Pak. J. Agri. Sci., Vol. 50(3), 329-335; 2013
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

GROWTH AND YIELD PERFORMANCE OF MAIZE (*Zea mays* L.) AS AFFECTED BY PLANTING METHODS AND NPK LEVELS

Abdul Rehman[1,*], Athar Mahmood[1], Zafar Iqbal[1], Zulfiqar Ahmed[2], Aurang Zeb[1] and Kaleem Ahmed[1]

[1]University College of Agriculture, University of Sargodha, Pakistan;
[2]Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan
[*]Corresponding author's e.mail: drabdulrehman18@yahoo.com

Two year research was conducted to find out the best combination of sowing geometry and levels of N, P and K fertilizers for maize hybrid 32-W-86. Four N-P-K levels viz., 0-0-0, 200-100-100, 250-125-125 and 300-150-150 kg ha^{-1} were tested in combination with 3 planting geometries viz., flat sowing in 75 cm spaced rows, ridge sowing on 75 cm spaced ridges and bed sowing (120 cm wide beds separated by 30 cm furrows) in randomized complete block design with factorial arrangement. During both years, treatment with 250-125-125 kg ha^{-1} NPK and 75 cm apart ridge sowing was found to be superior as it showed significantly higher grain yield (10.02 to 10.54 t ha^{-1}), number of cobs per plant (1.80 to 1.87), number of grains per cob (359.33 to 378.67), 1000-grain weight (306.46 to 320.62 g), biological yield (24.01 to 24.36 t ha^{-1}) and harvest index (41.76 to 43.51 %). Contrastingly, 0-0-0 NPK kg ha^{-1} fertilizer treatment in combination with all 3 planting geometries remained at lowest position with respect to grain yield. Grain yield showed significant positive relationship with number of cobs per plant, number of grains per cob, 1000-grain weight, biological yield and harvest index of maize.
Keywords: Maize, fertilizer, planting geometry, biological yield, harvest index

INTRODUCTION

In Pakistan, maize (*Zea mays* L.) is grown on an area of 0.95 million hectares with the annual grain production of 3.49 million tons and average grain yield of 3670 kgha^{-1} (Govt. of Pakistan, 2010a). The average grain yield of maize is not only substantially lower compared with other important maize growing countries but also less than the production potential of existing genotypes (Govt. of Pakistan, 2010b).

Fertilizer has an important role as it increases the maize yield. Nitrogen is an essential element and important determinant of plant growth and development. Nitrogen is a component of protein and nucleic acids and when N is sub-optimal, growth is reduced. Its availability in sufficient quantity throughout the growing season is essential for optimum maize growth (Haque *et al.,* 2001).

Phosphorus plays a key role in energy transfer and is essential for photosynthesis and other chemico-physiological processes in plants. Potassium is one of the most crucial plant nutrients involved in many physiological processes, potassium's impact on water relations, photosynthesis, assimilate transport and enzyme activation. The deficiency of K reduced number of leaves and the size of leaves and therefore can reduce productivity (Pettigrew, 2008). K influences water use efficiency (Quampah *et al*. 2011). Balanced use of N, P and K fertilizers play a pivotal role in increasing the yields of cereals (Asghar *et al.,* 2010).

Therefore application of optimum levels of N, P and K fertilizers is considered imperative under irrigated conditions (Asghar *et al.*, 2010). The NP combinations significantly affected the plant height, cob bearing plants, number of grains/cob, 1000-grain weight and grain yield (Hussain *et al.,* 2007; Sharar *et al.*, 2003). Phosphorus increases number of cobs per plot, 1000-grain weight and grain yield (Qasim *et al.*, 2001). Planting method influences germination, irrigation water requirement, root penetration and crop water uptake from soil (Ali *et al.,* 2003). Intercropping (Shave *et al*. 2012) and tillage (Reddy *et al*. 2012) also affect maize growth According to Abdullah *et al.* (2011) planting methods play a pivotal role to obtain better grain yield planting method plays an important role.

Suitable levels of N, P and K and best planting method are the important components of production technology package of any crop. Keeping in view, studies were planned to find out suitable sowing method and quantities of N, P and K for new maize hybrid 32-W-86.

MATERAL AND METHODS

Field experiments were conducted at the Agronomic research farm of University of Agriculture, Faisalabad, Pakistan during 2006 and 2007 to observe the effect of NPK rate and sowing methods on the production potential of spring maize and fertilizer use efficiency. The experimental site lies at 31° North latitude and 73° longitudes. Before sowing, soil samples collected to a depth of 30 cm and were analyzed for various physico-chemical properties. Soil texture was sandy clay loam and its chemical characteristics are given in Table 1. The meteorological data for the experimental years (2006 and 2007) were collected from the meteorological observatory of the Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan and are given in Figure1 and 2.

Table 1. Chemical analysis of the soil of experimental site

Determination	2006	2007
EC (dS m^{-1})	1.67	1.68
pH	8.2	8.2
Organic matter (%)	0.72	0.73
Total Nitrogen (%)	0.050	0.051
Available Phosphorus (ppm)	5.18	5.44
Available Potassium (ppm)	170	172

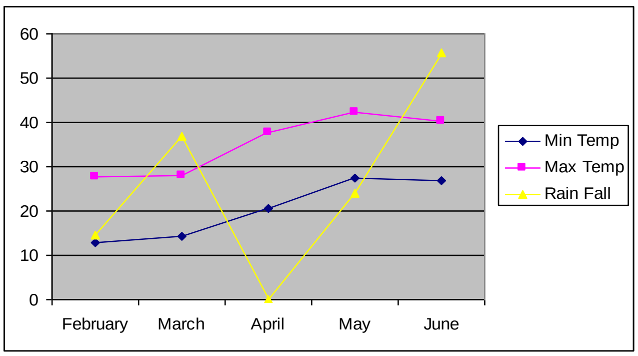

Figure 1. Meteorological data during the growing season of maize crop in 2006.

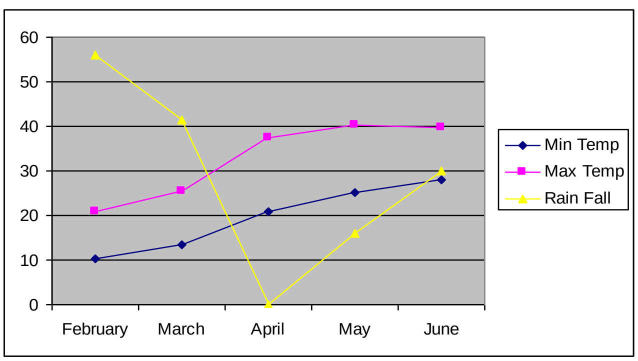

Figure 2. Meteorological data during the growing season of maize crop in 2007.

The Pioneer maize hybrid 32-W-86 was used as test crop. Treatments included four NPK combinations viz., 0-0-0, 200-100-100, 250-125-125 and 300-150-150 NPK kg ha^{-1} and three sowing methods viz., flat sowing in 75 cm spaced rows, ridge sowing on 75 cm apart ridges and bed sowing (120 cm wide beds separated by 30 cm furrows). During each year, experiment was laid out in randomized complete block design (RCBD) with factorial arrangement.

All the three types of nutrients were supplied in the form of chemical fertilizers. Whole of P and K were applied at sowing time, while ½ N was applied at sowing and remaining ½ N 60 days after sowing. Sowing dates were 19^{th} and 26^{th} of February during 2006 and 2007, respectively. All the other agro-management practices were kept optimum and uniform in all treatments. Parameters related to economic and biological yield of crop like, number of cobs per plant, number of grain rows per cob, number of grains per cob, 1000-grain weight (g), biological yield (t ha^{-1}) and harvest index (HI) were recorded at crop maturity using their standard procedures. Biological yield comprises grain, stover and pith yield. HI (%) was calculated by using the following formula:

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

Data collected in each year were subjected to Fisher's analysis of variance technique and treatments' means were compared with least significant different (LS) test at 5 % probability level (Steel *et al*., 1997). Regression analyses between grain yield and other parameters were done to assess relationship among them. 'MSTATC' computer software was used for data analysis and Microsoft Excel, computer package was employed for regression analyses (MSUA, 1986).

RESULTS

Number of cobs per plant**:** Data regarding number of cobs per plant are presented in Table 2 which revealed that number of cobs per plant was affected significantly by different NPK rates over unfertilized control, but different sowing methods did not affect the number of cobs per plant in both the years as well as their means. Year effect on the parameter under study was non-significant (Data not shown). Interactive effect of both factors remained significant in both the years of study, i.e. 2006 and 2007. In both years, maximum number of cobs per plant (1.80 and 1.87) was recorded in 75 cm apart ridge sowing fertilized @ 250-125-125 NPK kg ha^{-1}. However, it remained statistically at par with all other treatment combinations except those with unfertilized control. During both years, unfertilized control gave the minimum number of cobs per plant in combination with flat sowing.

Number of grains per cob**:** Number of grains per cob is an important yield parameter of maize. During both years, NPK application rate significantly affected the number of grains per cob over unfertilized control. Similarly this parameter was also affected significantly by various sowing methods during 2007 but not during 2006 (Table 3). Interactive effect was significant during both the years. In both 2006 and 2007, numbers of grains per cob were higher in 75 cm apart ridge sowing maize fertilized with 250-125-125 NPK

Table 2. Effect of NPK rate and sowing methods on number of cobs per plant of spring maize

Fertilizer treatments N-P-K (kg ha^{-1})	Sowing methods			Fertilizer means
	Flat sowing (75 cm apart rows)	Ridge sowing (75cm apart ridges)	Bed sowing (120 cm apart beds)	
		2006		
0-0-0	1.13 b	1.27 b	1.27 b	**1.22 b**
200-100-100	1.67 a	1.73 a	1.67 a	**1.69 a**
250-125-125	1.73 a	1.80 a	1.73 a	**1.76 a**
300-150-150	1.73 a	1.73 a	1.67 a	**1.71 a**
LSD $_{0.05}$		**0.39**		
Sowing method means	**1.57**	**1.63**	**1.58**	
		2007		
0-0-0	1.20 a	1.33 bcd	1.27 cd	**1.27 c**
200-100-100	1.53 abcd	1.67 ab	1.60 abc	**1.60 b**
250-125-125	1.77 a	1.87 a	1.73 a	**1.82 a**
300-150-150	1.80 a	1.77 a	1.67 ab	**1.78 ab**
LSD $_{0.05}$		**0.37**		
Sowing method means	**1.58**	**1.66**	**1.57**	

Means not sharing the same letters differ significantly from each other at 5% probability level.

Table 3. Effect of NPK rate and sowing methods on number of grains per cob of spring maize

Fertilizer Treatments N-P-K (kg ha^{-1})	Sowing methods			Fertilizer means
	Flat sowing (75 cm apart rows)	Ridge sowing (75cm apart ridges)	Bed sowing (120 cm apart beds)	
		2006		
0-0-0	218.33 c	223.67 bc	217.67 c	**219.89 b**
200-100-100	298.00 a	338.00 a	296.00 ab	**310.67 a**
250-125-125	350.33 a	359.33 a	324.67 a	**344.78 a**
300-150-150	348.00 a	356.00 a	338.33 a	**347.44 a**
LSD $_{0.05}$		**74.04**		
Sowing method means	**303.67**	**319.25**	**294.17**	
		2007		
0-0-0	227.33 f	253.33 ef	221.00 f	**233.89 c**
200-100-100	305.00 cd	361.00 ab	285.33 de	**317.11 b**
250-125-125	368.00 a	378.67 a	330.00 bc	**358.89 a**
300-150-150	369.67 a	372.33 a	357.67 ab	**366.56 a**
LSD $_{0.05}$		**37.10**		
Sowing method means	**317.5 a**	**366.33 a**	**298.50 b**	

Means not sharing the same letters differ significantly from each other at 5% probability level.

kg ha^{-1}. However, it remained statistically at par with all other rates of NPK except control. Contrastingly, the lowest values of number of grains per cob were recorded in 120/30 cm apart beds receiving 0-0-0 NPK kg ha^{-1}.

***1000-grain weight (g)*:** Grain weight is a vital yield contributing factor, which plays a decisive role in showing the potential of a variety. The 1000-grain weight was significantly affected by different rates of NPK over non-fertilized control in both years, while different sowing methods did not affect 1000-grain weight (Table 4). Year effect on 1000-grain weight was significant where more 1000-grain weight was recorded in 2007 than in 2006 (Data not shown). Interaction between the two factors also remained significant during both the years. In both years, 75 cm apart ridge sowing in combination with 250-125-125 NPK kg ha^{-1} attained the highest 1000-grain weight. However, it was at par with some other NPK and sowing method interactions.

***Biological yield*:** Biological yield is the overall expression of biological forces embodied in a production system. Data regarding biological yield are presented in Table 5 which revealed that it was significantly affected by different rates of NPK as well as sowing methods in both the years of study. Year effect on biological yield was significant and the

Table 4. Effect of NPK rate and sowing methods on 1000-grain weight (g) of spring maize

Fertilizer Treatments N-P-K (kg ha^{-1})	Sowing methods			Fertilizer means
	Flat sowing (75 cm apart rows)	Ridge sowing (75cm apart ridges)	Bed sowing (120 cm apart beds)	
		2006		
0-0-0	183.85 c	188.00 bc	217.48 b	196.44 b
200-100-100	295.27 a	300.99 a	288.72 a	295.00 a
250-125-125	298.77 a	306.46 a	292.08 a	299.10 a
300-150-150	284.24 a	290.17 a	283.25 a	285.89 a
LSD $_{0.05}$		30.9		
Sowing method means	265.54	271.41	270.38	
		2007		
0-0-0	210.37 d	211.89 d	206.73 d	209.66 c
200-100-100	301.02 c	306.17 bc	300.82 c	302.67 b
250-125-125	317.25 ab	320.62 a	315.15 ab	317.67 a
300-150-150	301.75 c	305.54 bc	299.34 c	302.21 b
LSD $_{0.05}$		12.5		
Sowing method means	282.60	286.05	280.51	

Means not sharing the same letters differ significantly from each other at 5% probability level.

Table 5. Effect of NPK rate and sowing methods on biological yield (t ha^{-1}) of spring maize

Fertilizer Treatments N-P-K (kg ha^{-1})	Sowing methods			Fertilizer means
	Flat sowing (75 cm apart rows)	Ridge sowing (75cm apart ridges)	Bed sowing (120 cm apart beds)	
		2006		
0-0-0	9.32 h	9.94 g	9.14 h	9.47 c
200-100-100	20.55 f	21.12 e	20.28 f	20.65 b
250-125-125	23.25 bcd	24.01 a	22.79 d	23.35 a
300-150-150	23.30 bc	23.52 ab	22.99 cd	23.27 a
LSD $_{0.05}$		0.50		
Sowing method means	19.11 b	19.65 a	18.80 c	
		2007		
0-0-0	10.48 f	10.13 fg	10.08 g	10.23 d
200-100-100	21.93 e	22.00 e	21.91 e	21.95 c
250-125-125	23.54 cd	24.22 a	23.36 d	23.71 b
300-150-150	24.01 ab	24.24 a	23.84 bc	24.03 a
LSD $_{0.05}$		0.38		
Sowing method means	19.99 a	20.15 a	19.80 b	

Means not sharing the same letters differ significantly from each other at 5% probability level.

higher value of biological yield (t ha^{-1}) was recorded in 2007 than 2006 due to favorable environmental conditions (Fig. 1 and 2). Interactive effect was also found to be significant in both the years. In both years, higher biological yields were produced by treatment, which was fertilized at the rate of 250-125-125 NPK kg ha^{-1} and crop was sown on 75 cm apart ridges. This treatment combination did not differ significantly from 300-150-150NPK kg ha^{-1} in interaction with 75 cm apart ridge sowing. However, minimum value of this parameter was observed in un-fertilized control under 120 cm bed sowing system.

***Grain yield*:** The final grain yield is a function of combined effect of all the individual yield contributing components. It is evident from data (Table 6) that different NPK rates and sowing methods significantly influenced the grain yield (t ha^{-1}) in both the years. Interactive effect between NPK rates and sowing methods was, also significant during both the years. The higher grain yield was obtained in treatment which was fertilized at the rate of 250-125-125 NPK kg ha^{-1} and crop was sown on 75 cm apart ridges. However, during both the years, it was statistically at par with same fertilizer level and 300-150-150 NPK kg ha^{-1} in combination with 75 cm apart flat sowing and 120 cm apart bed sowing. Contrarily, the lowest grain yield was observed in

Table 6. Effect of NPK rate and sowing methods on grain yield (t ha^{-1}) of spring maize

Fertilizer Treatments N-P-K (kg ha^{-1})	Sowing methods			Fertilizer means
	Flat sowing (75 cm apart rows)	Ridge sowing (75cm apart ridges)	Bed sowing (120 cm apart beds)	
		2006		
0-0-0	2.35 c	2.86 c	2.68 c	**2.63 c**
200-100-100	6.60 b	8.63 ab	6.31 b	**7.18 b**
250-125-125	8.85 ab	10.02 a	7.75 ab	**8.88 a**
300-150-150	8.21 ab	8.68 ab	7.41 ab	**8.10 ab**
LSD $_{0.05}$		2.65		
Sowing method means	6.50 ab	7.55 a	6.04 b	
		2007		
0-0-0	2.29 e	2.95 e	2.09 e	2.44 c
200-100-100	7.79 cd	9.13 abc	6.94 d	7.95 b
250-125-125	9.34 abc	10.54 a	8.67 abcd	9.52 a
300-150-150	9.02 abc	9.81 ab	8.39 bcd	9.07 ab
LSD $_{0.05}$		1.97		
Sowing method means	7.11 b	8.11 a	6.52 b	

Means not sharing the same letters differ significantly from each other at 5% probability level.

Table 7. Effect of NPK rate and sowing methods on harvest index (%) of spring maize

Fertilizer Treatments N-P-K (kg ha^{-1})	Sowing methods			Fertilizer means
	Flat sowing (75 cm apart rows)	Ridge sowing (75cm apart ridges)	Bed sowing (120 cm apart beds)	
		2006		
0-0-0	25.21 b	28.73 ab	29.30 ab	27.75 b
200-100-100	32.12 ab	40.84 a	31.12 ab	34.69 ab
250-125-125	38.07 a	41.76 a	34.03 ab	37.95 a
300-150-150	35.25 ab	36.89 ab	32.25 ab	34.80 ab
LSD $_{0.05}$		12.86		
Sowing method means	32.66	37.06	31.68	
		2007		
0-0-0	21.80 d	29.13 cd	20.77 d	23.90 b
200-100-100	35.50 abc	41.49 a	31.66 bc	36.22 a
250-125-125	39.68 ab	43.51 a	37.10 abc	40.10 a
300-150-150	37.58 abc	40.46 ab	35.19 abc	37.74 a
LSD $_{0.05}$		9.81		
Sowing method means	33.64	38.65	31.18	

Means not sharing the same letters differ significantly from each other at 5% probability level.

unfertilized plots under all geometries during both the years of study.

***Harvest index*:** Harvest index is the physiological efficiency of plants to convert the fraction of photo-assimilates to grain yield. Data regarding harvest index are presented in Table 7 which indicates that harvest index (%) was significantly affected by different rates of NPK but not by various sowing methods during both the years. Interaction between different rates of NPK and sowing methods was significant during both the years of study. During 2006 and 2007, the highest values of harvest indices (41.76% and 43.51%, respectively) were observed in treatment where crop sown on 75 cm apart ridges was fertilized @ 250-125-125 NPK kg ha^{-1}. However, it was at par with some other treatment combinations but the lowest values of this parameter were gained by unfertilized treatment in combination with 75 cm apart flat sowing and 120 cm apart bed sowing.

DISCUSSION

Grain yield is the end result of many complex morphological and physiological processes occurring during the growth and development of a crop. It showed a consistent increase with increase in NPK rate from 0-0-0 NPK kg ha^{-1} up to 250-125-125 NPK kg ha^{-1}. However, a small decline in grain yield was observed at 300-150-150 NPK kg ha^{-1}. Similar effect of fertilizer levels on maize yield and its components was reported by Maqsood *et al*. (2000) and, Ade diran and Banjoko (2003). Maximum grain yield at 250-125-125 NPK kg ha^{-1} suggests it to be the optimum level of the nutrient elements while a further increase from this level may retard growth. The excessive inorganic fertilizer application can induce nutrient imbalance, acidity, pollution of ground water as a result of leaching and reduce palatability (Sridhar and Adeoye, 2003). This could be a result of interference in the absorption and utilization of other elements (Uguru, 1996).

Ridge sowing gave the highest grain yield than the flat and bed sowing methods. These results are in line with previous work (Abdullah *et al.,* 2007). It might be due to well pulverized soil which nourished maize crop well and resulted in more values of yield contributing factors number of cobs per plant, number of grains per cob and 1000-grain weight.

The gain in biological yield of maize along with increasing doses of N, P and K up to 250, 125 and 125 kg ha^{-1}, respectively was also reported by Qasim *et al*. (2001). More biological yield obtained in ridge sowing has also been reported by Ali *et al*. (2001). Higher biological yield at higher fertilizer level may be attributed to the fact that NPK are primary nutrients required to promote meristematic and other physiological plant activities in roots, shoots and leaves leading to higher dry matter production. These activities also promote greater photosynthetic activities resulting in adequate assimilates for subsequent translocation to various sinks and hence the production of higher total dry matter (Jaliya *et al*., 2008; Farhad *et al*., 2011a, b).

Number of cobs per plant, number of grains per cob and 1000-grain weight is important yield components which integrate to make up final grain yield. The highest values of grain yield and its components at 250-125-125 kg ha^{-1} NPK level revealed that increased grain yield was the net result of increase in number of cobs per plant, number of grains per cob and 1000-grain weight. This association of grain yield with its components was further proved by significant positive relationship among them. These findings are in consonance with previous investigations which also reported who reported that increasing rate of NPK increased the number of cobs per plant, number of grains per cob and 1000-grain weight (Maqsood *et el*., 2000) up to their optimum level. The increased cob number, grain number and grain weight at 250-125-125 kg ha^{-1} NPK level was probably the result of physiological balance between vegetative and reproductive growth at this level. Increase in 1000-grain weight of maize in response to NPK fertilization due to enhancement in the source efficiency (dry matter accumulation) as well as sink capacity (kernel weight) has also been proved by previous researcher (Maqsood *et al*., 2000).

The significant influence of planting methods on number of grains per cob and non-significant influence on number of cobs per plant and 1000-grain weight were also seen in previous findings (Ali *et al*., 2001). Previous studies also reported an increase in harvest index at higher N-P-K application rates (Mahmood *et al*., 1999) whereas higher value of harvest index in ridge sowing was also supported by Abdullah *et al*. (2007).

REFERENCES

Abdullah, G. Hassan, I.A. Khan and M. Munir. 2007. Effect of planting methods and herbicides on yield and yield components of maize. Pak. J. Weed Sci. Res. 13:39-48

Adediran, J.A. and V.A. Banjoko. 2003. Comparative effectiveness of some compost fertilizer formulations for maize in Nigeria. Nig. J. Soil Sci. 13:42-48.

Ali, R., S.K. Khalil, S.M. Raza and H. Khan. 2001. Effect of herbicides and row spacing on maize (*Zea mays* L.). Pak. J. Weed Sci. Res. 9:171-178.

Bhagwan and K.S. Bhatia. 1990. Effect of sowing methods and mulching on the intercropping of black gram with maize under rainfed condition. Crop Res. (Hisar) 3:284-286.

Farhad, W., M.A. Cheema, M.F. Saleem H.M. Hammad and M.F. Bilal. 2011a. Response of maize hybrids to composted and non-composted poultry manure under different irrigation regimes. Int. J. Agric. Biol. 13:923-928.

Farhad, W., M.A. Cheema, M.F. Saleem and M. Saqib. 2011b. Evaluation of drought tolerant and sensitive maize hybrids. Int. J. Agric. Biol. 13:523-528.

Govt. of Pakistan. 2010a. Economic Survey of Pakistan, 2009-10. Ministry of Food and Agriculture, Federal Bureau of Statistics, Govt. of Pakistan, Islamabad. 21p.

Govt. of Pakistan. 2010b. Pakistan Statistical Year Book. Government of the Pakistan. 4p.

Haque, M.M., A. Hamid and N.I. Bhuiyan. 2001. Nutrient uptake and productivity as affected by nitrogen and potassium application levels in maize/sweet potato intercropping system. Korean J. Crop Sci. 46:1-5.

Hossain, M.A., A. Hamid and S. Nasreen. 2007. Effect of nitrogen and phosphorus fertilizer on N/P uptake and yield performance of groundnut (*Arachis hypogaea* L.). J. Agric. Res. 45:119-127.

Hussain, I.T. Mahmood, A. Ullah and A. Ali. 1999. Effect of nitrogen and sulphur on growth, yield and quality of hybrid maize (*Zea mays* L.). Pak. J. Biol. Sci. 2:637-638.

Jaliya, A.M., A.M. Falaki, M. Mahmud and Y.A. Sani. 2008.

Effects of sowing date and NPK fertilizer rate on yield and yield components of quality protein maize (*Zea mays* L.). ARPN J. Agric. Biol. Sci. 2:23-29.

Khalil, I.A. and A. Jan. 2002. Cropping Technology. National Book Foundation, Islamabad, Pakistan.

Mahmood, T., M. Saeed and R. Ahmad. 1999. Water and potassium management for enhanced maize (*Zea mays* L.) productivity. Int. J. Agri. Biol. 1:314-317.

Maqsood, M., R. Ali, N. Nawaz and N. Yousaf. 2000. The effect of NPK application in different proportions on the growth and yield of spring maize. Pak. J. Biol. Sci. 3:356-357.

MSUA. 1986. MSTAT Micro-computer statistical program. Michigan State Univ. of Agriculture, Michigan Lousing, USA.

Pettigrew, W.T. 2008. Potassium influences on yield and quality production for maize, wheat, soybean and cotton. Physiol. Plant. 133:670-681

Qasim, M., H. Himayrull and M. Subha. 2001. Effect of increasing levels of phosphorus and seed rate on the economic yield of maize. J. Biol. Sci. 1:40-42.

Quampah, A., R.M. Wang, I.H. Shamsi, G. Jilani, Q. Zhang, S. Hua and H. Xu. 2011. Improving water productivity by potassium application in various rice genotypes. Int. J. Agric. Biol. 13:9-17.

Reddy, S.S., E.Z. Nyakatawa and K.C. Reddy. 2012. Nitrogen uptake pattern by cotton in a long-term no-tillage system with poultry litter application. Int. J. Agric. Biol. 14:29-37.

Sharar, M.S., M. Ayub, M.A. Nadeem and N. Ahmad. 2003. Effect of different rates of nitrogen and phosphorus on growth and grain yield of maize (*Zea mays* L.). Asian J. Pl. Sci. 2:347-349.

Shave, P.A., A. Ter-Rumum and M.I. Enoch. 2012. Effects of time of intercropping of mucuna (*Mucuna cochinchinensis*) in maize (*Zea mays*) for weed and soil fertility management. Int. J. Agric. Biol. 14:469-472.

Sridhar, M.K.C. and G.O. Adeoye. 2003. Organo-mineral fertilizer from urban wastes. The Field 68:91-111.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach, 3rd Ed. McGraw Hill Book Co., Inc., NY, USA.

Uguru, M.I. 1996. Crop Production Techniques. Fulladu Publication Company, Nsukka, Nigeria.