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Full Length Research Paper

Effect of diverse use of nitrogen sources on grain yield, harvest index, nitrogen-use efficiency and phenological development of hybrid maize (*Zea mays* L.)

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A two-year field experiment was conducted to evaluate the effect of diverse use of nitrogen sources on grain yield, harvest index, nitrogen-use efficiency (NUE) and phenological development of hybrid maize (*Zea mays* L.) at the Agronomic Research Area, University of Agriculture, Faisalabad during autumn of 2008 and 2009. Experiments were laid out in a randomized complete block design (RCBD) with factorial arrangement comprising three replications with a net plot size of 3 m × 5 m. Experiments comprised two hybrids: that is, H_1 (Pioneer-30Y87) and H_2 (Pioneer-31R88) with combination of six nitrogen sources S_0: Control (0) kgNha^{-1}, S_1: Urea (50%) + poultry manure (50%), S_2: Urea (50%) + farm yard manure (50%), S_3: Urea (50%) + pressmud of sugarcane manure (50%), S_4: Urea (50%) + compost (50%), S_5: Urea (50%) + (poultry manure + farmyard manure + pressmud of sugarcane + Compost) 50%. Significant results of grain yield (t ha^{-1}), harvest index (%), nitrogen use efficiency (%), number of days taken to tassel, number of days taken to silk, and number of days taken to mature was obtained. Conclusively, hybrid maize H_1 (Pioneer 30Y87) performed best during 2008 as compared to 2009 at nitrogen sources S_1: Urea (50%) + poultry manure (50%). Overall, it was concluded that hybrid maize H_1 (Pioneer - 30Y87) produced better grain yield (6.14 t ha^{-1}) during 2008 when nitrogen sources S_1: Urea (50%) + Poultry manure (50%), was applied in combination as compared to grain yield (6.0 t ha^{-1}) in hybrid H_2 (Pioneer - 31R88) during 2009. Growth and quality attributes also performed better in 2008 as compared to 2009 at nitrogen sources S_1: Urea (50%) + poultry manure (50%).

Key words: Nitrogen sources, hybrid maize, yield, nitrogen use efficiency.

INTRODUCTION

Maize is ranked third among the cereal crops in the world after wheat and rice. In Pakistan, it is grown on an area of 1026 thousand hectares with total production of 2968 thousands tons having an average yield of 2892 kgha^{-1} (GOP, 2007).

Nitrogen plays a very important role In different growth process of plants, because it is an integral part of chlorophyll and enzyme (Power and Schepers, 1989). Application of nitrogen at rates of 0.168, 336.504 and 672 kgha^{-1} to maize in municipal solid waste amended soil increased total dry matter and total plant nitrogen (Erikson et al., 1999). It is highly nutritive and its seed contains starch (78%), protein (10%), oil (4.8%), fibre (8.5%), sugar (3.1%) and ash (1.7%) (Chaudry, 1983).

Poultry manure at the rate of 5 and 10 t ha^{-1} enhanced the maize production by 39 to 43% immediately and on residual basis it increased yield 73 and 93%.

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Combination of 5 t ha^{-1} cocoa pod ash and poultry manure 10 t ha^{-1} gave the highest yield of 6.5 and 5.58 t ha^{-1} on weight basis (Ayeni et al., 2008). Pressmud from the sugarcane is also a useful source of fertilizer as well as some chemicals, its usefulness is based on nutrient content of mud and spent wash (Partha and Sivasubramanian, 2006). Both agronomic efficiency and nitrogen use efficiency can be enhanced by using the combination of 75% nitrogen (urea) + 25% organic sources like farm yard manure (Shah et al., 2010). Adejumo et al. (2010) conducted an experiment to evaluate the relative effect of municipal solid waste (MSW) and cassava waste along with inorganic fertilizer on maize crop yield in lead affected soils. It was concluded that use of compost increased yield compared to inorganic fertilizers. Higher dose of MSW caused increase in plant height, dry matter yield, leaf area and grain yield. It was also observed that there was a significant reduction in soil lead concentration of all compost rates used. The maize root analyzed showed the uptake of lead by roots move in compost applied field compared to inorganic fertilizers. Therefore, it was concluded that different composites can be used for restoration of lead sites.

Organic matter (OM) and the total N status declined with application of N fertilizer alone but increased with integrated use of N fertilizer and OM, build up in S status was mostly through the organic S fertilizer. The use of farmyard manure (FYM) and green manure increased the K availability in the soil. The combined application of OM and inorganic N sustained the productivity even at lower level of N application. Incorporation of 5 t FYM and 6 t green manuring saved 70 to 80 kg N ha^{-1} (Muneshwar et al., 2001).

A number of factors are responsible for low yield of the crop. Inappropriate crop nutrition management and poor soil fertility are the most important factors responsible for the low yield. Soil fertility can be enhanced through the application of mineral fertilizers as well as with the addition of OM to the soil. Nevertheless, imbalanced use of fertilizer without the application of organic manure and without knowing the requirements of crops and fertility status of soil causes problems such as deterioration of soil structure, environmental and ground water pollution etc. Similarly, continuous use of chemical fertilizer caused the depletion of soil fertility. Organic matter improves the soil health and availability of nutrients. Organic materials are available in large amounts in the form of farm waste, city waste, poultry litter and industrial waste (food, sugar, cotton and rice industry).

MATERIALS AND METHODS

A two-year field experiment was conducted to study the effect of diverse use of nitrogen sources on grain yield, harvest index, NUE and phenological development of hybrid maize (*Zea mays* L.) at the Agronomic Research Area, University of Agriculture, Faisalabad during autumn of 2008 and 2009. Experiments were laid out in a randomized complete block design (RCBD) with factorial arrangement comprising three replications with a net plot size of 3 m × 5 m. Treatment comprised two hybrids: H_1 (Pioneer-30Y87) and H_2 (Pioneer-31R88), with combination of six nitrogen sources S_0: Control (0) kg N ha^{-1}, S_1: Urea (50%) + poultry manure (50%), S_2: Urea (50%) + farmyard manure (50%) , S_3: Urea (50%) + pressmud of sugarcane manure (50%), S_4: Urea (50%) + compost (50%), S_5: Urea (50%) + (PM + FYM + PMS + Compost) 50%. A recommended dose of fertilizer was applied. Urea was used as inorganic nitrogen source in split doses at the rate of 250 kg N ha^{-1} (half at sowing and half in two equal splits-half at knee height and remaining half at tasseling. All the organic sources, that is, farm yard manure, pressmud of sugarcane, compost and poultry manure were applied three week before sowing. Recommended 100 kg P ha^{-1} and 100 kg K ha^{-1} was applied at sowing some from organic sources (poultry manure, farm yard manure, pressmud of sugarcane and compost) and remaining from inorganic sources: single super phosphate (SSP) and sulphate of potash (SOP). Soil sample were analyzed chemically for their nutrients status before sowing of crop. All other practices were kept normal and uniform for all the treatments. Harvesting was done on 25 November 2008 and 10 November 2009.

The parameters like grain yield (t ha^{-1}), harvest index (%), nitrogen use efficiency (%), number of days taken to tassel, number of days taken to silk and number of days taken to mature were recorded, and data regarding all the traits were collected using standard procedures and analyzed by using Fisher's analysis of variance technique. LSD test at 5% probability was used to compare the differences among treatments means (Steel et al., 1997).

RESULTS AND DISCUSSION

Grain yield (t ha^{-1})

Grain yield in both 2008 and 2009 was significantly influenced by hybrid maize and nitrogen sources. Data in Table 1 showed that in both years, hybrid H_1 (6.14 and 6.08 t ha^{-1} in 2008 and 2009, respectively) produced higher grain yield compared to lower in hybrid H_2 (6.0 and 5.91 t ha^{-1}), respectively. This was followed by S_2 (urea + FYM) source which increased grain yield over the integrated nitrogen sources. These results are similar to the findings of Sudhu and Kapoor (1999), Tamayo et al. (1997) and Waseem et al. (2007).

Different nitrogen sources also had a significant effect on grain yield in both years. In 2008, nitrogen sources S_1 (7.05 and 6.92 t ha^{-1} in 2008 and 2009, respectively) produced highest grain yield while lowest grain yield was found in S_0 (3.73 and 3.73 t ha^{-1}), respectively. These observations confirmed the findings of Sudhu and Kapoor (1999), Tamayo et al. (1997) and Waseem et al. (2007).

Significant interactive effects between maize hybrids and integrated nitrogen sources were observed during both years. In 2008, maximum grain yield was recorded in H_1S_1 (7.12 t ha^{-1}) while minimum was found in interaction of H_2S_0 (3.57 t ha^{-1}). In 2009, grain yield increasing trend was similar to 2008. Rizwan et al. (2003) and Sharif et al. (2004) also reported similar interactive effects in maize.

During 2008, contrasts comparison between two hybrids

Table 1. Influence of integrated nitrogen sources for grain yield, Harvest index and nitrogen use efficiency attributes of hybrid maize in 2008 – 2009.

Treatment	Grain yield (t ha^{-1})		Harvest index (%)		Nitrogen use efficiency (%)	
Year	2008	2009	2008	2009	2008	2009
A-Hybrids						
H_1 : Pioneer-30Y87	6.14^{a}	6.08^{a}	41.26^{a}	40.90^{a}	10.56^{a}	10.06^{a}
H_2 : Pioneer-31R88	6.0^{b}	5.91^{b}	39.80^{b}	39.960^{b}	9.85^{b}	8.07^{b}
LSD = 0.05	0.02*	0.05*	0.74*	0.67*	0.13*	0.19*
B-Nitrogen Sources						
S_0 : Control 0 kg Nha^{-1}	3.73^{f}	3.73^{e}	36.25^{d}	36.25^{e}	0.0^{e}	0.0^{e}
S_1 : Urea (50%) + Poultry manure (50%)	7.05^{a}	6.92^{a}	42.74^{a}	42.54^{a}	15.42^{a}	12.74^{a}
S_2: Urea (50%) + Farm Yard Manure (50%)	6.63^{b}	6.57^{b}	41.06^{bc}	41.13^{bc}	12.29^{b}	11.36^{b}
S_3: Urea (50%) + Pressmud of sugarcane (50%)	6.40^{d}	6.33^{c}	40.17^{c}	39.73^{d}	11.37^{c}	10.39^{c}
S_4: Urea (50%) + Compost (50%)	6.19^{e}	6.16^{d}	41.86^{ab}	41.62^{ab}	10.62^{d}	9.70^{d}
S_5: Urea (50%) + (PM+FYM+PMS+Compost) 50%	6.43^{c}	6.28^{c}	41.11^{bc}	40.24^{cd}	11.56^{c}	5.20^{c}
LSD = 0.05	0.05*	0.87*	1.28*	1.17*	0.22*	0.34*
C-Interaction (H × NS)						
H_1S_0	3.57^{l}	3.57^{j}	35.94^{g}	35.94^{f}	0.0^{i}	0.0^{i}
H_1S_1	7.12^{a}	7.02^{a}	43.28^{a}	42.98^{a}	15.49^{a}	13.80^{a}
H_1S_2	6.91^{c}	6.80^{b}	43.01^{a}	43.32^{ab}	13.38^{b}	12.92^{b}
H_1S_3	6.59^{f}	6.45^{de}	42.2^{abc}	41.3^{abc}	12.10^{d}	11.54^{d}
H_1S_4	6.69^{e}	6.65^{c}	42.52^{ab}	42.31^{ab}	12.64^{c}	12.34^{c}
H_1S_5	6.01^{i}	6.01^{g}	40.56^{cd}	40.56^{cd}	9.78^{g}	9.76^{f}
H_2S_0	3.90^{k}	3.90^{i}	36.56^{fg}	36.56^{ef}	0.0^{i}	0.0^{i}
H_2S_1	6.99^{b}	6.82^{b}	42.2^{abc}	42.1^{abc}	15.36^{a}	11.68^{d}
H_2S_2	6.35^{g}	6.35^{e}	39.10^{de}	39.94^{d}	11.20^{e}	9.80^{f}
H_2S_3	6.21^{h}	6.21^{f}	38.07^{ef}	38.07^{e}	10.64^{f}	9.24^{g}
H_2S_4	5.70^{j}	5.66^{h}	41.19^{bc}	40.9b^{cd}	8.60^{h}	7.06^{h}
H_2S_5	6.85^{d}	6.56^{cd}	41.6^{abc}	39.92^{d}	13.33^{b}	10.65^{e}
LSD = 0.05	0.04*	0.2*	1.82*	1.65*	0.32*	0.47*

Mean values in column not comprising same letter vary significantly at P = 0.05; * =Significant at 5% level; N.S = non significant.

H_1 vs. H_2, S_1 vs. S_2, S_1 vs. S_3, S_1 vs. S_4, S_1 vs. S_5 highly significant for grain yield (t ha^{-1}) and S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources), S_3 vs. S_5 was having a non significant contrast comparison for grain yield (Table 2). As for contrast comparison, during 2009 among two hybrids H_1 vs. H_2, S_1 vs. S_2, S_1 vs. S_3, S_1 vs. S_4, S_1 vs. S_5, S_2 vs. S_3, S_2 vs. S_4, S_2 vs. S_5, S_3 vs. S_4, S_3 vs. S_5, S_4 vs. S_5, S_0 (Control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources) was highly significant for grain yield (t ha^{-1}), and S_3 vs. S_5 contrast comparison for grain yield (t ha^{-1}) was found to be non significant.

Harvest index (%)

Harvest index determines how many photosynthates are transformed into economic yield. It is the ratio of economic yields to biological yield. Hybrid maize showed significant effects on harvest index during both seasons. Data in Table 1 showed that H_1 (41.26 and 40.90%, in 2008 and 2009, respectively) produces significantly more harvest index compared to H_2 (39.80 and 39.96%, respectively) during 2009. These results are similar to Sudhu and Kapoor (1999), Tamayo et al. (1997) and Waseem et al. (2007).

The effect of nitrogen sources was also significant in both seasons. S_1 (42.74 and 42.54% in 2008 and 2009, respectively) produced maximum harvest index, and minimum harvest index was noted in S_0 (36.25 and 35.94%, respectively). Enhancement in harvest index was due to availability of nitrogen to plant at proper time and in proper proportion. These results are closely related with Negassa et al. (2001) and Nyamangera et al. (2003).

A significant interactive effect between maize hybrids and integrated nitrogen sources was observed during

Table 2. Contrast comparisons of hybrid maize and integrated nitrogen sources for grain yield, Harvest index and nitrogen use efficiency attributes in 2008 to 2009.

Treat	Grain yield (t ha^{-1})		Harvest index (%)		Nitrogen use efficiency (%)	
Year	2008	2009	2008	2009	2008	2009
H_1 vs. H_2	**	**	**	**	**	**
S_0 vs. S_1, S_2, S_3, S_4, S_5	N.S	**	*	N.S	N.S	N.S
S_1 vs. S_2	**	**	**	*	**	**
S_1 vs. S_3	**	**	**	**	**	**
S_1 vs. S_4	**	**	**	N.S	**	**
S_1 vs. S_5	**	**	**	**	**	**
S_2 vs. S_3	**	**	N.S	*	**	**
S_2 vs. S_4	**	**	N.S	N.S	**	**
S_2 vs. S_5	**	**	N.S	N.S	**	**
S_3 vs. S_4	**	**	**	**	**	**
S_3 vs. S_5	N.S	N.S	N.S	N.S	N.S	N.S
S_4 vs. S_5	**	**	N.S	*	**	*

H_1: Pioneer-30Y87, H_2: Pioneer-31R88, S_0: Control, S_1: Urea (50%) + poultry manure (50%), S_2: Urea (50%) + farmyard manure (50%), S_3: Urea (50%) + Pressmud of sugarcane (50%), S_4: Urea (50%) + Compost (50%), S_5: Urea (50%) + (PM + FYM + PMS + Compost) 50%.
Mean values in column not comprising same letter vary significantly at P = 0.05; * = Significant at 5% level; ** = highly significant at 5% level; N.S = non significant.

2008 and 2009. Maximum harvest index was recorded in H_1S_1 (43.28 and 42.98%, respectively) treatment combination, while minimum was found in H_1S_0 (35.94%).

These results corroborate the findings of Shih et al. (2010) and Nyamangera et al. (2003), who also reported similar interaction affecting harvest index in maize.

During 2008, contrasts comparison between H_1 vs. H_2, S_1 vs. S_2, S_1 vs. S_3, S_1 vs. S_4, S_1 vs. S_5, S_3 vs. S_4 was highly significant for harvest index (%). S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources) was having a significant contrast comparison for harvest index (%) and non significant contrast comparisons was observed in S_2 vs. S_3, S_2 vs. S_4, ,S_2 vs. S_5, S_3 vs. S_5, S_4 vs. S_5 for harvest index (%). Contrast comparison during 2009 among two hybrids S_0 (Control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources), S_1 vs. S_4, S_2 vs. S_4, S_2 vs. S_5, S_3 vs. S_5 was non significant for harvest index (%). S_1 vs. S_2, S_2 vs. S_3, S_4 vs. S_5 contrast comparison for harvest index (%) was found to be significant (Table 2) and highly significant contrast comparisons was observed in H_1 vs. H_2, S_1 vs. S_3, S_1 vs. S_5, S_3 vs. S_4 for harvest index (%).

Nitrogen use efficiency (kg kg^{-1})

Year effect on nitrogen use efficiency was significant. Crop planted during 2008 showed higher nitrogen use efficiency compared to crop grown in 2009. Influence of hybrid maize on nitrogen use efficiency was significant in both years. Data revealed that maximum nitrogen use efficiency was found in H_1 (10.56 kg kg^{-1}) as compared to H_2 (9.85 kg kg^{-1}) in 2008. Similarly, in 2009, H_1 gave (10.06 kg kg^{-1}) nitrogen use efficiency compared to H_2 which showed (8.07 kg kg^{-1}) nitrogen use efficiency as shown in (Table 1). These results are similar to the findings of Presterl et al. (2002).

The effect of nitrogen sources on nitrogen use efficiency was also significant in both seasons. In 2008, nitrogen sources S_1 produced maximum (15.42 kg kg^{-1}) nitrogen use efficiency and minimum nitrogen use efficiency noted in S_0 (0 kg kg^{-1}). Similarly, S_1 also gave maximum nitrogen use efficiency compared to all of the of nitrogen sources in 2009. Enhancement in nitrogen use efficiency was due to the availability of nitrogen to plant at proper time and in proper proportion as reported by Presterl et al. (2002b) and Raun and Jhonson (1999) working on maize.

A significant interactive effect of nitrogen use efficiency on maize hybrids and nitrogen sources was observed during both the years. In 2008, maximum nitrogen use efficiency was recorded in H_1S_1 (15.49 kg kg^{-1}) treatment combination interaction, while minimum nitrogen use efficiency was found in H_1S_0 (0 kg kg^{-1}) treatment combination. Similar trend of interaction was recorded in 2009. Presterl et al. (2002b) and Raun and Jhonson (1999) also noted similar interactive effects on nitrogen use efficiency.

In both 2008 and 2009 contrasts comparison (Table 2) between H_1 vs. H_2, S_1 vs. S_2, S_1 vs. S_3, S_1 vs. S_4, S_1 vs. S_5, S_2 vs. S_3, S_2 vs. S_4, S_2 vs. S_5, S_3 vs. S_4 was found to be highly significant for nitrogen use efficiency (kg kg^{-1}). Contrast comparison among S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources), S_3 vs. S_5 was non-significantly different from each other for nitrogen use efficiency (kg kg^{-1}), except in 2009 contrast comparison of S_4 vs. S_5 for nitrogen use efficiency (kg kg^{-1}) was observed to be significant for nitrogen use efficiency (kg kg^{-1}).

Phenological development

Number of days taken for tasselling

Hybrid maize significantly affected the number of days taken to tassel during 2009, and was non-significant in 2008. Data in Table 3 showed that maximum tasseling occur in H_1 (44.11 days) and minimum tasseling in hybrid H_2 (42.89 days) during 2009. These results are confirmation of Modarres et al. (1998), Sudhu and Kapoor (1999) and Tamayo et al. (1997).

The effect of integrated nitrogen sources was also significant in both seasons. S_1 (48 days) took maximum number of days to tassel, and minimum number of days to tasseling was noted in S_0 (40.50 days). Number of days taken for tasseling trend of year 2009 was at par with first year. Enhancement in number of days taken to tassel was due to availability of nitrogen to plant at proper time and in proper proportion. These results are very closely related with Martin (1981).

A non significant interactive effect between maize hybrids and integrated nitrogen sources was observed during both of the year.

During 2008 contrasts comparison between S_1 vs. S_2, S_1 vs. S_3, S_1 vs. S_4, S_1 vs. S_5 was highly significant for number of days taken for tasseling. H_1 vs. H_2, S_2 vs. S_3, S_2 vs. S_4, S_2 vs. S_5, S_3 vs. S_4, S_3 vs. S_5, S_4 vs. S_5, S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources) was having a non significant contrast comparison for number of days taken to tassel (Table 4). Contrast comparison during 2009 among S_1 vs. S_3 was significant for number of days taken to tassel. S_1 vs. S_4, S_1 vs. S_5 contrast comparison for number of days taken to tasseling was found to be highly significant (Table 4) and non significant contrast comparisons was observed in H_1 vs. H_2, S_1 vs. S_2, S_2 vs. S_3, S_2 vs. S_4, S_2 vs. S_5, S_3 vs. S_4, S_3 vs. S_5, S_4 vs. S_5, S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources) for number of days taken to tassel.

Number of days taken for silking

Number of days taken for silking by hybrid maize was significant during 2008 and 2009. The H_1 took maximum (53.67 days) and (52.66 days) in 2008 and 2009, respectively, number of days taken for silking and as compared to minimum number of days taken for silking is hybrid H_2 (52.17 days) and (57.0 days), respectively (Table 3).

The effect of nitrogen sources was found to be also significant in both seasons. Maximum (58.83 and 57.0 days in 2008 and 2009, respectively) number of days taken to silking was given by S_1, and minimum number of days taken to silking was noted in S_0 (44.0 and 45.0 days, respectively). Enhancement in number of days taken for tasseling was due to availability of nitrogen to plant at proper time and in proper proportion. Many researchers, Modarres et al. (1998), Rizwan et al. (2003), Sharif et al. (2004), Hance et al. (2008) and Martin (1981). A non significant interactive effect between integrated nitrogen sources and maize hybrids was observed on silking during both the year.

In 2008, contrasts comparison between H_1 vs. H_2, S_1 vs. S_3, S_1 vs. S_4, S_1 vs. S_5 was significant for number of days taken for silking. S_1 vs. S_2, S_2 vs. S_3, S_3 vs. S_5, S_4 vs. S_5 were having a highly significant contrast comparison for number of days taken for silking (Table 4), while non significant contrast comparison was observed for number of days taken for silking of S_2 vs. S_5, S_3 vs. S_4, S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources). Contrast comparison during 2009 among H_1 vs. H_2, S_1 vs. S_4, and S_1 vs. S_5 was significant for number of days taken for silking. S_1 vs. S_2, S_1 vs. S_3, S_4 vs. S_5, contrast comparison for number of days taken for silking was found to be highly significant (Table 4) and non significant contrast comparisons was observed in S_2 vs. S_3, S_2 vs. S_4, S_2 vs. S_5, S_3 vs. S_4, S_3 vs. S_5, S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources) for number of days taken for silking.

Number of days taken to mature

Number of days taken to maturity by hybrid maize was non significant during 2008 and 2009. The average number of days taken to maturity was ranged 105.18 to 108.17 days (Table 3).

The effect of nitrogen sources was also significant in both seasons. S_1 took maximum (116.0 and 115.50 days in 2008 and 2009, respectively) number of days taken to mature and minimum number of days taken to mature was noted in S_0 (101.0 and 99.83 days, respectively). Enhancement in number of days taken to mature was due to availability of nitrogen to plant at proper time and in proper proportion. These results are very closely related with those of Hamid and Nasab (2001) and Amanullah et al. (2009).

Significant interaction between maize hybrids and nitrogen sources was observed during both years. In 2008, maximum number of days taken to mature was recorded in H_2S_1 (118 days), while minimum number of days taken to mature was found in interaction of H_2S_0 (101 days). In 2009, maximum number of days taken to maturity was recorded in H_1S_1 (116 days) and minimum number of days taken to maturity was found in interaction of H_1S_0 (98 days). Many researchers (Hamid and Nasab, 2001; Amanullah et al., 2009; Martin, 1981) also found similar interactive effects on number of days taken to mature.

In 2008, contrasts comparison between S_2 vs. S_3, S_2 vs. S_4, was number of days taken to mature. S_1 vs. S_2, S_1 vs. S_3, S_1 vs. S_4, S_1 vs. S_5 was having a highly significant contrast comparison for number of days taken to mature Table 4), while non significant contrast comparison was

Table 3. Impact of nitrogen sources on phenological development of hybrid maize during 2008 to 2009.

Treatment	Number of days taken for tasseling		Number of days taken for silking		Number of days taken to mature	
Year	2008	2009	2008	2009	2008	2009
A - Hybrids						
H_1: Pioneer-30Y87	44.38	44.11[a]	53.67[a]	52.66[a]	108.17	106.33
H_2: Pioneer-31R88	43.27	42.89[b]	52.17[b]	50.94[b]	107.50	105.11
LSD = 0.05	N.S	1.08*	1.34*	1.46*	N.S	N.S
B - Nitrogen sources						
S_0: Control 0 kg Nha^{-1}	40.50[c]	40.67[c]	44.0[c]	45.0[d]	101.0[d]	99.83[d]
S_1: Urea (50%) + poultry manure (50%)	48.0[a]	47.0[a]	58.83[a]	57.0[a]	116.0[a]	115.5[a]
S_2: Urea (50%) + farmyard manure (50%)	43.66[b]	43.0[b]	53.83[b]	51.50[bc]	109.0[b]	112.5[b]
S_3: Urea (50%) + pressmud of sugarcane (50%)	43.50[b]	42.83[b]	53.50[d]	52.50[bc]	106.5[c]	108.5[c]
S_4: Urea (50%) + compost (50%)	43.66[b]	43.0[b]	53.50[b]	53.83[b]	106.5[c]	109.5[c]
S_5: Urea (50%) + (PM+FYM+PMS+Compost) 50%	43.66[b]	44.50[b]	53.83[b]	50.50[c]	108b[c]	108.5[c]
LSD = 0.05	2.19*	1.88*	2.32*	2.53*	2.32*	2.08*
C - Interaction (H × NS)						
H_1S_0	40.0	41.33	43.0	46.0	101.0[f]	98.0[g]
H_1S_1	49.33	48.67	59.67	58.0	118.0[a]	116.0[a]
H_1S_2	43.33	44.0	55.0	53.0	110.0[c]	110.0[c]
H_1S_3	44.0	42.67	54.67	54.0	108[cd]	107.0[d]
H_1S_4	45.33	43.0	56.0	54.0	104[ef]	113.0[b]
H_1S_5	44.33	45.0	53.67	51.0	108[cd]	113.0[b]
H_2S_0	41.0	40.0	45.0	45.0	101.0[f]	101.6[f]
H_2S_1	46.66	45.33	58.0	56.0	114.0[b]	116.0[a]
H_2S_2	44.0	42.0	52.67	50.0	108[cd]	115.0[b]
H_2S_3	43.0	43.0	52.33	51.0	105[ed]	110.0[c]
H_2S_4	42.0	43.0	51.0	53.6	109.0[c]	106.0[de]
H_2S_5	43.0	44.0	54.0	50.0	108[cd]	104[ef]
LSD = 0.05	N.S	N.S	N.S	N.S	3.27*	2.95*

Mean values in column not comprising same letter vary significantly at P = 0.05; * = Significant at 5% level; N.S = non significant.

observed for number of days taken for maturity of H_1 vs. H_2, S_2 vs. S_5, S_3 vs. S_4, S_3 vs. S_5, S_4 vs. S_5, S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources). Contrast comparison during 2009 among S_3 vs. S_5, S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources) was significant for number of days taken to mature. S_3 vs. S_5 ,S_0 (control) vs. S_1, S_2, S_3, S_4, S_5 (nitrogen sources) contrast comparison for number (of days taken to maturity was found to be highly significant (Table 4) and non significant contrast comparisons was observed in S_2 vs. S_3, S_2 vs. S_4, S_3 vs. S_4, S_4 vs. S_5

Table 4. Contrast comparison nitrogen sources on phenological development of hybrid maize during 2008 – 2009.

Treat	Number of days taken for tasseling		Number of days taken for silking		Number of days taken to mature	
Year	2008	2009	2008	2009	2008	2009
H_1 vs. H_2	N.S	N.S	*	*	N.S	**
S_0 vs. S_1, S_2, S_3, S_4, S_5	N.S	N.S	N.S	N.S	N.S	*
S_1 vs. S_2	**	N.S	**	**	**	**
S_1 vs. S_3	**	*	*	**	**	**
S_1 vs. S_4	**	**	*	*	**	**
S_1 vs. S_5	**	**	*	**	**	**
S_2 vs. S_3	N.S	N.S	**	N.S	*	N.S
S_2 vs. S_4	N.S	N.S	*	N.S	*	N.S
S_2 vs. S_5	N.S	N.S	N.S	N.S	N.S	**
S_3 vs. S_4	N.S	N.S	N.S	N.S	N.S	N.S
S_3 vs. S_5	N.S	N.S	**	N.S	N.S	*
S_4 vs. S_5	N.S	N.S	**	*	N.S	N.S

H_1: Pioneer-30Y87, H_2: Pioneer-31R88, S_0: (Control), S_1: Urea (50%) + poultry manure (50%), S_2: Urea (50%) + farmyard manure (50%), S_3: Urea (50%) + pressmud of sugarcane (50%), S_4: Urea (50%) + compost (50%), S_5: Urea (50%) + (PM + FYM + PMS + Compost) 50%.
Mean values in column not comprising same letter vary significantly at P = 0.05; * = Significant at 5% level; ** = highly significant at 5% level; N.S = non significant.

for number of days taken for maturity.

Conclusion

On the basis of the results, it was concluded that hybrid maize H_1 (Pioneer-30Y87) produced better grain yield (6.14 t ha^{-1}) in 2008 when nitrogen sources S_1: Urea (50%) + Poultry manure (50%) was applied in combination as compared to grain yield (6.0 t ha^{-1}) in hybrid H_2 (Pioneer 31R88) in 2009. Harvest index (%), nitrogen use efficiency (%) and phenological development attributes was also performed better in hybrid maize H_1 (Pioneer 30Y87) in 2008 as compared to 2009 at nitrogen sources S_1: Urea (50%) + poultry manure (50%).

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