Pak. J. Agri. Sci., Vol. 51(1), 41-47; 2014
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

IMPACT OF LEVEL AND SOURCE OF COMPOST BASED ORGANIC MATERIAL ON THE PRODUCTIVITY OF AUTUMN MAIZE (*Zea mays* L.)

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Organic manure from different sources could be an effective substitute of chemical fertilizers. Therefore, the present study compares the effect of varying level (0, 2, 4, 6, 8, 10 t ha^{-1}) of two types of compost, i.e poultry manure compost (PM compost) and press-mud compost (PrM compost) on the yield of maize. The experiment was conducted at Agronomic Research Area, University of Agriculture Faisalabad, Pakistan for two consecutive years 2011 and 2012. Results of this study revealed that all the levels and sources of compost based organic material had significant effect on the yield and yield parameters of autumn maize. Maximum plant height, cob diameter, cob length, cob weight, number of grain rows per cob, number of grains per cob, 1000-grain weight biological yield, grain yield and harvest index were produced by the application of 10 t ha^{-1} PM compost. Whereas, the number of cobs per plant was not significantly affected by level and source of compost based organic material. It was concluded that 10 t ha^{-1} PM compost could be used lucratively for optimizing maize yield.

Keywords: Autumn maize, organic manure, compost, nutrition, yield

INTRODUCTION

Maize is serving as food for significant amount of world population (FAO, 2009). It is extensively grown in temperate, subtropical and tropical region of the world (Chaudhary, 1983; FAO, 2009). In Pakistan, it is also widely cultivated and utilized (Kara, 2001), but farmers of Pakistan are attaining its low yield due to deficiencies of certain nutrients (especially nitrogen and phosphorous) and organic matter in the soil (Hussain *et al.,* 2006). Maize requires heavy doses of nutrients for its better production. Consequently, astute dose of nutrients through appropriate and efficient source become essential (Tolessa and Friesen, 2001).

Sole application of chemical fertilizers to meet the crop nutrient demand is deleterious for both soil and environment health (Tolessa and Friesen, 2001). It is costly input and usually unavailable to farmer at peak season. Hence, organic manures from different sources could be an effective substitute of chemical fertilizers which improve the crop yield and soil properties (physical and chemical) as well (Jamwal, 2005). It has also been proved that organic sources contribute a lot in organic matter percentage in the soil (Pathak *et al.,* 2005; Iqbal *et al*., 2012). Thus, under prevailing conditions application of organic manures becomes a promising solution (Prabu *et al*., 2003).

Among the different organic manures poultry manure and press-mud are the important source of nutrients and organic matter. Different field studies confirmed the effectiveness of these manures in crop production (Khan, 2008; Muhammad and Khattak, 2009). However, the effectiveness of these manures varies considerably in its composted and non-composted form (Farhad *et al.,* 2011). It is observed that composting of these wastes gave a valuable product, which is proven to be more supportive to plant growth (Sarangi, 2009). So far, the optimum dose of these organic manures is still not known to meet the crop demand. Therefore, the present study was planned to examine the yield of autumn maize under different level and source of compost based organic material.

MATERIALS AND METHODS

The proposed trial was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during two growing seasons of 2011 and 2012. The experimental soil was analyzed for the chemical analysis (Table 1). Soil texture was classified as a Cambisol according to the FAO/WRB (FAO, 1998). Soil ECe was determined by the Conductivity Bridge method (Jackson, 1973) and soil pH was measured potentiometrically with glass electrode in a mixture of soil: water at ratio of 1:2.5 w/v (Sparks, 1996). However, soil organic matter was determined by the Modified Walkley-Black procedure according to Nelson and Sommers (1982). While N was determined by the Kjeldahl method (Bremner, 1965). For available P Olsen method according to Black (1965) was followed and for available K flame photometry was employed (Knudsen *et al.,* 1982).

Table 1. Chemical analysis of experimental soil before experimentation

Determination	Units	Value
Soil type	-----	Sandy loam
Sand	%	65
Silt	%	17
Clay	%	18
ECe	(dSm^{-1})	0.41
pH	-----	8.4
Organic matter	%	0.62
Nitrogen	%	0.044
Available P	ppm	7.09
Available K	ppm	151

The total rainfall, maximum, minimum and average temperatures, net sunshine and average relative air humidity data for 2011 and 2012 during the autumn maize growing period (June-November) were collected from the meteorological observatory of the Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan and are shown in Fig. 1.

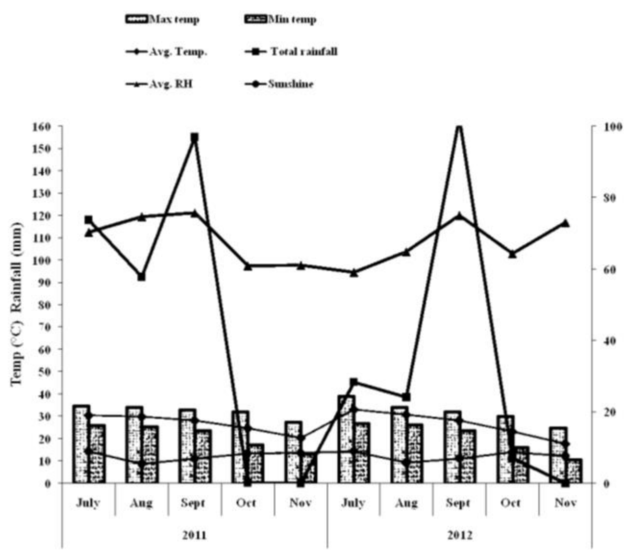

Figure 1. Meteorological data showing mean monthly minimum, maximum and average temperature, total rainfall, sunshine and average relative humidity during the growing seasons of autumn maize (2011 and 2012)

The experiment was laid out in Randomized Complete Block Design with three replications. The designed treatments were 0, 2, 4, 6, 8 and 10 t ha^{-1} PM compost (poultry manure compost) and PrM compost (press-mud compost). The compost was produced in two steps using the PM (poultry manure) and PrM (press-mud) collected from sugar mill and poultry sheds, respectively. In first step, PM and PrM were put in the pits according the capacity of pits for aerobic decomposition. In addition, urea was added to increase the microbial population for enhancing the rate of decomposition. The pit size was 3 m x 3 m x 1.20 m. In the second step, partial decomposed material from the pits was placed into heaps for further decomposition. The heaps were kept moist by watering every week (Rahman, 2009).

Maize hybrid Pioneer 30Y87 was sown on 75 cm apart ridges by manual dibbling method (by placing two seeds manually per hill at 25 cm apart hills) on well prepared seed bed. All the NPK demand of the crop was fulfilled by the PM compost and PrM compost according to the treatments. PM and PrM composts were analyzed for various chemical parameters before their application to the experiment (Table 2). Irrigations were applied with fifteen days intervals. Crop was kept weeds free by hoeing twice to avoid weed crop competition. All other agronomic practices were kept constant and uniform for all treatments.

Standard procedures were followed to collect the data for yield parameters. Ten plants from each plot were selected at random and their height was measured with the help of measuring tape and then averaged. Total number of cobs from each plot was divided by total number of plants to get number of cobs per plant. Cobs from randomly selected 10 plants were removed and their diameter (with the help of Vernier Caliper) and length (cm) were measured and then averaged. Cob weight was determined by selecting the ten cobs from each plot and averaged them.

Table 2. Chemical analysis of PM compost and PrM compost

	Determination	Composition (%)	
		2011	**2012**
A	**PM compost**		
	Nitrogen	2.51	2.57
	Phosphorous	1.85	1.88
	Potassium	1.91	1.97
	Dry matter	73.0	74.06
B	**PrM compost**		
	Nitrogen	0.90	0.98
	Phosphorous	0.54	0.61
	Potassium	0.77	0.80
	Dry matter	44.99	45.03

For number of grain rows per cob, grain rows were counted from ten selected cobs from each plot and then averaged. Grains from 10 randomly selected ears of each treatment were shelled, counted and converted into average number of grains per cob. Similarly, 1000 grains were counted at random from each sub plot of each treatment and weighed at 10-12% moisture content. Four rows were harvested and data on biological yield were recorded as weight of stalk along with husk at harvest. After shelling the cob weight was also added to the weight of each sub plot and then converted into t ha^{-1}. The grain yield was determined by harvesting four central rows in each subplot. The cobs from harvested plants were detached and then threshed, weighed and converted into t ha^{-1}. Harvest index (HI) of each plot was calculated by using the formula given by Hunt (1978)

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

The data were analyzed statistically using Fisher's analysis of variance technique and LSD at 5% probability was used to compare the differences among treatments' means (Steel *et al*., 1997).

RESULTS

Comparison of treatments' means showed that during 2011 as well as in 2012 plant height was significantly affected by the different level and source of compost based organic material. Data (Table 3) further indicated that year effect on plant height was also significant, because taller plants were produced in 2011 than in 2012. In 2011, maximum plant height was produced by the application of 10 t ha^{-1} PM compost. It was, however, statistically at par with 8 t ha^{-1} PM compost. Minimum plant height was produced by the control (unfertilized). Almost similar trend was observed in the following year (2012).

The data regarding the number of cobs per plant as affected by level and source of compost based organic material are given in Table 3, which revealed that treatments had no significant effect on parameter under discussion. Year showed insignificant effect on the number of cobs per plant.

Results disclosed (Table 3) that cob diameter was significantly affected by the different treatments of rate and source of compost based organic material during both years. However, year effect on cob diameter was non-significant. In 2011, statistically maximum cob diameter was produced with 10 t ha^{-1} PM compost and it was found at par with 8 t ha^{-1} PM compost. Whilst, the minimum cob diameter was recorded in the control where no fertilizer was applied. Similar trend was observed in 2012.

The outcomes regarding the cob length (Table 3) showed that cob length varied significantly due to application of different treatments during 2011 and 2012. Nonetheless, year showed no significant effect on cob length. During 2011, maximum cob length was observed in plots where the 10 t ha^{-1} PM compost was applied. It was however, found statistically at par with 8 t ha^{-1} PM compost and 10 t ha^{-1} PrM compost. The minimum cob length was noted in control plots. Similar results were observed in the next year of experiment (2012).

It is clear from the data presented in Table 3 that different level and source of compost based organic material differed significantly among themselves in producing the cob weight. Results further revealed that year had no significant effect on the cob weight. During 2011, more cob weight was recorded with the addition of 10 t ha^{-1} PM compost and it was not found statistically dissimilar with 8 t ha^{-1} PM compost and 10 t ha^{-1} PrM compost. Whereas, minimum cob weight was attained in control where no fertilizer was applied. Almost similar trend was recorded in 2012.

The outcomes related the number of grain rows per cob (Table 4) showed that influence of various level and source of compost based organic material was significant on number of grain rows per cob in 2011 and in 2012. Furthermore, the parameter under discussion was also

Table 3. Impact of level and source of composted organic material on plant and cob of maize

Treatments (compost)	**Plant height (cm)**		**Number of cobs per plant**		**Cob diameter (cm)**		**Cob length (cm)**		**Cob weight (g)**	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Control	184.7 g	178.2 h	1.03	1.07	3.12 e	3.02 d	13.04 g	12.96 h	94.6 g	91.1 h
2 t ha^{-1} PM	215.8 ef	207.1 efg	1.07	1.10	3.57 d	3.23 cd	15.67 ef	15.30 fg	155.5 ef	151.4 fg
4 t ha^{-1} PM	221.7 cde	215.7 cde	1.07	1.17	3.72 d	3.39 c	18.11 cd	17.27 de	179.9 cde	173.2 de
6 t ha^{-1} PM	234.9 bc	221.3 cd	1.07	1.13	4.13 bc	3.78 b	20.51 b	19.48 bc	198.1 bc	192.3 cd
8 t ha^{-1} PM	248.7 ab	232.5 ab	1.00	1.07	4.31 ab	4.12 a	22.47 a	21.69 a	223.9 a	215.3 ab
10 t ha^{-1} PM	254.3 a	239.2 a	1.03	1.10	4.40 a	4.16 a	22.52 a	22.11 a	231.8 a	226.5 a
2 t ha^{-1} PrM	204.2 f	200.1 g	1.10	1.00	3.49 d	3.13 cd	15.12 f	14.60 gh	137.4 f	133.4 g
4 t ha^{-1} PrM	212.5 ef	204.1 fg	1.10	1.17	3.51 d	3.17 cd	15.42 ef	15.17 fg	144.0 f	141.9 g
6 t ha^{-1} PrM	219.4 def	211.2 def	1.07	1.27	3.63 d	3.31 cd	16.80 de	16.49 ef	169.0 de	164.8 ef
8 t ha^{-1} PrM	231.8 cd	219.7 cd	1.00	1.13	4.04 c	3.73 b	19.72 bc	18.44 cd	186.4 cd	180.7 de
10 t ha^{-1} PrM	236.6 bc	225.4 bc	1.13	1.10	4.15 bc	3.92 ab	21.35 ab	20.33 ab	211.8 ab	204.21 bc
LSD value (0.05)	15.36	11.07	1.03	1.07	0.25	0.32	1.65	1.80	24.85	20.16
Year Effect	224.06 a	214.05 b	1.12	1.06	3.82	3.54	18.25	17.62	24.85	20.16
LSD value (0.05)	9.61		NS		NS		NS		NS	

PM compost = Poultry manure compost; PrM compost = Press-mud compost; Means sharing similar letter(s) within a column do not differ significantly at p = 0.05

Table 5. Impact of varying level of composted organic manures on yield and harvest index of maize (%)

Treatments	Biological yield (t ha^{-1})		Grain yield (t ha^{-1})		Harvest index (%)	
	2011	2012	2011	2012	2011	2012
Control	9.59 g	9.48 g	2.15 i	2.10 i	22.40 e	22.25e
2 t ha^{-1} PM compost	13.51 d	12.82 de	3.44 fg	3.22 g	25.48 cd	25.19 cd
4 t ha^{-1} PM compost	15.68 c	14.99 c	4.28 e	4.01 e	27.33 cd	26.70 bc
6 t ha^{-1} PM compost	16.24 c	16.11 bc	4.94 cd	4.56 d	30.40 ab	28.32 b
8 t ha^{-1} PM compost	17.55 ab	16.88 ab	5.72 ab	5.48 b	32.55 a	32.46 a
10 t ha^{-1} PM compost	18.21 a	17.80 a	6.08 a	5.87 a	33.38 a	32.98 a
2 t ha^{-1} PrM compost	11.77 f	11.01 f	2.87 h	2.65 h	24.41 de	24.22 de
4 t ha^{-1} PrM compost	12.53 e	12.15 ef	3.12 gh	2.98 g	24.89 de	24.52 cd
6 t ha^{-1} PrM compost	14.07 d	13.30 d	3.83 f	3.50 f	27.22 cd	26.33 bcd
8 t ha^{-1} PrM compost	16.02 c	15.73 bc	4.55 de	4.41 d	28.38 bc	28.02 b
10 t ha^{-1} PrM compost	17.11 b	16.77 ab	5.33 bc	5.19 c	31.17 ab	30.94 a
LSD value (0.05)	0.73	1.15	0.44	0.27	3.02	2.23
Year Effect	14.75 a	14.28 b	4.21 a	3.99 b	27.97	27.45
LSD value (0.05)	0.32		0.16		NS	

PM compost = Poultry manure compost; PrM compost = Press-mud compost; Means sharing similar letter(s) within a column do not differ significantly at p = 0.05

significantly affected by the year. More number of grain rows per cob was recorded in 2011 than in 2012. Maximum number of number of grain rows per cob were noticed where 10 t ha^{-1} PM compost was applied and it was however, found statistically at par with 8 t ha^{-1} PM compost. The minimum number of grain rows per cob was observed in control where no fertilizer was applied. Almost similar trend was observed in 2012.

Data pertaining to the number of grains per cob revealed that all the treatments exhibited significant effect on the parameter under discussion during both years. Year effect was also significant with relatively more number of grains per cob in 2011 than 2012. In 2011, more number of grains per cob was obtained by the application of 10 t ha^{-1} PM compost that was statistically at par with number of grains per cob attained from 8 t ha^{-1} PM compost. However, minimum number of grains per cob was obtained in control where no fertilizer was applied. Same pattern of results was observed in the following year of experiment (2012).

Results presented in Table 4 revealed that 1000-grain weight remained significant due to influence of various treatments during both years (2011 and 2012). Effect of year was also found significant on parameter under study. Highest 1000-grain weight was obtained in the year 2011 than in 2012. Statistically, maximum increase in 1000-grain weight was observed with the fertilization of 10 t ha^{-1} PM compost that was recorded statistically at par with 8 t ha^{-1} PM compost and 10 t ha^{-1} PrM compost. Whereas, maximum decline in 1000-grain weight was observed in control. Almost, similar results were recorded in 2012.

Results indicated (Table 5) that there was a significant increase in the biological yield with the fertilization of different level and source of compost based organic material during both years. Year had also significant effect on the biological yield. Significantly maximum biological yield was recorded in 2011 as compared to biological yield attained in 2012. During 2011, 10 t ha^{-1} PM compost gave maximum increase in biological yield which was not dissimilar to the biological yield obtained with 8 t PM ha^{-1} compost. Whilst, minimum biological yield was attained in unfertilized control. Almost, same results were obtained in 2012.

The grain yield of maize differed significantly due to varying level and source of compost during 2011 and 2012. Year had also significant effect on the grain yield. In 2011, more grain yield was recorded as compared to grain yield in 2012. In first year of experiment (2011), maximum increase in grain yield was observed where10 t ha^{-1} PM compost was applied to maize. It was however, statistically at par with 8 t ha^{-1} PM compost. While, significantly maximum decline in grain yield was observed in control (unfertilized). Same pattern of results was noted in 2012.

Data concerning the harvest index (Table 5) reflected that all the treatments exhibited significant effect on the parameter under study. However, year effect was insignificant on harvest index. In the first year of experiment (2011), highest value of harvest index was noted by the application of 10 t ha^{-1} PM compost that was found statistically not different from 8 t ha^{-1} PM compost and 10 t ha^{-1} PrM compost. Whereas, minimum value of harvest index was given by control (no fertilizer). Almost similar trend was noted in following year (2012).

DISCUSSION

In general, outcomes of the two years field studies indicated that PM compost and PrM compost levels showed significant effects on all the tested yield parameters of autumn planted maize except the number of cobs per plant.

Plant height is an important parameter. Maximum, plant height was produced with 10 t ha^{-1} PM compost in both years. These results might obtain due to rapid mineralization (Antil *et al.*, 2012) and better availability of nutrient throughout the growing period (Amanuallah *et al.*, 2010; Dev-Raj and Antil, 2012). Significant effect of application of highest rate of PM compost on plant height has also been reported by other scientists (Ayoola and Makinde, 2009; Achieng *et al.*, 2010). Moreover, highest plant height was observed in 2011 over that of 2012 because of favourable temperature and more rainfall in 2011 (Fig. 1).

During both years of experiment, number of cobs per plant remained unaffected due to application of varying level of PM compost and PrM compost. This was possibly due to varietal character of used hybrid (Pioneer 30Y87). Non-significant effect of different sources of organic manures on cobs per plant has also been reported by other researchers (Maqsood *et al.*, 2001; Farhad *et al.*, 2009; Iqbal, 2010).

Cob length, diameter and weight being important yield attributes contribute more to grain yield by influencing the number of grains per cob and grain size. In present research, applied treatments remarkably affected the cob length, diameter and weight. Nonetheless, as compared to other treatments 10 t ha^{-1} PM compost gave maximum increase in cob length, diameter and weight. Such results were might be obtained because of better cob development on account of improved supply of micro and macro nutrients (Amanuallah *et al.*, 2010). These results are in line with the findings of Khan (2008) and Iqbal (2010) who also claimed comparable effect of increased level of organic manure on cob diameter, length and weight of maize. Maize growth is affected by manure application (Tahir *et al*., 2012).

Number of grain rows per cob and number of grains per cob are also important yield contributing parameters. Promoting effect of different level and source of compost based organic material was observed on number of grain rows per cob and number of grains per cob. Maximum increase in above mentioned parameters in response to 10 t ha^{-1} PM compost might be due to fact that a soil which receives organic manures has more nitrogen supplying capacity compared to chemical fertilizer (Gunapala and Scow, 1998). Improvement in soil physical properties with highest rate of PM compost could be another possible reason of such results. Moreover, this level of PM compost might have corrected the deficiency of nutrients other than NPK. Whilst minimum number of grain rows in control treated plants was because of commonly absence of more than one entire grain rows in cobs; called zipper pattern (Nielsen, 2010). Similarly, Warren *et al*. (2006) and Khan (2008) also reported minimum number of grain rows in control. However better results of above mentioned parameters were attained in 2011 than in 2012. This was due to optimum environmental conditions (temperature, relative humidity and rainfall) during 2011.

Weight of 1000 grains shows the amount of photo-assimilates translocation in the economic parts compared with vegetative parts. More the grain weight higher will be the economic yield. In 2011 and 2012 highest 1000-grain weight was attained in case of 10 t ha^{-1} PM compost. This was due to more translocation of photo-assimilates into grain. Nevertheless, the production of photo-assimilates was triggered by optimum provision of nutrients. Insufficient supply of nutrients might be reason of decline in 1000-grain weight with lower rates of PM and PrM compost. Similar results were obtained by Bajpai *et al.* (2002) and Pooran *et al*. (2002) due to increased level of PM compost. In addition, during 2011 more 1000-grain weight was attained than in 2012. More temperature, sunshine and rainfall might be reasons of maximum 1000-grain weight in 2011.

Biological and grain yield depend upon the physiological functions carried out during growth and development as a result of uptake of nutrients. The highest biological and grain yield at 10 t ha^{-1} PM compost was due to better physiological functions under optimum nutrients supply (Nevens and Reheul, 2003). It was observed that nitrogen application significantly influenced the total dry matter, chiefly by increasing the LAI. Hence, the variation in grain yield due to different rate and source of compost was related to the differences in size of photosynthetic surface and to the relative efficiency of total sink activity (El-Yazied *et al.*, 2007; Mansouri *et al.*, 2010). It has been stated that nitrogen has far more potent influence on the total photosynthesis of plants through its effect on the leaf area (Watson, 1952). However, cumulative behavior of the yield contributing parameters (cob length, cob diameter, number of grains per cob, grain weight per cob and 1000-grain weight) against the 10 t PM compost (Khan, 2008) would be another possible reason of such results. Furthermore, compost might have posed considerable impact in improving soil health (Melero-Sanchez *et al.*, 2008) and ultimate increased crop productivity (Dev-Raj and Antil, 2012). Our results were in agreement with previous studies conducted by Ayoola and Makinde (2009), and Dev-Raj and Antil (2012). More grain and biological yield in 2011 than in 2012 was due to optimum environmental conditions during 2011 which might have supported the different growth stages of crop plant.

HI (Harvest index) reflects physiological efficiency of crop to partition the dry matter into its grain yield. Significantly, highest harvest index was attained at 10 t ha^{-1} PM compost compared to unfertilized control. This reflects the more portioning of dry matter into grains produced through higher rate of photosynthesis. Nonetheless, minimum harvest index in control was possibly due to minimum production of dry matter on account of inadequate nutrients supply. Similarly, Khan (2008) and Farhad *et al.* (2009) also reported maximum HI by the increased rate of organic manure.

Conclusion**:** The present study inferred that among different level and source of compost based organic material, 10 t ha^{-1} PM compost could be applied successfully for optimizing maize yield. The novelty of our approach is that it compared the consequences of various level and source of compost based organic materials on the productivity of maize simultaneously. In future, further level and source of compost based organic material could be tested for optimizing the maize yield.

Acknowledgement**:** The authors acknowledge the support provided by the Analytical Lab, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan.

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