inorganic nitrogen (Table 2). The uptake ranged between 4.49 to 69.56 kg/ha at all three growth stages including the absolute control. The higher value (69.6 kg/ha) was recorded in 75 per cent N with PMS (69.6 kg/ha) at tasseling stage and the lower value (4.49 kg/ha) was recorded in absolute control at knee high stage. Phosphorus uptake could be higher in PMS with 75 per cent N than PMS with 100 per cent N at tasseling stage due to the increase in P uptake up to a certain level of N and thereafter it might have decreased due to the reduction in availability of P in soil with increasing levels of N with PMS. The results are in accordance with the findings of N'Dayegamiye (2003).

Table 2. Effect of PMS with different levels of N on uptake by maize

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Knee-high	Tasseling	Harvest	Knee-high	Tasseling	Harvest	Knee-high	Tasseling	Harvest
T_1- Absolute control	19.40	49.23	79.90	4.49	9.24	15.23	10.20	34.60	45.14
T_2 - Recommended dose of NPK	41.10	90.56	137.50	29.24	35.26	41.56	29.56	61.63	80.01
T_3 - PMS alone @ 5 tons/ha	35.61	89.37	109.10	19.40	29.33	29.77	20.20	44.80	62.91
T_4 - 100% N + PMS @ 5 tons/ha	58.90	148.50	188.81	36.21	65.21	52.49	36.20	79.40	81.76
T_5 - 75% N + PMS @ 5 tons/ha	51.60	139.20	174.20	38.56	69.56	59.21	40.25	81.51	98.56
T_6 - 50% N + PMS @ 5 tons/ha	47.50	128.30	165.23	33.21	61.56	48.79	34.69	74.80	72.56
T_7 - 25% N + PMS @ 5 tons/ha	44.80	115.65	154.26	29.33	58.77	43.51	30.85	72.40	61.78
Mean	42.70	108.69	144.14	27.21	46.99	41.51	28.85	64.16	71.82
	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	SEd	$CD_{0.05}$		SEd	$CD_{0.05}$		Sed	$CD_{0.05}$	
T	4.9	9.9		1.7	3.5		2.3	4.6	
S	3.2	6.5		1.1	2.3		1.5	3.0	
T × S	8.5	17.2		3.0	6.0		4.0	8.0	

Potassium uptake: Potassium uptake was significantly different in all treatments at all three growth stages. The value ranged from10.2 to 98.6 kg/ha, higher value (98.6 kg/ha) recorded in 75 per cent in PMS with 75 per cent N applied plot which could be due to the reason that increased concentration of K in soil solution and corresponding increase in absorption leads to increased production of dry matter resulting in marked increase in K uptake. Another possible reason could be that when NH_4^+ ion availability increases in the soil through N application it releases K^+ ions from clay lattice into soil solution leading to increased K availability to the plants which ultimately results in the increased K uptake as K content and DMP are much higher in N fertilized treatments. Same results were reported by Ramamoorthy et al (2002).

Effect on yield

The grain and stover yield of the maize crop was found to be significantly influenced by the application of PMS with different levels of nitrogen (Table 3). The grain and stover yield of maize ranged from 2.2 to 4.9 tons/ha and 3.9 to 4.1 tons/ha respectively. Higher value was recorded in the treatment 75 per cent N with PMS and the lower in the absolute control. Soil received PMS with 75 per cent N recorded the higher value (4.9 tons/ha) and it was 12 per cent higher over PMS with 100 per cent N. Increase in yield with the application of industrial waste with fertilizer may be attributed to the potential effect of this amendment in increasing water holding capacity, microbial population, physico-chemical properties and nutritional properties of soil. This is confirmed by the findings of Kadalli et al. (2000) and Mathakiya and Meisheri (2007). The treatment consisting of 75 per cent recommended N + PMS @ 5 tons/ha recorded higher grain and stover yield than 100 per cent recommended N + PMS @ 5 tons/ha.

Table 3. Yield of maize under PMS with different levels of nitrogen (tons/ha)

Treatment	Grain yield	Stover yield
T1- Absolute control	2.2	4.0
T_2- Recommended dose of NPK	4.4	7.9
T_3- PMS alone @ 5 tons/ha	3.5	6.4
T_4- 100% N + PMS @ 5 tons/ha	4.4	8.0
T_5- 75% N + PMS @ 5 tons/ha	5.0	9.0
T_6- 50% N + PMS @ 5 tons/ha	4.3	7.9
T_7- 25% N + PMS @ 5 tons/ha	4.3	7.7
Mean	4.0	7.3
SEd	0.09	0.16
$CD_{0.05}$	0.20	0.35

CONCLUSION

From the field experiment it was found that 75 per cent recommended N with full dose of P and K recorded higher yield and quality of maize. During the three stages nutrient uptake was higher due to slow release of nutrients and higher nutrient content in plant. Maize yield was generally increased with the application rate of PMS with inorganic fertilizer that also increased the quality of maize.

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Received: 12.10.2015 ***Accepted: 7.2.2016***