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Growth and Yield of Hybrid Maize as Influenced by Fertilizer Management

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ABSTRACT

An experiment was carried out at the Agronomy Field Laboratory, Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Bangladesh during the *rabi* season (December to May), 2012-13 to study the effect of different organic and inorganic fertilizers on growth and development of hybrid maize (Denali). The experiment was laid out in Randomized Complete block Design with three replications with 30 plots. Ten fertilizer treatments (T_1= Compost, T_2= Cow dung, T_3= Poultry manure, T_4= Recommended fertilizer dose, T_5= Compost + Half recommended fertilizer dose, T_6= Compost + Full recommended fertilizer dose, T_7= Cow dung + Half recommended fertilizer dose, T_8= Cow dung + Full recommended fertilizer dose, T_9= Poultry manure + Half recommended fertilizer dose, T_{10}= Poultry manure + Full recommended fertilizer dose. The recommended fertilizer dose was 500 Kg ha^{-1} urea + 250 Kg ha^{-1} TSP + 200 Kg ha^{-1} MP + 15 Kg ha^{-1} $ZnSO_4$ + 6 Kg ha^{-1} Boric Acid. And the rate of Compost, Cow dung and Poultry manure was 10t/ha. The effect of different manure and fertilizer doses on the yield and yield attributes were significant. The plant height, number of leaves per plant, weight of stem per plant, weight of leaves per plant, length of cob, grain weight per cob, diameter of cob, no. of grains per row, no. of total grains per cob, 1000-grain weight, yield $plant^{-1}$, yield ha^{-1} were significantly affected by different manures and fertilizer uses with different doses. The treatments T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} gave grain yield 10.16, 9.09, 8.49, 14.34, 13.35, 18.12, 11.99, 17.09, 11.40 and 15.98 t ha^{-1}, respectively. The T_6 Treatment gave higher grain yield (18.12) t ha^{-1} and the T_3 treatment performed lowest grain yield (8.49 t ha^{-1}). The application of compost and full dose fertilizer is higher yielding. Balance nutrition with enough organic matter enrichment of the soil is the cause of this result.

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Introduction

Maize (*Zea mays* L.) is one of the most important crops cultivated throughout the world (FAO, 2009) as food, feed and industrial raw material which ranked third largest cereals following rice and wheat respectively (Dilshad et al., 2010). It is one of the efficient crops which can give high biological yield as well as grain yield in short period of time due to its unique photosynthetic mechanism (C_4 plant). Maize is the most important staple food for poor households in the developing world accounting for 73% in Sub Saharan Africa, 46% in South Asia, and 44% in Latin America. In the developed countries, maize is mainly used as animal feeds accounting for 70% of total usage (Bekele et al., 2011). At present maize is a major crop among the cereals of Bangladesh because of its highest yield potentiality and uses. Maize is well suited to the existing agro-climate condition and cropping pattern of Bangladesh. The production area of maize is increasing day by day. Presently, the crop covers an area of about 375628 acres and produces 887391 metric ton in this country (BBS, 2010).

Maize is a multipurpose crop. It contains about 80% starch, 10% proteins, 4.5% oil, 3.5% fiber and 2% minerals (Reddy, 2006). Every part of the plant and its products are used in one form or the other. Grain can be used for human consumption in various ways such as by frying into khoi, roast cobs or popped grain, flour, Chattu etc. and the green part of the plant can be used for feed to

cattle. As a commercial crop, maize is used for manufacturing starch, corn flakes, alcohol etc. As a food it can be consumed directly as green cobs, roast cobs or popped grain, flour, Chattu, poultry feed and its stalk can be used as cattle feed. Maize grain consumption (currently about 1.2 million tons per year) in Bangladesh is directly related to the poultry industry (FAO, 2010).

For maximum production of hybrid maize judicious management is very much important. Manure and fertilizer management is one of the most important factors for securing good yield of maize. Most of the farmer in our country used only high doses of chemical fertilizers for higher production. But it is already known that only the use of chemical fertilizer cause higher cost and toxic for land. The use of costly chemical fertilizers can be minimized or replaced by the use of locally available organic manures (Hegde, 1998). Furthermore, integrated use of organic and inorganic manures sustains the productivity of soil and crops in an integrated cropping system. This approach restores and sustains soil health and productivity in the long run, besides meeting the nutritional needs of crops (Satyajeet et al., 2007).

Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Sharma and Mittra, 1991). Improvement of environmental conditions and public health concerns as well as the need to reduce the cost of fertilizing crops are also important reasons for advocating increased use of organic materials (Seifritz, 1982). Application of organic manures also improves the soil physical and microbial properties (Belay et al., 2001).

Finally, to elucidate the growth and yield performance of hybrid maize was carried out to know the effect of organic and inorganic fertilizer on growth and yield of hybrid maize.

Materials and Methods

An experiment was conducted at the Agronomy Field Laboratory of Hajee Mohammad Danesh Science and Technology University, Bangladesh during the period from December 2012 to April 2013 to study fertilizer management on maize field of Denali hybrid maize variety. The study included variety- Denali hybrid maize; Fertilizer doses viz, T_1= Compost, T_2= Cow dung, T_3= Poultry manure, T_4= Recommended fertilizer dose, T_5= Compost + half recommended fertilizer dose, T_6= Compost + full recommended fertilizer dose, T_7= Cow dung + half recommended fertilizer dose, T_8= Cow dung + full recommended fertilizer dose, T_9= Poultry manure + half recommended fertilizer dose, T_{10}= Poultry manure + full recommended fertilizer dose. A Randomized Complete Block Design was used with three replications. The size of a unit plot was 4.2 m × 2.5 m. Total number of plots was 30.

Land preparation started in mid-December and fertilizers were applied as per treatment specification. In hybrid maize, the recommended fertilizer dose was 500 Kg ha^{-1} urea + 250 Kg ha^{-1} TSP + 200 Kg ha^{-1} MP + 15 Kg ha^{-1} Gypsum + 6 Kg ha^{-1} Boric Acid. The rate of Compost, Cow dung and Poultry manure was 10 t ha^{-1}. Seeding was done on 22 December 2012 at a spacing of 70 cm × 25 cm. The grain cobs were harvested on 10 April 2013. Observations were made in the respect of plant height, number of leaves per plant, weight of stem per plant, weight of leaves per plant, length of cob, grain weight per cob, diameter of cob, no. of rows per cob, no. of grains per row, no. of total grains per cob, 1000-grain weight, grain yield cob^{-1}, grain yield ha^{-1} and stover yield per plant.

Design of The Experiment and Layout

The experiment was laid out in a Randomized Complete Block Design with three replications. The whole experimental area was first divided into three blocks. Each block was later divided into 10 plots. The size of each unit plot was 4.2 m × 2.5 m. Total number of unit plots are 30. The individual plots and the blocks were separated for irrigation drainage by 1.0 m and 1.5 m channels, respectively.

Detailed Procedures of Recording Of Data

Plant height was measured from the base of the plant up to the tip of the tallest leaf. Total number of leaves per plant from the sample plants was counted and recorded. Weight of dried leaves was taken by using an electric balance. Weight of dried stem was taken by using an electric balance. Weight of cob was taken by using an electric balance. Cob length was recorded from the base to the apex of each cob. Cob diameter was recorded from averaged three point of each cob. Total number of rows per cob from the sample plants was counted and recorded. Total number of grains per row from the sample plants was counted and recorded. Total number of grains per plant from the sample plants was counted and recorded. One thousand clean dried grains were counted from the grains obtained from sample plants of each plot and weighed by using an electric balance and recorded. Grains obtained from each unit plot were sun-dried at l4% moisture and weighed carefully. The dry weights of grains of 10 sample plants were added to the respective plot yield to record the final grain yield/plant (g). Grains obtained from each unit plot were sun-dried at l4% moisture and weighed carefully. The dry weights of grains of 10 sample plants were added to the respective plot yield to record the final grain yield ha^{-1}. After separation of grain from cob weight of dried portion was taken by using an electric balance.

Statistical Analysis

The collected data were compiled and tabulated before statistical analysis. Analysis of variance (ANOVA) was done with the help of a computer package (MSTAT-C) (Russel, 1986). Differences among the treatment means were determined using the Duncan's Multiple Range Test (DMRT) comparison method (Gomez and Gomez, 1984).

Results and Discussions

Plant Height

The plant height of Denali hybrid maize variety significantly varied due to different treatments tested. All the treatments gave different plant height due to the different treatments ranging from 213.6 to 149.6 cm. The maximum plant height (213.6 cm) was obtained when T_6 treatment was applied. It was also found that the lowest

plant height (149.6 cm) was noted with the treatment T_3 (Table 1). The result may be the highest due to the use of compost with full recommended dose of fertilizer contains with all nutrients in balanced dose ultimately the plant may able to complete its growth in proper time with faster speed. On the other hand the lowest plant height was observed in the treatment T_1 which contains only compost and cow dung. For that reason, the plant height may become lower due slow supply of nutrients.

Number of Leaves Per Plant

The number of leaves per plant of different treatments varied from 12.47 to 10.17 and the maximum and the minimum number of leaves per plant were found in the treatment T_6 and T_1, T_2 respectively. In T_6 treatment recorded the highest number of leaves per plant which was statistically similar with T_8 and T_{10} with the value of 12.37 and 12.43, respectively. Application of T_1 and T_2 treatments recorded the lowest number of leaves per plant (10.17) which was statically similar with T_3 treatment with the value of 10.30 (Table 1). The result may be highest due to the compost with full dose of fertilizer make the plant vigorous in its growth resulting higher number of leaves per plant observed. Besides this only compost or cow dung may not be able to supply balance nutrients for increasing number of leaves per plant.

Weight of Leaves Per Plant

Weight of leaves per plant of Denali hybrid maize varied significantly due to different treatments. The weight of leaves per plant ranged from 46.28 to 29.66 g. The highest value (46.28 g) was experienced in the treatment T_6 which statistically significant with T_8 and T_{10} treatments with the value of 46.09 and 45.53 g, respectively. The lowest weight of leaves (29.66 g) was obtained in the treatment T_3 which statistically significant with T_1 and T_2 with the value of 29.80 and 29.67 g, respectively (Table 1). The result may be highest due to the highest supply of nutrients from compost with full dose of fertilizers which makes the leaves cells more strong resulting increasing in dry weight of leaves. On the other hand only, compost cow dung or poultry manure unable to supply sufficient food of the leaves resulting lowest in dry weight. Similar result was found by Meille and Pellerin (2008).

Stem Weight Per Plant

A significant variation in the parameter was noted due to different fertilizer treatments. The weight of stem per plant due to different treatments ranged from 80.13 g to 34.17 g. The highest value (80.13 g) of stem weight per plant manifested with the treatment T_6 which was statistically similar with T_8 and T_{10} with the values of 72.07 g and 70.48 g respectively. T_3 treatment produced the lowest value (34.17 g) of stem weight per plant which was statistically similar with T_1 and T_2 treatment with the value 34.97 g and 35.22 g respectively (Table 1). The result of increasing stem weight was directly controlled by the combination of compost and full dose chemical fertilizer. The finding may be due to that with the treatment T_6 the cell of the stem may be more closer srtonger causes increasing in weight. In case of treatement T_1, T_2 and T_3 the result in vice versa.

Weight of Cob

Cob weight of Denali hybrid maize varied significantly due to different treatments. The weight of cob ranged from 351.3 to 170.5 g. The highest value (351.3 g) was experienced in the treatment T_6. The lowest number of cob weight value (170.5 g) was obtained in the treatment T_3 (Table 1). Research output might be the highest due to the compost and full recommended fertilizer dose and the cob may store highest amount of food from green parts of plants which causes increased weight of cob. Besides poultry manure unable to make plant srong that is why cob weight also lowest.

Cob Length

The length of cob was significantly varied by the use of compost and chemical fertilizers. It was showed that the cob length ranged from 22.45 to 5.15 cm. The highest cob length (22.45 cm) was found in the T_6 treatment. The lowest result (15.15 cm) was recorded in T_2 treatment which was statistically significant with T_3 treatment with the value of 15.43 cm (Table 1).

Table 1 Yield and yield attributes of hybrid maize (Denali) as influenced by the organic and inorganic treatments

TC	PH	LNP	WDLP	WSP	WC	CL	CD	NRC	NGR	NGC
T_1	154.7^{f}	10.17^{c}	29.80^{d}	34.97^{e}	191.8^{g}	16.06^{e}	13.07^{e}	15.27^{c}	35.13^{g}	537.3^{f}
T_2	153.1^{f}	10.17^{c}	29.67^{d}	35.22^{e}	180.2^{h}	15.15^{f}	12.73^{ef}	15.20^{c}	32.93^{h}	504.6^{g}
T_3	149.6^{g}	10.30^{c}	29.66^{d}	34.17^{e}	170.5^{i}	15.43^{f}	12.44^{f}	15.23^{c}	31.93^{i}	493.5^{g}
T_4	187.8^{c}	11.10^{b}	41.55^{b}	62.30^{bc}	271.4^{d}	18.59^{c}	16.07^{c}	16.87^{b}	41.87^{c}	685.0^{c}
T_5	182.9^{d}	11.13^{b}	36.09^{c}	56.70^{cd}	254.2^{e}	18.47^{c}	16.10^{c}	16.53^{b}	40.53^{d}	670.9^{c}
T_6	213.6^{a}	12.47^{a}	46.28^{a}	80.13^{a}	351.3^{a}	22.45^{a}	18.56^{a}	18.67^{a}	48.63^{a}	798.3^{a}
T_7	179.2^{e}	11.03^{b}	35.85^{c}	49.14^{d}	231.9^{f}	17.64^{d}	14.52^{d}	16.57^{b}	39.00^{e}	630.1^{d}
T_8	205.6^{b}	12.37^{a}	46.09^{a}	72.07^{ab}	324.4^{b}	20.19^{b}	17.27^{b}	18.67^{a}	44.87^{b}	758.6^{b}
T_9	178.0^{e}	11.23^{b}	35.66^{c}	48.68^{d}	225.3^{f}	17.47^{d}	14.38^{d}	16.47^{b}	38.10^{f}	595.3^{e}
T_{10}	203.4^{b}	12.43^{a}	45.53^{a}	70.48^{ab}	304.4^{c}	20.60^{b}	17.03^{b}	18.70^{a}	44.23^{b}	738.4^{b}
LSD	2.723	0.466	1.686	11.310	8.986	0.482	0.601	0.925	0.705	25.90
CV%	0.88	2.42	2.61	12.28	2.05	1.54	2.31	3.21	1.04	2.32

TC: Treatment combination; PH: Plant height (cm); LNP: Leaves number plant^{-1}; WDLP: Weight of dry leaves plant^{-1}; WSP: Weight of stem plant^{-1}; WC: Weight of cob (g); CL: Cob length (cm); CD: Cob diameter (cm); NRC: Number of rows cob^{-1}; NGR: Number of grains row^{-1}; NGC: Number of grains cob^{-1}

Increasing of the cob length due to the application of T6 treatment for the reason of proper nutrient supply to the cob. There for the length was increased but in case of T_2 the cob may devoid from recommended demand of nutrients resulting the lowest length of cob Bukhsh et al. (2012) was found similar result.

Cob Diameter

The effect of different fertilizer and organic manures treatment on cob diameter was significant. The cob diameter varied from 18.56 to 12.44 cm due to different treatments. The highest cob diameter (18.56 cm) was in T_6 treatment. The least value (12.44 cm) of cob diameter was recorded in the treatment T_3 that was statistically similar with T_2 treatment with the value of 12.73 cm, respectively (Table 1). Research outcome might be due to that with the application of compost with full dose of fertilizer. The cob able to make its vigorous growth which causes increase in diameter. Sufficient nutrient supply may enhance the individual size of grain finally increase in cob diameter. But in case of only poultry manure it might be vice versa.

Number of Rows Per Cob

A significant variation of number of rows per cob was noted due to different fertilizer treatments. The number of rows cob^{-1} due to different treatments ranged from 18.70 to 15.20. The highest value (18.70) of number of rows per cob manifested with the treatment T_{10} which was statistically similar with T_6 and T_8 with the values of 18.67 and 18.67, respectively. T_2 treatment recorded the lowest value 15.20 in the number of rows per cob. This treatment was statistically similar with T_1 and T_3 treatment with the value 15.27 and 15.23 respectively (Table 1). This result indicate that combined application of organic and inorganic fertilizer increases the number of rows per cob of hybrid maize. The result may be the highest due to the application of T_6 treatment and the plant become more vigorous in growth which increases pollination of flower and increased the number of rows per cob.

No of Grains Per Row

A significant variation in number of grains per row was reflected due to combined application of compost and fertilizers. The number of grains per row varied from different treatments. The maximum (48.63) and the minimum (31.93) number of grains per row were found in the treatment T_6 and T_3, respectively (Table 1). The reason behind the result might be taken into consideration is that in their cases also enhance the amount of pollination that is why all grains may become vital and uniform. For this reason, the highest number of grains per row may be obtained in the application of the compost and full recommended fertilizer dose. For the application of poultry manure it might lack pollination and result was minimized.

No of Grains Per Cob

The effect of different fertilizer and organic manures on number of grains per cob was significant. The number of grains per cob varied from 798.3 to 493.5 due to different treatments. The number of highest grains per cob was (798.3) in treatment T_6 (Table 1). The least number (493.5) of grains per cob was recorded in the treatment T_3 that was statistically similar with T_2 treatment. The result might be due to highest supply of nutrient. Similar results were found by Meille and Pellerin (2008) and Bukhsh et al. (2012).

1000-Grain Weight

The result draws the attention about the effect of organic manures and inorganic fertilizer on 1000-grain weight of hybrid maize and the variation in weight was slim due to different treatments. The highest value (389.1 g) was noted in the treatment T_6 (Fig. 1). The lowest value (292.4 g) in the treatment T_3. Similar result was found by Jalali et al. (2010). Research output is such due to best development of each grain by T_6 treatment which causes highest 1000-grain weight.

Grain Yield Per Cob

The effect of incorporation of various types of organic and inorganic fertilizers on hybrid maize yield was found statistically significant. The highest grain yield per cob (302.1 g) was recorded in T_6 treatment. On the other hand, the lowest grain yield per cob (140.7 g) was observed in T_3 treatment (Fig. 2). Size of grain might be uniform and highest in weight which increase grain yield per cob Nagaraj et al. (2004) and Tasneem et al. (2004) were found similar result.

Grain Yield Per Hectare

A significant variation of grain yield was noted due to different fertilizer treatments. The grain yield per hectare due to different treatments ranged from 18.12 to 8.49 t ha^{-1}. The highest value (18.12 t ha^{-1}) of grain yield per hectare manifested with the treatment T_6. T_3 treatment produced the lowest value (8.49 t ha^{-1}) of grain yield per hectare (Fig. 3). The result might be able to that their treatment increases individual grain weight as result the per hectare yield of grain increase. Nagaraj et al. (2004); Channabasavanna (2002) and Tasneem et al. (2004) were found similar result.

Stover Yield Per Cob

The effect of different fertilizers and organic manures treatment on stover yield per cob was statistically significant. The stover yield per cob varied from 41.24 to 20.75 g due to different treatments. Stover yield per cob was highest (41.24 g) with T_6 treatment. The least value (20.75 g) of stover yield per cob was recorded in the treatment T_3 that was statistically similar with T_1 and T_2 treatments with the value of 21.55 g and 21.20 g, respectively (Fig. 4). This variation of result might be due to application of various manures and various doses of chemical fertilizer with alone or combined. Achieng et al. (2012) was found the similar result.

Soil Available Nitrogen (SAN, kg ha^{-1})

The soil available nitrogen represents a fraction of the total nitrogen susceptible to absorption by plant. Nitrogen is generally taken up by the plant in the form of nitrate $N0_3$ form under aerobic and as NH_4 ions under anaerobic condition of plant growth showed by Jat et al. (2013).

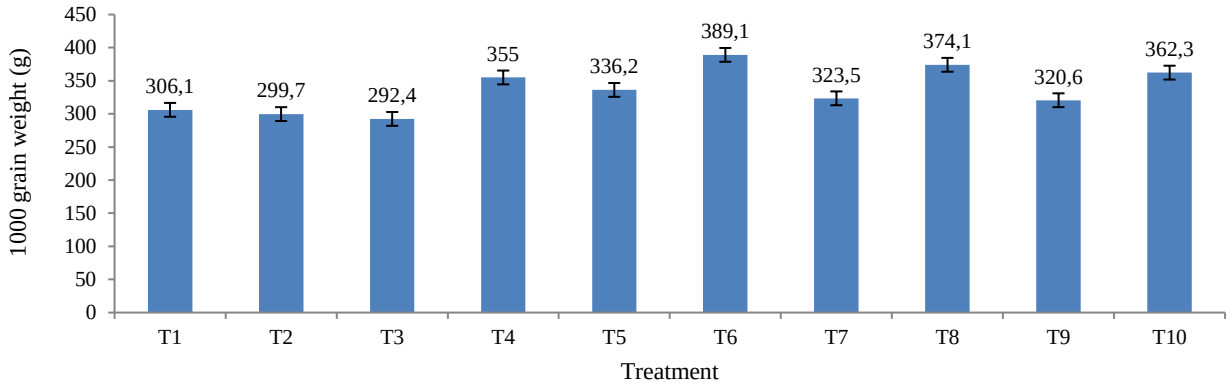

Figure 1 Effect of fertilizer treatments on 1000-grain weight on hybrid maize

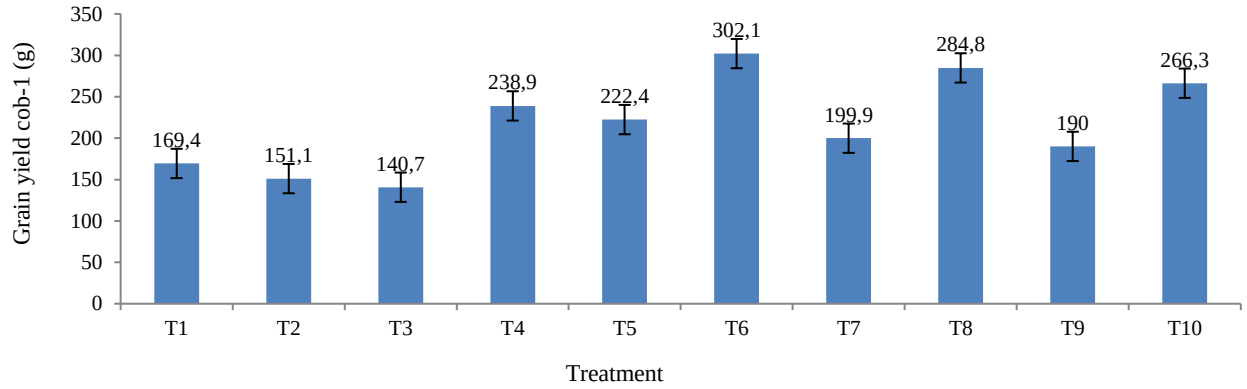

Figure 2 Effect of fertilizer treatments on grain yield per cob on hybrid maize

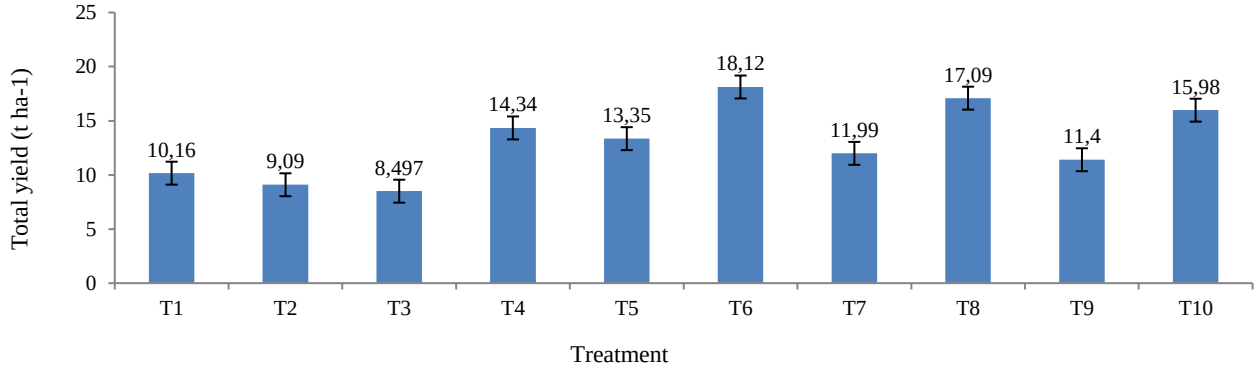

Figure 3 Effect of fertilizer treatments on grain yield ha^{-1} on hybrid maize

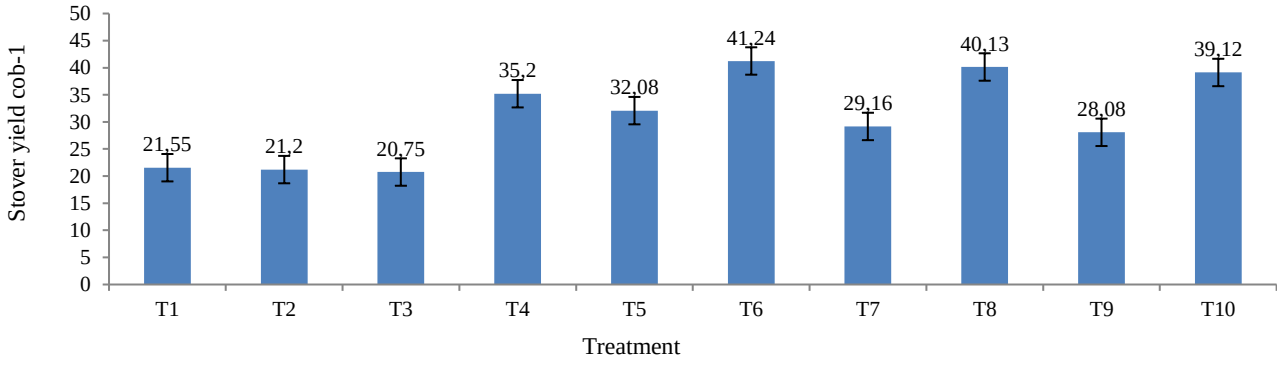

Figure 4 Effect of fertilizer treatments on stover yield per cob on hybrid maize

Highly significant difference was recorded among the treatments used in the trial on soil available nitrogen after maize harvest. Compare to control T_1 (Cow dung) which was recorded with the lowest SAN (370.05 kg ha^{-1}) and other treatments after harvest, T_{10} (Poultry manure + full recommended fertilizer dose) was recorded with the highest SAN (537.16 kg ha^{-1}) which contains a combination of organic and inorganic sources of nutrients and which was found to be statistically the same with T_6 (Compost + Full recommended fertilizer dose) (Table 2). The above result was in similar position with Sharma et al. (2012) who reported that application of FYM along with RDF increases overall land productivity than sole use of inorganic fertilizer and Chaudhry et al. (2009) revealed that integration of organic and inorganic sources of nutrient improved soil fertility status.

Table 2 Soil properties after harvest influenced by the organic and inorganic treatments

Treatments combination	Soil Available N (kg/ha)	Soil Available P (kg/ha)	(%) Soil Organic Carbon
T_1	370.05^{c}	12.30^{c}	0.66^{d}
T_2	477.35^{ab}	13.26^{c}	0.87^{c}
T_3	540.45^{b}	14.97^{b}	1.45^{a}
T_4	420.54^{bc}	9.40^{d}	1.30^{b}
T_5	435.86^{b}	13.34^{c}	1.31^{b}
T_6	508.66^{ab}	17.69^{ab}	1.45^{ab}
T_7	510.45^{ab}	9.80^{d}	0.84^{c}
T_8	499.56^{b}	13.35^{c}	1.51^{a}
T_9	489.76^{b}	16.65^{b}	1.45^{ab}
T_{10}	537.16^{a}	19.68^{a}	1.43^{ab}
LSD	69.95	1.50	0.18
CV%	2.5	1.5	1.05

Soil Available Phosphorus (SAP, kg ha^{-1})

The available soil P performed so many functions including root development, carbohydrate metabolism, flowers, seeds and fruit formation, formation of high energy bond in ATP and so showed by Jat et al. (2013). Highly significant difference was recorded due to effect of organic and inorganic fertilizers on SAP after harvest. Compared with the rest of the treatments used in this trial T_4 (full recommended dose of fertilizer) was found to have lowest SAP (9.4 kg ha^{-1}) whereas, T_{10} (Poultry manure + full recommended dose of fertilizer) was recorded with highest SAP (19.68 kg ha^{-1}) more than any of the treatments used which was found to be statistically the same with T_6 (Compost + Full recommended fertilizer dose) in their action towards improvement of SAP (Table 2). The result obtained are in similar position with Sharma et al. (2012) who reported that application of FYM along with RDF increases overall land productivity than sole use of inorganic fertilizer as well as Chaudhry et al. (2009), who shows that integration of organic and inorganic sources of nutrient improved soil fertility status.

Soil Organic Carbon SOC (%)

Carbon was considered as the major constituent of organic matter and the estimation of organic matter are carried out through organic carbon which is considered to be about 58% of soil organic matter Jat, et al. (2013). Highly significant increase of SOC was observed due to the treatments effect on soil after harvest. The maximum increased of SOC (1.51%) at harvest was observed in plot containing the T_8 (Cow dung + Full recommended fertilizer dose) which was statistically same with T_3, T_6, T_9 and T_{10} and these resulted in superior growth and development of crop in such plots during the period of the trial, whereas the lowest increased (0.66%) among the treatments was observed in T_1 where only compost was used (Table 2). This result was similar to the reports shown by Sarwar et al. (2012) who reported that replacement of 25% or 50% N with organic manure increases the organic matter content in the soil after harvest as well as Kannan et al. (2013) who shows that integration of organic and inorganic nutrients sources resulted in maximum organic carbon whereas Ravi et al. (2012) reported that soil organic matter increases when poultry litter was applied on maize.

Conclusion

A significant variation was observed among the treatments in respect of different parameters of hybrid maize. From the discussion it could be concluded that the application of compost 10000 Kg ha^{-1} combined with chemical fertilizers of 500 Kg Urea ha^{-1}, 250 Kg TSP ha^{-1}, 200 Kg MoP ha^{-1}, 15 Kg Gypsum ha^{-1}, 6 Kg Boric acid ha^{-1} increased the yield of hybrid maize than the single use or combination of cow dung and poultry manure with chemical fertilizers.

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