African Journal of Agricultural Research Vol. 7(17), pp. 2713-2719, 5 May, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.2255
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Effect of organic and inorganic fertilizer on maize hybrids under agro-environmental conditions of Faisalabad-Pakistan

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Accepted 27 March, 2012

Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Furthermore, maize (*Zea mays* L.) crop is the 3rd cereal crop of Pakistan after wheat and rice. According to the economic survey of Pakistan, it is cultivated on the area of approximately, 1.11 million hectare and production from this area was 4.04 million tones. A field experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad-Pakistan to examine the effect of organic and inorganic fertilization on maize productivity. The experiment was laid out in Randomized Complete Block Design (RCBD), with four replications. Two maize hybrids were used in this experiment. The results showed that maize yield and its component such as cobs per plant, cob length, number of grains per cob, 1000-grain weight were maximum when the plots were fertilized at 100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as poultry manure. Further research is desired to investigate maximum yield by using organic source of fertilizer than inorganic source of fertilizer to avoid lethal effects on human health created by inorganic fertilizers.

Key words: Organic farming, maize productivity, inorganic fertilizer, semi-arid conditions, Pakistan.

INTRODUCTION

Maize is one of the most widely distributed crops of the world (Kaul et al., 2011). This crop being the highest yielding cereal crop in the world is of significant importance for countries like Pakistan, where rapidly increasing population has already out stripped the available food supplies. In Pakistan, maize is the third important cereal after wheat and rice (Bukhsh et al., 2011). It accounts for 4.8% of the total cropped area and 3.5% of the value of agricultural output (Khaliq et al., 2011). Furthermore, it is grown on about 1118 thousand hectares with annual production of 4036 thousand tones of grain and average yield of 3598 kg ha^{-1} (GOP, 2010).

Intensive cropping system requires highly fertilized soils and those soils should be maintained through integrated plant nutrient management system (Bationo and Koala, 1998). Organic manure provides many advantages such as improves soil tilth, aeration, water holding capacity

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Abbreviations: **GOP,** Government of Pakistan; **RCBD,** randomized complete block design; **FYM,** farm yard manure; **NPK,** nitrogen-phosphorus-potash; **TSP,** triple super phosphate; **SOP,** sulphate of potash; **PM,** poultry manure; **PH,** plant height; **LAI,** leaf area index; **PP,** plant population.

and stimulates micro-organisms in the soil that make plant nutrients readily available (Choudhary and Bailey, 1994; Lal, 1997). The fertilization can affect enzymatic activities inside the soil profile (Yang et al., 2008; Zhu et al., 2008). Proper application of organic and inorganic fertilizers canincrease the activities of soil micro-organisms and enzymes and soil available nutrient contents (He and Li, 2004; Saha et al., 2008). He and Li (2004) indicated that combined application of organic and inorganic fertilizers can increase the activities of soil invertase and available nutrient content. Furthermore, the application of organic manure mixed up with chemical fertilizer can prove to be an excellent procedure in maintaining and improving the soil fertility, and increasing fertilizer use efficiency. For this reason, it could be helpful to study the effect of application of organic manure combined with chemical fertilizer by using integrated nutrient management system, which has been the research focus all over the world (Reganold, 1995; Liu et al., 1996). In addition, application of organic manure could improve the soil quality and is more profitable in environment protection when compared with application of chemical fertilizer alone (Reganold, 1995). The soil with organic manure continually applied had lower bulk density and higher porosity values, porous and buffering capacities (Edmeades, 2003). The influence of different nutrients applied to soil on farmland ecosystem was different (Yang et al., 2004). Therefore, the present study was carried out to evaluate the effect of different corn hybrids under the integrated use of organic and inorganic fertilizers under the agro-climatic conditions of Faisalabad-Pakistan.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at Agronomic Research Area, University of Agriculture, Faisalabad (31.26°N, Longitude 73.06°E and Altitude 184 m), and Pakistan during the autumn season of 2008. Faisalabad shows the semi-arid environmental conditions Nasim et al. (2011).

Experimental design and treatments

The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement having three replications keeping net plot size as 7.0 × 3.8 m. Two maize hybrids (H_1 = Pioneer-3062, H_2 = Pioneer-3061) with best qualities (sown in may till mid July, takes 90 to 100 days for maturity, cobs are long with full size of grains resistant to diseases and finally bear the capacity of drought tolerance (Ali et al., 2004; Salah et al., 2011), were sown in main plots and different fertilizer levels (F_1 = control, F_2 = whole N as urea, F_3 = whole N as farmyard manure (35.31 t ha^{-1}), F_4 = whole N as poultry manure (P.M) (12.98 t ha^{-1}), F_5 = half N as FYM (19.01 t ha^{-1}) + 100 kg N ha^{-1} as urea, F_6 = half N as P. M. (7.01 t ha^{-1}) + 100 kg N ha^{-1} as urea) were kept in the sub plots. Whole N indicated 200 kg N ha^{-1} while half N shows 200 kg N ha^{-1} in the fertilizer treatments.

Crop management strategy

The crop was sown on 29th of July, 2008 (Figure 1) manually with the help of dibbler keeping recommended distance of ridges and plants (P × P = 20 cm, R × R = 70 cm) with seed rate of 25 kg ha^{-1}. A recommended fertilizer amount of NPK (200: 100: 75, kg ha^{-1}) was applied. The sources of fertilizer were urea, TSP, SOP, FYM and PM used and amounts of P and K were adjusted with TSP and SOP including quantity of P and K received by FYM and PM. The fertilizers were used in such a way that half the amount of N from urea and full amount of P, K, FYM and PM were applied at the time of sowing, while the remaining half amount of the urea was applied with second irrigation according to the treatments. All the cultural practices (hoeing, weed management, irrigation and plant protection measures etc) were kept normal for the crop.

Final harvest data

The crop was harvested when it completed its physiological maturity at (2nd November, 2008). The parameters that were recorded during the course of study included days taken to 50% tasseling and silking, leaf area index (LAI) at tasseling, total dry matter (g m^{-2}) at tasseling, plant population (m^{-2}), number of grains (m^{-2}), mean grain weight (g), grain yield (kg ha^{-1}) and harvest index (%).

Total number of plants per plot was counted at final harvest from an area of 1 m^2, the number of grains was counted from randomly selected sample of ten cobs $plot^{-1}$ and then average number of grains (m^{-2}) was calculated. Furthermore, after threshing of crop, thousand grains were taken from each plot and weighed, as well as, total grain weight was recorded from each plot and finally, grain yield (on hectare basis) was calculated, respectively. As the harvest index (%) was measured as it is the ratio of economic yield to the biological yield in percentage. In addition, quality parameters (grain oil and protein contents) were also observed at the final harvest (Nasim et al., 2012).

Statistical analysis

The data collected during the season were statistically analyzed by using the computer statistical program MSTAT-C. Analysis of variance technique was employed to test the overall significance of the data, while the least significance difference (LSD) test at P = 0.05 was used to compare the differences among treatment means (Steel et al., 1997).

RESULTS AND DISCUSSION

Soil, growing media and environmental conditions

The chemical analysis of experimental site was carried out prior to sowing of the crop. All the characteristics of experimental soil such as soil texture, structure and soil pH etc and other parameters are shown in Table 1.

The analysis of FYM and PM were carried out (Table 2). The detailed weather conditions (minimum and maximum temperature, solar radiation and precipitation) are explained in Figures 1 and 2 that were observed during the crop cycle.

50% tasseling and silking (days)

Data (Table 3) showed that maize hybrids had non-

Table 1. The chemical analysis of experimental location under agro-climatic conditions of Faisalabad-Pakistan.

Characteristics	Unit	Value
Soil texture		Silty clay loam
Organic matter	%	1.21
Total nitrogen	%	0.06
Phosphorus (available)	ppm	0.99
Potassium (available)	ppm	178
Soil pH	-	7.6
Soil EC	dS m^{-1}	1.5

Table 2. The chemical analysis of organic manures under agro-climatic conditions of Faisalabad-Pakistan.

Characteristics	Unit	Values	
		*FYM	**PM
Dry matter	%	19.99	47.0
Moisture	%	78.00	51.0
Nitrogen	%	0.57	1.51
Phosphorus	%	0.26	0.78
Potassium	%	0.63	0.37

*Farm yard manure, **poultry manure.

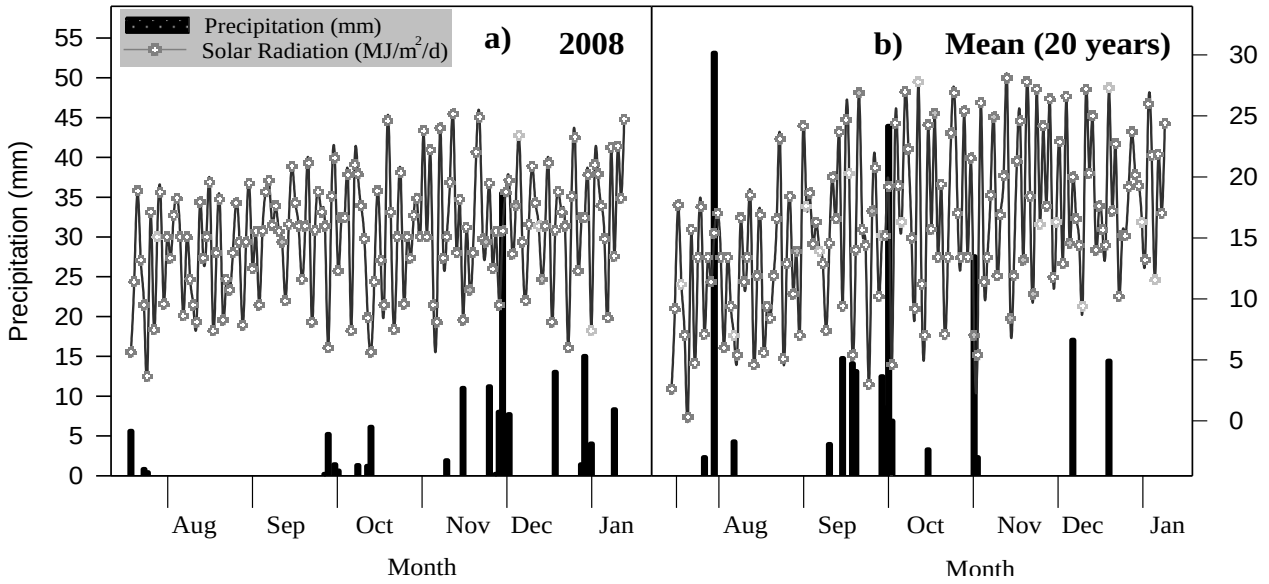

Figure 1. Mean monthly solar radiation and precipitation under agro-environmental conditions of Faisalabad Pakistan (2008 and mean of 20 years).

significant effect on days taken to 50% tasseling on an average that this period extended from 48.26 to 52.95 days. The organic and inorganic fertilizers that were applied to maize significantly affected the duration of tasseling. The assessment of individual treatment means indicated that maximum number of days to tasseling (52.95) was taken where maize crop was fertilized with 100 kg N ha^{-1} as poultry manure + 100 kg N ha^{-1} as urea (F_6) but statistically at par with other treatments except control (F_1). The period of silking was delayed in Pioneer-3061 as compared to Pioneer-3060. Furthermore, fertilizer application affected days taken to 50% silking as it was observed in tasseling. Maximum number of days to 50% silking (56.55) was noted in plots where maize crop

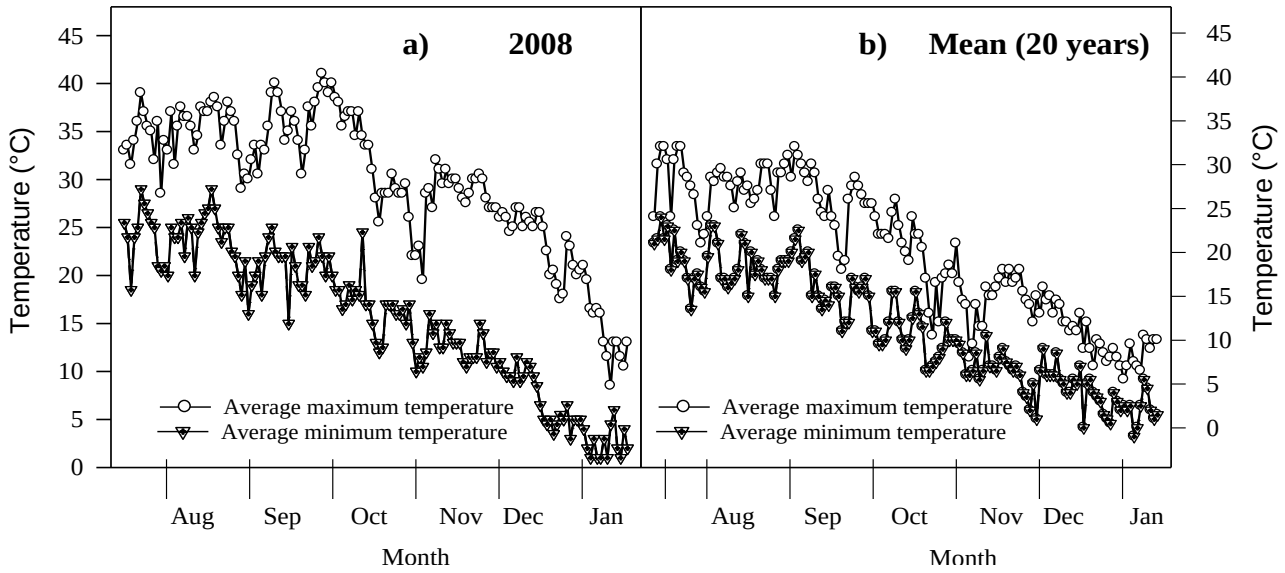

Figure 2. Mean monthly temperature (minimum & maximum) under agro-environmental conditions of Faisalabad-Pakistan (2008 and mean of 20 years).

Table 3.The effect of organic and inorganic fertilizers on phenology and growth of maize hybrids under agro-climatic conditions of Faisalabad-Pakistan.

Treatment	50% tasseling (days)	50% silking (days)	Plant height (cm)	LAI (at tasseling)	Total dry matter (at tasseling)(g/m^2)
(A) Hybrids					
H_1	49.63	56.55^a	197.01^a	4.87	1759.27
H_2	52.36	52.21^b	190.18^b	4.79	1726.26
Significance	NS	*	*	NS	NS
(B) Fertilizers					
F_1	48.26^b	51.59^b	169.58^d	3.95^d	1169.26^d
F_2	50.21^a	54.26^a	17.7.39^{bc}	4.62^c	1999.43^a
F_3	51.15^a	54.75^a	190.72^c	4.72^{bc}	1770.29^c
F_4	51.76^a	54.99^a	194.99^b	4.76^{abc}	1812.86^b
F_5	51.99^a	55.12^a	196.78^b	4.74^{ab}	1825.86^b
F_6	52.95^a	56.10^a	207.45^a	4.89^a	1870.96^{ab}
Significance	NS	*	*	*	*
A x B	NS	NS	NS	NS	NS
Mean	51.94	53.07	190.29	4.26	237.26

Means sharing at 5% level (P) same letter did not differ significantly; *= Significant; NS = Non-significant.

was fertilized at the rate of 100 kg N ha^{-1} as poultry manure + 100 kg N ha^{-1} as urea. All other treatments were statistically at par with each other.

Plant height (cm)

Pioneer-3062 showed significantly more pH (197.01 cm) than Pioneer-3061 (190.18 cm). Both the organic and inorganic fertilizers affected pH significantly, the maximum (207.45 cm) height plant was found in F_6 treatment (plot fertilized with mixture of 100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as poultry manure) followed by F_5 (100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as FYM) which was statistically at par with F2 treatment (200 kg N ha^{-1} as urea) as well as, F4 (200 kg N ha^{-1} as poultry manure).

Minimum pH was recorded in F1 treatment (no fertilizer and manure was applied (Table 3). These results also confirmed the findings carried out by Borin and Sartori (1989); Thomassims et al. (1995) and Tamayo et al. (1997).

The increase in pH in the treatment (½ urea + ½ poultry manure) was observed as nitrogen was available from both urea as well as PM so it enhanced the growth of plants.

Leaf area index at tasseling

Non significant differences in LAI between two maize hybrids were found, while fertilizer treatments had significant differences and maximum LAI at tasseling (4.89) was observed in F6 (fertilized with a combination of 100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as PM) followed by F5 (100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as FYM) that was statistically at par with treatments F2 (200 kg N ha^{-1} as urea) and F4 (200 kg N ha^{-1} as PM). The minimum LAI was produced by the crop in control plots where no fertilizer was applied (Table 3).

Total dry matter at tasseling

The maize hybrids did not affect by total dry matter (TDM), when the crop was at tasseling stage (Table 3). The maximum TDM at tasseling (1999 gm^{-2}) was observed by F2 (200 kg N ha^{-1} was applied as urea) which was statistically at par with F6 (combination of 100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as PM) where fertilizer was (1871 g m-2) as shown in the Table 4. Similar findings were also observed from the studies carried out by He and Li (2004) and Saha et al. (2008). Variations in grain number might be due to differences in genetic potential of maize hybrids.

The findings also confirmed the results reported by Chaudhary et al. (1998); Sharma and Gupta (1998) and Younas et al. (2002). The levels of organic and inorganic fertilizers significantly influenced the number of grains (m^{-2}). The treatment F_6 (100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as PM) produced more number (3301) of grains m^{-2} than F_4 (200 kg N ha^{-1} as PM) which produced 3012 grains m^{-2} but it (F_6) was not statistically different from plot fertilized with 200 kg N ha^{-1} as FYM (F_5), while minimum number of grains was recorded from plots where no fertilizer and manure was applied, that is, control plots (Table 4).

Mean grain weight (g)

It is considered that grain weight contribute significant impacts on final yield of a crop. It is clear from Table 4 that the corn hybrids, Pioneer-3062 and Pioneer-3061 differed significantly from each other. Pioneer-3062 produced more mean grain weight (0.451 g) than Pioneer-3061 (0.254 g).

These results also corroborates the findings of Younas et al. (2002) who also observed that genetic potential had significant effect on mean grain weight. The maximum mean grain weight (0.299 g) was observed from F_6 that was statistically similar to F_2, F_5 and F_4 which produced 0.282, 0.279 and 0.281 g, respectively (Table 4). While minimum mean grain weight (0.236 g) was obtained from control plot (F_1). These findings are in line with the results of Rutunga et al. (1998); Sevaram et al. (1998) and Ma et al. (1999). Furthermore, the increase in mean grain weight was mainly due to reasonable sufficient supply of nutrients from both urea and PM throughout the duration of grain filling and development.

Grain yield (kg ha^{-1})

Grain yield is the main output for which the crop was sown. Grain yield differed significantly among different maize hybrids; Pioneer-3062 produced more grain yield (5612 kg ha^{-1}) than Pioneer-3061 (5325 kg ha^{-1}). The findings also have the similar approaches with the results explained by Ma et al. (1999) and Younas et al. (2002), who also observed that genetic potential had significant effect on mean grain weight and finally, grain yield. The treatment F_6 produced maximum grain yield (6058 kg ha^{-1}) which was statistically at par with F_2 (Table 4). F_5 also produced statistically similar yield as that of F_2 (Table 4). Whereas, control (F_1) plot gave minimum yield (4340 kg ha^{-1}). The increase in grain yield in the treatments was mainly due to maximum number of grains per cob as well as, number of cobs per plant. This result is also in line with the findings carried out by Tamayo et al. (1997).

They observed that combined use of mineral and organic manure gave maximum yield.

Harvest index (%)

Harvest index is the ratio of economic yield to biological yield represented in percent. The data presented in Table 4 showed that the corn hybrids differed significantly from each other in their harvest index. Pioneer-3062 gave more harvest index (23.01%) than Pioneer-3061 (21.87%).

Furthermore, various levels of organic and inorganic fertilizers had significant effect on harvest index. The comparison of treatment means showed that maximum harvest index (27.09%) was recorded from F_6. Treatments F_2 and F_5 have almost the same trend with each other as regards harvest index. Moreover, F_3 and F_4 were also statistically at par with each other.

The lowest harvest index (17.72%) was recorded in control treatment as shown in Table 4. Results also corroborate with Shah and Arif (2001) who also noted the positive effects of fertilizers (organic and inorganic) combined with each other.

Grain protein and oil content (%)

Grain protein and oil content of the maize hybrids were

Table 4. Effect of organic and inorganic fertilizers on yield and yield components of maize hybrids under agro-climatic conditions of Faisalabad-Pakistan.

Treatments	Plant population (m^2)	Number of grains (m^2)	Mean grain weight (g)	Grain yield (kg ha^{-1})	Harvest index (%)	Grain protein content (%)	Grain oil content (%)
(A) Hybrids							
H_1	6.79	3201^a	0.451^a	5612^a	23.01^a	10.02	4.12
H_2	6.67	3129^b	0.254^b	5325^b	21.87^b	9.81	4.05
Significance	NS	*	*	*	*	NS	NS
(B) Fertilizers							
F_1	6.22	2499^d	0.236^b	4340^d	17.72^d	9.01^d	4.02^b
F_2	6.60	3243^a	0.282^a	5867^{ab}	24.26^b	11.09^b	7.97^a
F_3	6.65	2855^c	0.260^b	5201^c	18.99^c	9.29^c	3.95^b
F_4	6.68	3012^b	0.281^a	5354^c	22.26^c	9.95^c	3.99^b
F_5	6.71	3126^{ab}	0.279^a	5720^b	24.35^d	11.16^b	4.95^a
F_6	6.69	3301^a	0.299^a	6058^a	27.09^a	12.01^a	4.92^a
Significance	NS	*	*	*	*	*	*
Interaction (A x B)	NS	NS	NS	NS	NS	NS	NS
Mean	6.82	3015	0.289	5404	21.99	8.99	4.93

Means sharing at 5 % level (P) same letter did not differ significantly; *= Significant, NS = Non-significant.

also determined. The quality of the crop is reliant on the existence of protein and oil in its seeds/grains. The maize hybrids showed non-significant differences for quality parameters. As in yield and yield component parameters, the F_6 treatment gave maximum (12.01%) protein content but the highest oil content was observed in the F_5 treatment, and this was statistically at par with F_6 and F_2 treatments (Table 4). Similar results were also clarified by Rutunga et al. (1998); Sevaram et al. (1998) and Ma et al. (1999).

Conclusion

The hybrid Pioneer-3062 gave excellent results with respect to grain yield and yield components as well as, grain protein and oil contents than Pioneer-3061. As such, Pioneer-3062 is recommended to grow under agro-climatic of Faisalabad. Among different fertilizer treatments, maximum yield was observed in the case of F_6 treatment (plots in which 100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as PM) gave outstanding results as compared to other treatments. Furthermore, from our results, it seems that use of organic and inorganic fertilizers in proper combination (50:50) received higher yields than the sole application of either of the fertilizer or manure particularly, in hybrid corn under agro-climatic conditions of Faisalabad (Semi arid environment), Pakistan.

ACKNOWLEDGMENT

The authors are grateful to all the members of Agro-Climatology Laboratory, Department of Agronomy, University of Agriculture, Faisalabad-Pakistan, for their manual and spiritual support.

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