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Effects of Poultry Manure, Household Waste Compost and Inorganic Fertilizers on Growth and Yield of Maize (*Zea mays* L.)

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Abstract: *To observe the comparative effects of poultry manure, household waste compost and fertilizers and their combinations on growth and yield of maize (Zea mays L.), this experiment was conducted in the crop field of the Department of Soil Science, University of Chittagong, Bangladesh during Rabi season in 2010-2011. 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. Maize seeds were sown in the month of January, 2011 in lines 75 cm apart. Seed to seed distance was 25 cm. The results indicated that all the fertilizer treatments improved growth as shown by the number of leaves, length of root and shoot, dry weights of root and shoot. Better growth under fertilizer treatments resulted in higher yield of the crop. But there were significant differences among the fertilizer treatments. For example, the highest yield (6.65 t ha^{-1}) was obtained in the treatment with poultry manure alone and with 25% NPK + 75% poultry manure. These two treatments increased yield of maize by 579 percent over the control (no fertilizer). NPK alone (120 kg N, 60 kg P and 80 kg K) also increased yield but by 309 %. The treatment 50% NPK + 50% poultry manure increased yield by 499 %.*

Key words*: Yield, poultry manure, maize, growth compost.*

I. Introduction

Synthetic fertilizers have become the primary nutrient sources for agriculture over the last 50 years because of certain advantages behind their use. But their extravagant use has created several environmental problems. They may create soil acidity [1] and nutrient imbalance which may result in reduction of crop yield [2]). Chemical fertilizers are costly too, and are not always affordable to poor farmers [3]. Organic fertilizers including farm yard manure, composts, poultry manure, pig manure and sheep manure, etc. may be used for crop production as substitutes or supplements of the chemical fertilizers. 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 [4]. 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 [5].

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. 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 [6, 7]. Sustainable yield levels could be achieved only by applying appropriate combination of green manures or organic manures and chemical fertilizers [8, 9]. It is highly likely that the use of composted organic materials along with chemical fertilizers may be an effective approach for improving crop yield levels [10]. The integrated use of organic and inorganic nutrient sources was shown to increase the potential of organic fertilizer [11] along with improving the efficiency of inorganic fertilizers. So their use could be reduced up to certain levels. A balanced and integrated use of organic and inorganic nutrient sources may help sustain crop production. Improved yields of various crops have been reported by addition of organic manures [7, 12, and 13]

Maize is an important cereal crop that provides staple food to large number of human population in the world. It occupies third position in production next to wheat and rice in the world. Now maize is one of the most important food grains in the world as well as in developing countries. In Bangladesh, the cultivation of maize has been gaining popularity in recent years. The above facts have led to the undertaking of the present study on composting of household wastes and their application along with poultry manure and inorganic fertilizers to a maize crop in the crop field of the Department of Soil Science, University of Chittagong with a view to determine the optimum rate of poultry manure, household waste compost or their combination with inorganic fertilizers and their effect on growth and yield of maize (*Zea mays* L.).

II. Materials and Methods

2. 1. Field Experiment

A field experiment was conducted to study the effects of organic and inorganic fertilizers on the growth, yield and quality of Maize (*Zea mays* L.) during Rabi season in 2010-2011 at the Crop Field of the Department of Soil Science, University of Chittagong. For the study, poultry manure was obtained from nearby poultry farms. Separately compost was prepared from household wastes collected from some of the University Halls. Thirty experimental plots (2.2 m x 2.2 m) separated by 0.5 m margins were prepared in three adjacent blocks in the crop field. There were ten plots in each block for the ten treatment combinations comprising of poultry manure (PM), household waste compost and inorganic fertilizers- T1(Control), T2 (NPK alone @ 120 kg N ha^{-1}, 60 kg P ha^{-1} and 80 kg K ha^{-1}), T3 (Compost alone @ 30 t ha^{-1}), T4 (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), T5 (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), T6 (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), T7 (PM alone @30 t ha^{-1}), T8 (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), T9 (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), T10 (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 kitchen composts were applied basal at the final stage of soil preparation.

Maize variety Hybrid Corn seed 984 Gold (*984 F-1 Hybrid Thailand*) was used in the experiment. 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. Seedlings emerged after 6 to 7 days after sowing. One healthy seedling was retained in each point. There were finally eighteen plants in each plot. Irrigation was applied as and when necessary. The experimental plot was kept free of weeds by regular weeding. To control the pests and diseases, necessary plant protection measures including manual collection and destruction of *Helicoverpa armigera* larvae were done i.e. by using forceps, removal of infected plants leaf with knife also taken as and when required.

Plant height and number of leaves were recorded at 30, 60, 90 days after seedling emergence. The fruits were harvested when they were fully mature and turned to deep yellow colour after about four months. Dry weights of shoot and root, number of cobs and grain yield was recorded after harvest.

2. 2. Determination of Soil Properties

Soil texture was determined by hydrometer method [14], pH in a 1:2.5 soil/water suspension with glass electrode pH meter, organic carbon by wet-oxidation method [15], total nitrogen by micro-Kjeldahl digestion and distillation, available phosphorus by Bray and Kurtz-II method [16], and exchangeable potassium, calcium and magnesium by 1N NH_4OAC saturation [17]. 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. 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 [18] and SPSS version 12 [19] were used for these analyses.

III. Results

3. 1. Growth parameters of maize

Mean values of number of leaves per plant, plant height and root length and dry weight of shoot and root are given in Table 1. Number of leaf was the minimum at the control in all the periods of recording, 30 DAS, 60 DAS and at maturity. The corresponding values were 5.00, 7.00 and 9.33. Addition of all kinds of fertilizers, inorganic, compost and poultry manure increased the number of leaves significantly. Addition of NPK alone (treatment T2) increased the number to 6.00, 11.00 and 16.00 at the respective periods. Although higher than the control, compost alone treatment (T3; 5.67) had lower values than NPK alone. Poultry manure alone (T7) gave the highest number of leaves at all the periods, 30 DAS (7.67), 60 DAS (14.67) and maturity (23.00). Reducing the proportion of compost and increasing the proportion of inorganic fertilizers gave similar

values to the inorganic fertilizers. On the other hand, increasing the proportion of inorganic fertilizers and decreasing poultry manure reduced number of leaves over PM alone. However, at maturity, the number of leaves in treatments T7 (23.00), T9 (20.33), T8 (19.67), T10 (19.33) had number of leaves plant^{-1} statistically similar to each other.

Height of plants varied from 14.58 (control) to 25.89 cm (T7) at 30 DAS, 32.50 (control) to 133.22 cm (T7) at 60 DAS, and 50.42 (control) to 241.75 cm (T7). Thus, the minimum value was obtained in the control and the maximum values were always obtained with the PM alone. Fertilizer increased height of plants but at different rates with kind and combination. In compost alone the values were 19.28 cm at 30 DAS, 77.06 cm at 60 DAS, and 134.83 cm at maturity. NPK alone produced 21.75 cm at 30 DAS, 89.11 cm at 60 DAS and 156.47 cm at maturity. Values of plant height at maturity in treatments T7, T8 and T9 did not differ significantly. Plant height in NPK alone was significantly lower than PM alone. Fertilizer addition increased height of plants more than 2 to 5 times in different combinations.

Length of root was measured only at maturity. It was the minimum in the control (28.67) and maximum in T4 (49.33) treatment. Significantly similar root length to the maximum was obtained in the treatment T8 (46.00). The treatments T2 (36.67), T3 (39.33) and T6 (40.67) produced similar but lower than the maximum value. All other fertilizer treatment had intermediate root length.

Oven dry weight of shoot at maturity varied from 21.75 (control) to 140.27g (PM alone) plant^{-1} respectively (Table 1). The highest shoot weight was found with T7 (140.27 g) treatment and the lowest weight of shoot was observed with T1 (21.75 g) treatment. However, there was no significant difference between treatment T1 (21.75 g; Control) and T2 (56.91 g ; NPK alone) in case of shoot weight. The treatments T7 (140.27 g; PM alone), T8 (134.25 g; 50% NPK+ 50% PM) and T9 (108.58 g; 50% NPK+ 50% PM) were also statistically similar. Treatment T4 (72.58 g), T5 (80.95 g) and T6 (61.69 g) were statistically similar with treatment T3 (80.47 g; Compost alone) and are not significantly different from each other though these treatments were combinations of inorganic fertilizers and compost in different proportions.

Table 1 Growth parameters of maize under different fertilizer, manure and compost treatments

Treatment	Number of leaves plant^{-1}			Height of plants (cm plant^{-1})			Root length (cm plant^{-1})	Dry wt of Shoot (g plant^{-1})	Dry wt of Root (g plant^{-1})
	30 DAS	60 DAS	Maturity	30 DAS	60 DAS	Maturity			
T_1	5.00 d	7.00 d	9.33 d	14.58 c	32.50 e	50.42 e	28.67 e	21.75 d	3.71 e
T_2	6.00 c	11.00 bc	16.00 bc	21.75 abc	89.11 cd	156.47 cd	36.67 d	56.91 cd	14.97 de
T_3	5.67 c	10.00 c	14.33 c	19.28 abc	77.06 d	134.83 d	39.33 cd	80.47 bc	22.40 cde
T_4	6.00 c	11.00 bc	16.00 bc	20.00 abc	77.22 d	134.44 d	49.33 a	72.58 bc	23.07 cde
T_5	6.00 c	11.00 bc	16.00 bc	17.28 bc	76.16 d	135.05 d	42.33 bc	80.95 bc	18.63 de
T_6	6.00 c	10.67 bc	15.33 c	21.92 abc	76.78 d	131.64 d	40.67 cd	61.69 bcd	14.99 de
T_7	7.67 a	14.67 a	23.00 a	25.89 a	133.22 a	241.75 a	41.00 c	140.27 a	55.42 a
T_8	7.00 b	13.33 a	19.67 ab	24.70 ab	125.11 ab	224.33 ab	46.00 ab	134.25 a	51.73 ab
T_9	6.67 b	13.33 a	20.33 a	23.97 ab	120.78 ab	217.58 ab	39.00 cd	108.58 ab	43.12 abc
T_{10}	6.00 c	12.67 ab	19.33 ab	22.64 ab	106.33 bc	190.03 bc	42.33 bc	85.10 bc	29.84 bcd

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

Root dry weight of maize at harvest ranged from 3.71 (T1-Control) to 55.42g (T7-PM alone) plant^{-1}. The treatments T2 (14.94g; NPK alone), T3 (22.40g; Compost alone), T4 (23.07 g; 25% NPK+ 75% Compost), T5 (18.63 g; 50% NPK+ 50% Compost) and T6 (14.99 g; 75% NPK + 25% Compost) did not show any significant difference from treatment T1. In treatments T8 (51.73 g; 25% NPK+ 75% PM), T9 (43.12 g; 50% NPK+ 50% PM) and T10 (29.84 g; 75% NPK+ 25% PM) where increasing proportion of inorganic fertilizer with decreasing amount of poultry manure combination show statistically similar dry weight of root compared with treatment T7 where poultry manure alone was added.

3. 2. Yield parameters of maize

Number of cobs plant^{-1}, weight of 50 grains, grain yield and yield increase over control at harvest grown under different treatments are presented in Table 2. The highest value of number of cobs plant^{-1} was found in treatment T7 (1.17; poultry manure alone) and the lowest was in treatment T1 (0.63; Control). There were no significant differences among the treatments except T1. In other words all the fertilizer treatments increased number of cobs plant $^{-1}$ to the same extent. It also indicated that NPK alone (1.13 cobs plant^{-1}), compost alone (1.00 cobs plant^{-1}), poultry manure alone (1.17 cobs plant^{-1}) and their different combinations had similar effects on number of cobs.

Weight of fifty grains varied from 9.76 (T1-Control) to 14.14 g (T7- poultry manure alone). Although there were different kinds of fertilizer combinations with poultry manure and kitchen waste compost and also

compost and poultry manure, there was no significant difference observed in weight of 50 grains. Therefore, grain sizes in all the treatments were similar.

Grain yield ranged from 0.98 (T1-Control) to 6.65 ton ha^{-1} (T7- Poultry manure alone and T_8 - 25% NPK+ 75% Poultry manure). The treatment T2 (4.01 ton ha^{-1}; NPK alone) differed significantly from the treatment T1 (Control), though there were no significant differences among the treatments T3 (4.89 ton ha^{-1}; Compost alone), T4 (5.04 ton ha^{-1}; 25% NPK+ 75% Compost), T5 (4.59 ton ha^{-1}; 50% NPK+ 50% Compost) and T6 (4.18 ton ha^{-1}; 75% NPK + 25% Compost). The treatment T8 (6.65 ton ha^{-1}; 25% NPK+ 75% Poultry manure) and T9 (5.87 ton ha^{-1}; 50% NPK+ 50% Poultry manure) showed similar results compared with the treatment T7 where full poultry manure was added.

Table 2 Yield parameters of maize under different fertilizer, manure and compost treatments

Treatment	Number of cobs $plant^{-1}$	Weight of 50 grains (g)	Grain Yield (ton ha^{-1})	Yield increase (%)
T_1	0.63 b	9.76 b	0.98 d	0 d
T_2	1.13 a	13.00 a	4.01 c	309 c
T_3	1.00 a	12.71 a	4.89 bc	399 bc
T_4	1.10 a	13.29 a	5.04 bc	414 bc
T_5	1.07 a	12.72 a	4.59 bc	368 bc
T_6	1.10 a	12.82 a	4.18 c	327 c
T_7	1.17 a	13.64 a	6.65 a	579 a
T_8	1.10 a	14.14 a	6.65 a	579 a
T_9	1.07 a	13.34 a	5.87 ab	499 ab
T_{10}	0.97 a	12.75 a	5.08 bc	418 bc

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

Yield increase of maize in treatments T7 (poultry manure alone) and T8 (25% NPK+ 75% Poultry manure) over control was 579 %. The treatment T2 (309 %; NPK alone) significantly differ from the control treatment. Yield increase in treatments T3 (399 %; compost alone), T4 (414 %; 25% NPK+ 75% Compost), T5 (368 %; 50% NPK+ 50% Compost) and T6 (327 %; 75% NPK + 25% Compost) were statistically similar but significantly different from the control treatment. Increasing the proportion of inorganic fertilizer with decreasing poultry manure in treatment T9 (499 %) and T10 (418 %) reduced yield increase than that of T7.

IV. Discussion

The results of the present study indicated that the experimental soil was very poorly fertile, and profitable crop growing without fertilizer application is not feasible there. All the fertilizer treatments improved growth as indicated by the number of leaves, length of root and shoot, dry weights of root and shoot. Better growth under fertilizer treatments resulted in higher yield of the crop. But there were significant differences among the fertilizer treatments. For example, the highest yield (6.65 t ha^{-1}) was obtained in the treatment with poultry manure alone and with 25% NPK + 75% PM. These two treatments increased yield of maize by 579 percent over the control (no fertilizer). NPK alone (120 kg N, 60 kg P and 80 kg K) also increased yield but by 309 %. The treatment 50% NPK + 50% PM increased yield by 499 %.

Earlier Obi and Ebo [9] observed that addition of poultry manure at 10 t ha^{-1} significantly improved average maize height and seed yield. Application of poultry manure along with recommended dose of fertilizer produced taller plants (187.5 cm), longer cobs (14.35 cm) with bigger diameter (15.6 cm) and heavy weight of cobs (170.5 g cob^{-1}) than application of only inorganic fertilizers [20]. Poultry manure has long been recognized as the most desirable organic fertilizer. It improves soil fertility by adding both major and essential nutrients as well as soil organic matter which improve moisture and nutrient retention [21]. Addition of N and P fertilizer enhances root development, which improves the supply of other nutrients and water to the growing parts of the plants, resulting in an increased photosynthetic area and thereby more dry matter accumulation [22]. Reports of nutrition studies carried out in the tropics have shown significant increase in plant height, number of branches per plant leaf area index, crop growth rate total dry matter and grain yield per unit area due to nitrogen and phosphorus application [23].

Poultry manure at 1.0 t ha^{-1} has shown significantly higher weight of cob, number of grains per cob, grain weight per cob and 100 grain weight of maize crop over vermi-compost and FYM [24]. The application of poultry manure at 1.0 t ha^{-1} recorded significantly higher seed yield (5.05 t ha^{-1}) of maize over no application (4.12 t ha^{-1}) and it was on par with application of FYM at 10 t ha^{-1} (4.75 t ha^{-1}) [25]. Nagaraj et al.[26] reported that application of poultry manure at 5 t ha^{-1} gave significantly higher grain yield of maize (5.15 t ha^{-1}) among organic and was followed by FYM at 10 t ha^{-1} (4.57 t ha^{-1}) and incorporation of green leaf manure at 5 t ha^{-1} (4.48 t ha^{-1}). Chandrasekhar et al. (2000)[20] observed that the application of poultry manure at 10 t ha^{-1} along with 150:75:37.5 kg NPK ha^{-1} (100% recommended dose of fertilizer) recorded significantly higher grain (5.08 t ha^{-1}) and fodder yields (7.44 t ha^{-1}) than application of vermicompost at 2.5 t ha^{-1}, FYM and only RDF alone.

The percent increase in grain yield with application of poultry manure, vermicompost and FYM was 33, 16 and 14% respectively over chemical fertilizer alone. Results of these studies supported findings of the effects of poultry manure on growth and yield of maize. However, the yield of maize in the control plots of the present study was much lower than those obtained in the above mentioned investigations. There was only 0.98 t ha^{-1} yield of grains in the control treatment. Actually, the crop failed in the control plots. Poor fertility and poor physical conditions may be the reasons of this failure. Maintenance of the fertility status of the soil is an important aspect to obtain a stable and sustainable yield.

Although not very high, reasonable increases in the yield of maize was obtained by the use of inorganic fertilizers alone (NPK alone). The yield of grain value in NPK alone plots was 4.01 t ha^{-1}. Benefits of N fertilization toward increasing grain yields in maize have been extensively documented [27, 28]. Probably the dose of NPK used as NPK alone in the present investigation was not adequate for maize in this low fertility soil. The soil initially contained only 0.08 percent total nitrogen. In NPK alone, 120 kg ha^{-1} of nitrogen was used. In relation to the native N, this amount appears to be low. Nitrogen deficiency or excess can result in reduced maize yields. Maize nitrogen requirement can be as high as 150 to 200 kg per hectare. However, nitrogen requirement and utilization in maize also depend on environmental factors like irrigation, varieties and expected yield [29]. Hardas and Aragiaanne-Hrestos [30] reported that N 180 kg ha^{-1} was optimum for maize. Singh et al. [31] also reported that application of N 200 kg ha^{-1} increased grain yield of maize. The efficiency of the applied N to satisfy the N demand of the crop depends on the type of fertilizer, timing of fertilizer application and seasonal trends [32, 33]. Crop response to N fertilizer is also influenced by soil type, crop sequence and the supply of residual and mineralized N [34]. However, the overall performance of the crop was satisfactory. More than 4.0 t ha^{-1} yields were obtained in plots where fertilizers combinations were applied. In the present experiment, yield ranged from 4.01 to 6.65 t ha^{-1} in the amended plots. Poultry manure alone and poultry manure in combination with NPK always gave higher growth and yield than compost combinations and NPK alone.

One of the objectives of the present study was to observe the efficiency of composts prepared from house-hold wastes in increasing yield of crops. In this direction, household wastes were regularly collected for a period of two months from several student halls of the University of Chittagong and the collected materials, mixture of vegetable and animal origin, were allowed to decompose. When decomposed to a satisfactory level, the compost was applied to the field and maize was grown in combination with other treatments in the present experiment. Compost (30 t ha^{-1}) and partial compost and NPK fertilizers increased growth and yield of maize over control but not to the same extent as poultry manure. Compost alone gave a yield of 5.04 t ha^{-1}.

V. Conclusion

Application of poultry manure, household waste compost and NPK fertilizers alone or in combination in the poorly fertile soil of the crop field of the Department of Soil Science, University of Chittagong, enhanced growth and yields of maize. Ten treatments were applied and on the basis of growth and yield the treatments can be ranked as T7 (Poultry manure alone) = T8 (25% NPK+ 75% Poultry manure) > T9 (50% NPK+ 50% Poultry manure) >T10 (75% NPK+ 25% Poultry manure) > T4 (25% NPK+ 75% Compost) > T3 (Compost alone) >T5 (50% NPK+ 50% Compost) > T6 (75% NPK + 25% Compost) > T2 (NPK alone) > T1 (control). However, the compost prepared from the household wastes also gave satisfactory yields.

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