Effects of NPK Fertilizers, Household Waste Compost and Poultry Manure on Soil Fertility and Nutrient Uptake by Maize (*Zea mays* L.)

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Abstract

A field experiment was conducted to observe the comparative effects of fertilizers, household waste compost and poultry manure and their different combinations on soil fertility and nutrient uptake of maize (*Zea mays* L.). There were ten treatments, one control and nine fertilizer combinations. In three separate treatments, NPK, household compost and poultry manure were applied alone. In three treatments, NPK and compost were used in different proportions. In three other treatments, NPK and poultry manure were combined together. The results indicated that poultry manure alone or in different combination with inorganic fertilizer increased total N, available P, exchangeable K, Ca and Mg in soil after one month of treatment application; increased total N, exchangeable K and Ca after one month of sowing seeds of maize; and increased available P and exchangeable Ca at harvest over control. Increasing the proportion of NPK fertilizer with decreasing poultry manure decreased available P at harvest, exchangeable K and Mg at all the stages compared to poultry manure alone. Compost alone or in different combination with NPK fertilizer increased exchangeable K and Ca in soil at all the three stages. Nitrogen uptake by shoot, root and grain of maize varied significantly from 0.19 to 1.50, 0.01 to 0.19 and 0.07 to 1.43 g plant^{-1}; P uptake from 0.04 to 0.42, 0.01 to 0.17 and 0.03 to 1.06 g plant^{-1}, potassium from 0.14 to 3.04, 0.06 and 1.30, 0.04 and 1.80 g plant^{-1}; Calcium uptake from 0.05 to 0.38, 0.01 to 0.18 and 0.00 to 0.07 g plant^{-1}; and Mg uptake ranged from 0.03 to 0.34, 0.00 to 0.12 and 0.00 to 0.11 g plant^{-1}, respectively. Uptake of nutrient was very low in control, low in full NPK, higher in compost and the highest in the poultry manure treatments.

1. Introduction

Bangladesh is an agricultural country. Overall agricultural productivity of the country is declining for depletion of soil fertility. Low soil organic matter content is the main cause of low productivity, and it is considered as one of the most serious threats to the sustainability of agriculture in Bangladesh. Chemical fertilizer cannot be avoided completely since they are the potential sources of high amount of nutrients in easily available forms. But continuous application of chemical fertilizers alone is not desirable as it has been reported to deteriorate soil health. Manures and composts play important roles in soil by modifying the chemical environment of the soil that leads to improved nutrient contents (Omotayo and Chukwuka, 2009; Mahmoodabadi et al., 2010) and they increase biological activity in soil including organic matter decomposition, mineralization and nutrient transformation that leads to improved soil fertility. Poultry manure is a valuable fertilizer and can serve as a suitable alternate to chemical fertilizers. Poultry manures provide organic matter to soil and nutrients to crops (Warren et al., 2006). Poultry manure is a good source of major and minor mineral elements that are capable of enhancing soil fertility on application (Thomas, 1997). Compost is increasingly being considered as a soil conditioner and fertilizer (Stranon et al., 1995). The application of biowaste and vegetable waste composts increases soil organic matter and total N content (Nevens and Reheul, 2003; Hartl and Erhart, 2005). The integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interaction to increase nutrient use efficiency and thereby reduce environmental hazards (Ahmad et al., 1996, Khaliq et al., 2004). Application of poultry manure+FYM was found to increase the availability in soil and subsequently the nutrient uptake in maize (Sharma and Saxena, 1990). Now maize is one of the most important food grains in the world as well as in developing countries like Bangladesh. Keeping these views in mind, the present experiment was under taken to study the effects of inorganic fertilizer, household waste compost and poultry manure alone and their different combination on soil fertility and nutrient uptake by maize.

2. Materials and Methods

2.1. Field experiment

Thirty experimental plots (2.2 m×2.2 m) separated by 0.5 m margins were prepared in three adjacent blocks in the crop field of the Department of Soil Science, University of Chittagong. There were ten plots in each block for the ten treatment combinations comprising of poultry manure (PM), household waste compost and inorganic fertilizers- T_1 (Control), T_2 (Full NPK @ 120 kg N ha^{-1}, 60 kg P ha^{-1} and 80 kg K ha^{-1}), T_3 (Full Compost @ 30 t ha^{-1}), T_4 (25% NPK+75% compost i.e. 30 kg N ha^{-1}, 15 kg P ha^{-1} and 20 kg K ha^{-1}+ 22.5 t ha^{-1} compost), T_5 (50% NPK+50% compost i.e.60 kg N ha^{-1}, 30 kg P ha^{-1} and 40 kg K ha^{-1}+ 15 t ha^{-1} compost), T_6 (75% NPK+25% compost i.e. 90 kg N ha^{-1}, 45 kg P ha^{-1} and 60 kg K ha^{-1}+7.5 t ha^{-1} compost), T_7 (Full PM @30 t ha^{-1}), T_8 (25% NPK+75% PM i.e. 30 kg N ha^{-1}, 15 kg P ha^{-1} and 20 kg K ha^{-1}+22.5 t ha^{-1} PM), T_9 (50% NPK+50% PM i.e.60 kg N ha^{-1}, 30 kg P ha^{-1} and 40 kg K ha^{-1}+15 t ha^{-1} PM), T_{10} (75% NPK+25% PM i.e. 90 kg N ha^{-1}, 45 kg P ha^{-1} and 60 kg K ha^{-1}+7.5 t ha^{-1} PM). The treatments were arranged according to a randomized complete block design. Nitrogen in the form of urea was applied in 3 splits. One-third of nitrogen fertilizer (i.e. urea) was applied as basal dose before sowing, the 2nd dose was given after one month of sowing and the third installment was given at the flowering stage. Phosphorus and potassium fertilizers were also applied as basal. All of poultry manure and household waste composts were applied basal at the stage of soil preparation before one month of sowing seeds of maize. The seeds were sown in lines 75 cm apart with seed to seed distance of 25 cm. In each point two seeds were sown. Seeds were sown at a depth of 2.5 cm below surface. One healthy seedling was retained in each point after seedling emergence. Irrigation was applied as and when necessary. The fruits were harvested when they were fully mature and turned to deep yellow colour after about four months. Soil was collected from each plot before sowing seeds, after one month of sowing seeds and after harvest.

2.2. Determination of soil properties

Soil texture was determined by hydrometer method (Day, 1965), pH in a 1:2.5 soil:water suspension with glass electrode pH meter, organic carbon by wet-oxidation method (Walkley and Black, 1934), total nitrogen by micro-Kjeldahl digestion and distillation, available phosphorus by Bray and Kurtz-II method (Bray and Kurtz, 1945) and exchangeable potassium, calcium and magnesium by 1N NH_4OAC saturation (Jackson, 1973). The experimental soil was sandy clay loam (68% sand, 11% silt and 21% clay) with pH 4.18, organic matter content 1.20%, CEC 6.71 cmol kg^{-1}, total nitrogen 0.07%, available P (Bray & Kurtz II P) 6 mg kg^{-1}, exchangeable K 0.20 cmol kg^{-1}, exchangeable Ca 1.94 cmol kg^{-1} and exchangeable Mg 1.05 cmol kg^{-1}. Poultry manure used in the experiment contained pH 7.65, total nitrogen 0.28%, available P (Bray & Kurtz II P) 14.17 mg kg^{-1}, exchangeable K 12.65 cmol kg^{-1}, exchangeable Ca 7.44 cmol kg^{-1} and exchangeable Mg 0.44 cmol kg^{-1}. Compost with pH 8.35 contained total nitrogen 0.15%, available P (Bray & Kurtz II P) 4.77 mg kg^{-1}, exchangeable K 34.65 cmol kg^{-1}, exchangeable Ca 8.12 cmol kg^{-1} and exchangeable Mg 0.38 cmol kg^{-1}.

2.3. Determination of nutrient uptake by maize

Oven dried (65^0C to constant weight) and ground plant samples were digested with a mixture of H_2SO_4, H_2O_2 and lithium sulfate for the determination of N, P, K, Ca and Mg in the plant tissues (Allen et al., 1986). The concentrations of Ca and Mg in the digest were measured by atomic absorption spectrophotometer (Varian nov AA). Micro-Kjeldahl method as described by Jackson (1973) was used for the determination of nitrogen. Phosphorus was determined by vanadomolybdo phosphoric yellow colour method in nitric acid system according to Jackson (1973). Potassium was measured by flame photometer. Nutrient uptake was calculated from the nutrient concentrations obtained from the tissue analysis.

2.4. Statistical analysis

The significance of differences between the means of the treatments was evaluated by one way analysis of variance followed by Duncan's Multiple Range Test at the significance level of 5%. The statistical software Excel (Excel Inc., 2003) and SPSS version 12 (SPSS Inc., 2003)] were used for these analyses.

3. Results and Discussion

3.1. Nutrient content in soil

3.1.1. Total nitrogen in soil

After one month of treatment application nitrogen content in soil was found to vary from 0.09 (Control) to 0.14% (T_7 and T_8) (Table 1). The treatments T_2, T_4 and T_6 did not differ among themselves and from control. The treatments T_3, T_5, T_9 and T_{10} are significantly different from control treatment. Nitrogen concentration in soil after one month of sowing seeds varied from 0.10 (Control) to 0.12% (T_7, T_8 and T_9). The treatments T_2, T_3, T_4, T_5 and T_6 showed statistically similar values. The value of N concentration in soil after harvest ranged from 0.08 to 0.09%. The lowest value was found in seven treatments, named T_1, T_2, T_3, T_5, T_9 and T_{10}. Maximum value was found in treatment T_6, T_7 and T_8.

3.1.2. Available phosphorus in soil

Available phosphorus in soil ranged from 7.00 (T_1 and T_3) to

15.00 mg kg^{-1} (T_7) at after one month of treatment (Table 1). Treatments T_3 and T_6 showed similar available P with control treatment. Increasing the proportion of synthetic fertilizer with decreasing proportion of poultry manure had significant effect on available P in treatment T_8 and T_9 except T_{10} compared with T_7 treatment. The value of available P in soil after one month of sowing was 6.00 (T_1, T_3 and T_5) to 16.00 mg kg^{-1} (T_7). In treatments T_2, T_4, T_6 and T_{10}, similar values of available P were found. Treatment T_8 and T_9 showed significant variation with treatment T_1. After harvest, available phosphorus varied from 6.00 (T_1, T_2, T_4 and T_5) to 14.00 mg kg^{-1} (T_7). Increasing the proportion of synthetic fertilizer with decreasing proportion of poultry manure had positive effect on P concentration in soil as compared with control.

3.1.3. Exchangeable K^+ in soil

Exchangeable K^+ in soil after one month of treatment application varied from 0.20 (T_1) to 1.45 cmol kg^{-1} (T_7) (Table 2). Full NPK fertilizer (T_2) improved the K concentration in relation to control. Increasing the proportion of inorganic fertilizer with decreasing proportion of compost decreased K concentration in treatments T_4, T_5 and T_6 in relation to T_3 where full compost was applied. Exchangeable K^+ decreased in treatments T_8, T_9 and T_{10} over T_7 (Full poultry manure). Exchangeable K^+ in soil after one month of sowing ranged from 0.30 (T_1) to 1.15 cmol kg^{-1} (T_7). The treatments T_2, T_3, T_5 and T_6 had significantly higher exchangeable K^+ in relation to control treatment T_1. Increasing the proportion of inorganic fertilizer with decreasing proportion of compost decreased exchangeable K^+ in treatments T_4, T_5 and T_6 over T_1 (control). Exchangeable K^+ decreased over T_7 in treatments T_8, T_9 and T_{10}. Exchangeable K^+ in soil after harvest varied from 0.25 (T_1) to 0.70 cmol kg^{-1} (T_7). Similar values to control were found in treatments T_2, T_3, T_5, T_6, T_9 and T_{10} which are not significantly different from each other. The treatments T_8 and T_9 were significantly different from control and also with each other.

Table 1: Effects of fertilizers, compost and poultry manure on total nitrogen and available phosphorus content in soil of experimental field at different stages of maize growth

Treatment	Nitrogen (%)			Phosphorus (mg kg^{-1})		
	After one month of treatment	After one month of sowing	After harvest	After one month of treatment	After one month of sowing	After harvest
T_1	0.09^c	0.10^b	0.08^a	7.00^d	6.00^d	6.00^e
T_2	0.11^{bc}	0.11^{ab}	0.08^a	13.33^{abc}	7.00^{cd}	6.00^e
T_3	0.12^{ab}	0.11^{ab}	0.08^a	7.00^d	6.00^d	7.00^{de}
T_4	0.12^{bc}	0.10^b	0.08^a	11.33^c	7.00^{cd}	6.00^e
T_5	0.12^{ab}	0.11^{ab}	0.08^a	14.67^a	6.00^d	6.00^e
T_6	0.11^{bc}	0.10^b	0.09^a	8.00^d	7.00^{cd}	5.00^e
T_7	0.14^a	0.12^a	0.09^a	15.00^a	16.00^a	14.00^a
T_8	0.14^a	0.12^a	0.09^a	12.00^{bc}	9.00^{bc}	12.00^{ab}
T_9	0.13^{ab}	0.12^a	0.08^a	12.00^{bc}	10.00^b	10.00^{bc}
T_{10}	0.12^{ab}	0.11^{ab}	0.08^a	14.33^{ab}	8.00^{bcd}	9.00^{cd}

Figures in the same column denoted by the same letter (s) did not differ significantly according to DMRT at $p<0.05$

3.1.4. Exchangeable Ca^{2+} in soil

Exchangeable Ca^{2+} in soil ranged from 1.99 (T_1) to 6.48 cmol kg^{-1} (T_4) after one month of treatment application (Table 2). Exchangeable Ca^{2+} was significantly increased in treatments T_3, T_5, T_7, T_8, T_9 and T_{10} over T_1 (control). Exchangeable Ca^{2+} in soil after one month of sowing ranged from 1.94 (T_1) to 5.35 cmol kg^{-1} (T_3). Although similar Ca^{2+} values were observed in treatments T_4 and T_7, the values were significantly different from control T_1. Exchangeable Ca^{2+} decreased gradually in treatments T_8, T_9 and T_{10} over T_7. The exchangeable Ca^{2+} in soil at maturity varied from 2.12 (T_1) to 7.73 cmol kg^{-1}(T_3) Increasing the proportion of inorganic fertilizer with decreasing proportion of compost negatively affected exchangeable Ca^{2+} in treatments T_4, T_5 and T_6 over T_3.

3.1.5. Exchangeable Mg^{2+} in soil

The value of exchangeable Mg^{2+} in soil after one month of treatment varied from 1.19 (T_1) to 9.23 (T_7) cmolkg^{-1} (Table 2). Application of full compost and full poultry manure significantly increased the value of exchangeable Mg^{2+} in treatments T_3 and T_7 compared with control treatment T_1. The values of exchangeable Mg^{2+} in soil after one month of sowing ranged from 1.42 (T_1) to 6.43 cmol kg^{-1} (T_7). There was no significant difference in exchangeable Mg^{2+} in treatments T_2, T_3, T_5, T_6 and T_{10} from T_1. The treatment T_4, T_8, T_9 increased exchangeable Mg^{2+} over control. Increasing the proportion of inorganic fertilizer with decreasing proportion of poultry manure significantly decreased exchangeable Mg^{2+} in soil in T_8, T_9 and T_{10} treatments over T_7 treatment. At harvest, the value of exchangeable Mg^{2+} in soil ranged from 1.05 (control, T_1) to 4.09 cmol kg^{-1} (T_7). Although different types of fertilizer combinations were used with compost and poultry manure, there was no significant variation in treatments T_2, T_4, T_5, T_6 and T_{10} from T_1 (control). Treatment T_3, T_8 and T_9 increased Mg^{2+} over control.

3.2. Nutrient uptake by maize

3.2.1. Nitrogen uptake

Nitrogen uptake by shoot, root and grain of maize varied significantly from 0.19 to 1.50, 0.01 to 0.19 and 0.07 to 1.43 g plant^{-1}(Table 3). The highest and the lowest uptake of N in shoot were found in treatment T_7 and T_1, respectively. Similar result was found in root and grain. Full NPK fertilizer (0.07 g plant^{-1}) application showed similar uptake by root in relation control. The treatments T_3, T_4, T_5, T_6, T_9 and T_{10} were statistically similar with each other in N uptake by root. In treatment T_8, T_9 and T_{10} where increasing the proportion of NPK fertilizer with decreasing proportion of poultry manure were given, significantly lower uptake of N in shoot, root and grain was noticed over the treatment T_7.

3.2.2. Phosphorus uptake

Phosphorus uptake ranged from 0.04 to 0.42, 0.01 to 0.17 and 0.03 to 1.06 g plant^{-1} in shoot, root and grain of maize, respectively (Table 3). In shoot, root and grain the maximum uptake of P occurred in the treatment T_7. Full NPK fertilizer showed similar P uptake by shoot and root to control treatment. Although different fertilizers and their combinations were used in treatments T_2, T_3, T_4, T_5, T_6, and T_{10} but they were statistically similar among themselves and to the control in P uptake by root. In maize grain P uptake in treatments T_2, T_3, T_4, T_5 and T_{10} was similar statistical significance. The treatments T_8, T_9 and T_{10} involved combination of poultry manure and NPK. Increasing NPK fertilizer with reduced poultry manure decreased P uptake by maize shoot, root and grain in treatment T_8, T_9 and T_{10} over the treatment T_7.

3.2.3. Potassium uptake

Uptake of potassium varied between 0.14 and 3.04 g plant^{-1}, 0.06 and 1.30 g plant^{-1}, and 0.04 and 1.80 g plant^{-1} by shoot, root and grain of maize, respectively (Table 3). The minimum and the maximum values were obtained in the control and T_7, respectively. Application of fertilizer, compost and manure significantly increased K uptake by shoot, root and grain of maize in all treatments over control treatment T_1. There were similar K uptake by shoot and root in treatments T_3, T_4, and T_5. There was also no significant difference in the uptake of K by shoot and grain in treatments T_7 and T_8. Increasing proportion of NPK fertilizer with decreasing proportion of poultry manure reduced K uptake by root in treatments T_8, T_9

Table 2: Effects of fertilizers, compost and poultry manure on exchangeable K^+, Ca^{2+} and Mg^{2+} in soil

Treatment	K^+ (cmol kg^{-1})			Ca^{2+} (cmol kg^{-1})			Mg^{2+} (cmol kg^{-1})		
	After one month of treatment	After one month of sowing	After harvest	After one month of treatment	After one month of sowing	After harvest	After one month of treatment	After one month of sowing	After harvest
T_1	0.20^{e}	0.30^{e}	0.25^{d}	1.99^{d}	1.94^{e}	2.12^{g}	1.19^{e}	1.42^{d}	1.05^{e}
T_2	0.55^{d}	0.55^{cd}	0.35^{cd}	2.63^{d}	2.71^{de}	3.02^{fg}	1.57^{de}	1.79^{cd}	1.33^{de}
T_3	0.95^{bc}	0.70^{cd}	0.35^{cd}	6.21^{ab}	5.35^{a}	7.73^{a}	2.70^{c}	2.33^{cd}	2.08^{cd}
T_4	0.75^{cd}	0.75^{c}	0.45^{bc}	6.48^{a}	5.32^{a}	6.94^{ab}	2.73^{c}	2.63^{c}	1.97^{cde}
T_5	0.75^{cd}	0.70^{cd}	0.35^{cd}	4.25^{c}	4.80^{ab}	6.24^{bc}	1.69^{de}	2.33^{cd}	1.82^{cde}
T_6	0.60^{d}	0.55^{cd}	0.35^{cd}	2.18^{d}	2.96^{cde}	3.80^{ef}	1.68^{de}	1.71^{cd}	1.38^{de}
T_7	1.45^{a}	1.15^{a}	0.70^{a}	5.00^{bc}	5.28^{a}	5.07^{cd}	9.23^{a}	6.43^{a}	4.09^{a}
T_8	1.10^{b}	0.95^{b}	0.60^{ab}	5.11^{bc}	4.21^{abc}	6.61^{ab}	4.26^{b}	3.97^{b}	3.53^{ab}
T_9	0.95^{bc}	0.65^{cd}	0.40^{cd}	4.19^{c}	3.85^{bcd}	6.25^{bc}	2.99^{c}	2.52^{c}	2.71^{bc}
T_{10}	0.75^{cd}	0.50^{d}	0.25^{d}	4.06^{c}	3.60^{bcd}	4.59^{de}	2.29^{cd}	2.19^{cd}	1.83^{cde}

Figures in the same column denoted by the same letter (s) did not differ significantly according to DMRT at $p<0.05$

Table 3: Effects of fertilizer, compost and poultry manure on N, P and K uptake (g plant^{-1}) by maize

Treatment	N			P			K		
	Shoot	Root	Grain	Shoot	Root	Grain	Shoot	Root	Grain
T_1	0.19^{g}	0.01^{d}	0.07^{g}	0.04^{e}	0.01^{c}	0.03^{e}	0.14^{f}	0.06^{g}	0.04^{f}
T_2	0.61^{f}	0.07^{cd}	1.32^{b}	0.11^{de}	0.03^{c}	0.55^{c}	1.08^{e}	0.29^{f}	0.62^{e}
T_3	0.64^{f}	0.09^{c}	1.06^{de}	0.19^{cd}	0.05^{bc}	0.63^{c}	1.68^{c}	0.49^{e}	0.86^{d}
T_4	0.73^{e}	0.08^{c}	1.25^{bc}	0.17^{cd}	0.06^{bc}	0.59^{c}	1.47^{c}	0.50^{e}	1.06^{c}
T_5	0.87^{d}	0.10^{bc}	0.97^{ef}	0.20^{bcd}	0.05^{bc}	0.54^{cd}	1.66^{c}	0.42^{e}	0.92^{cd}
T_6	0.72^{e}	0.08^{c}	0.91^{f}	0.14^{d}	0.04^{bc}	0.45^{d}	1.27^{d}	0.33^{f}	0.78^{de}
T_7	1.50^{a}	0.19^{a}	1.43^{a}	0.42^{a}	0.17^{a}	1.06^{a}	3.04^{a}	1.30^{a}	1.80^{a}
T_8	1.40^{b}	0.16^{ab}	1.31^{bc}	0.39^{a}	0.14^{a}	0.99^{a}	2.87^{a}	1.14^{b}	1.67^{a}
T_9	1.19^{c}	0.13^{abc}	1.21^{c}	0.28^{b}	0.11^{ab}	0.78^{b}	2.30^{b}	0.93^{c}	1.38^{b}
T_{10}	0.65^{f}	0.09^{c}	1.08^{d}	0.24^{bc}	0.05^{bc}	0.60^{c}	1.57^{c}	0.61 d	0.84^{d}

Figures in the same column denoted by the same letter (s) did not differ significantly according to DMRT at $p<0.05$

and T_{10} over T_7.

3.2 4. Calcium uptake

Calcium uptake by shoot, root and grain of maize ranged from 0.05 to 0.38, 0.01 to 0.18 and 0.00 to 0.07 g plant^{-1}, respectively (Table 4). The lowest uptake of Ca by shoot, root and grain was found with T_1 (control) treatment and the highest uptake of Ca by shoot and root was found with treatment T_7. Different fertilizers and their combinations showed similar value in Ca uptake by shoot of maize in treatments T_3, T_4, T_5, T_6, T_8, T_9 and T_{10}. Treatments with inorganic fertilizers, organic fertilizer and their combinations showed no significant differences in Ca uptake by root in relation to control in treatments T_2, T_3, T_4, T_5, T_6, T_9 and in T_{10}, respectively. Treatments T_2, T_3, T_5, T_6, T_9 and T_{10} were statistically similar in Ca uptake by maize grain.

3.2.5. Magnesium uptake

It showed that Mg uptake ranged from 0.03 to 0.34, 0.00 to 0.12 and 0.00 to 0.11 g plant^{-1} in shoot, root and grain of maize, respectively (Table 4). The highest uptake of Mg by plant shoot, root and grain was found in T_7 treatment (full poultry manure). Uptake of Mg in shoot in treatments T_2, T_3, T_4, T_5 and T_{10} were statistically similar. Application of full NPK, full compost and combinations of NPK & compost fertilizers plant made little difference in the uptake of Mg in roots. These treatments showed only 0.02 to 0.04 g plant^{-1} uptake of Mg. Combinations of poultry manure showed relatively higher uptake of Mg in treatments T_8, T_9 and T_{10}. Fertilizers caused a higher uptake of Mg in grain, but there was little difference among different fertilizers and their combinations.

Uptake of nutrients refers to the amounts of nutrients accumulated in the whole plant. The values of uptake of N, P, K, Ca and Mg in shoot were 0.19-1.82 g plant^{-1}, 0.04-0.42 g plant^{-1}, 0.15-3.04 g plant^{-1}, 0.05- 0.37 g plant^{-1} and 0.03 to 0.34 g plant^{-1}, respectively. Uptake was very low in control, low in full NPK, higher in compost and the highest in the poultry manure treatments. This was due to high concentration of nutrient and high growth of plants in poultry manure. Das et al. (1992) reported in rice that, application of poultry manure at 5 t ha^{-1} resulted in increased uptake of Ca, Mg, K and Fe. Dravid and Biswas (1996) found that phosphorus utilization was increased with application of poultry manures to wheat crop. Gupta et al. (1996) reported that application of poultry manure increased the N and P uptake. Poultry manure more readily supplies P to plants than other organic manure sources (Garg and Bahla, 2008). Application of poultry manure at 1.0 t ha^{-1} recorded maximum uptake of N, P and K by maize crop (249.2 kg, 43.9 kg and 170.7 kg ha^{-1} respectively (Itnal and Palled, 2001). In the present study total uptake (crop removal) of N, P, K, Ca and Mg were in the following corresponding ranges 17.42 - 198.72 kg ha^{-1}, 5.17 - 104.63 kg ha^{-1}, 15.55 - 391.05 kg ha^{-1}, 3.86 - 41.53 kg ha^{-1} and 2.46 - 36.26 kg ha^{-1}. Gao et al. (2009) observed 68-238 kg ha^{-1} N, 14-55 kg ha^{-1} P and 62-316 kg ha^{-1} K total uptake from soil under different fertilizer treatments in Northern China.

Table 4: Effects of fertilizer, compost and poultry manure on Ca and Mg uptake (g plant^{-1}) by maize

Treatment	Ca			Mg		
	Shoot	Root	Grain	Shoot	Root	Grain
T_1	0.05^{d}	0.01^{b}	0.00^{b}	0.03^{e}	0.00^{d}	0.00^{b}
T_2	0.15^{cd}	0.03^{b}	0.05^{a}	0.12^{d}	0.03^{cd}	0.06^{ab}
T_3	0.29^{ab}	0.06^{b}	0.05^{a}	0.15^{cd}	0.04^{cd}	0.07^{a}
T_4	0.28^{ab}	0.08^{b}	0.07^{a}	0.15^{cd}	0.03^{cd}	0.07^{a}
T_5	0.29^{ab}	0.07^{b}	0.05^{a}	0.15^{cd}	0.02^{cd}	0.06^{ab}
T_6	0.22^{bc}	0.04^{b}	0.03^{ab}	0.09^{de}	0.02^{cd}	0.06^{ab}
T_7	0.38^{a}	0.18^{a}	0.07^{a}	0.34^{a}	0.12^{a}	0.11^{a}
T_8	0.36^{a}	0.18^{a}	0.07^{a}	0.28^{ab}	0.10^{ab}	0.09^{a}
T_9	0.27^{abc}	0.09^{b}	0.06^{a}	0.22^{bc}	0.07^{abc}	0.07^{a}
T_{10}	0.22^{bc}	0.07^{b}	0.04^{ab}	0.17^{cd}	0.05^{bcd}	0.06^{ab}

Figures in the same column denoted by the same letter (s) did not differ significantly according to DMRT at $p<0.05$.

4. Conclusion

Poultry manure provided the highest nitrogen and other nutrients in soil which have contributed to their higher uptake by maize. However, the compost prepared from household waste also gave satisfactory results.

5. References

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