SELECTING OPTIMUM PLANTING DATE FOR SWEET CORN IN PESHAWAR, PAKISTAN

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ABSTRACT

Planting at proper time and selection of suitable variety are important components of cropping system. The present study was conducted at New Developmental Farm, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan during 2008 to document some phenological stages and grain yield of landraces of sweet corn planted on different dates. RCBD with split plot arrangement was used. Sweet corn landraces, MNG, MNS, SWB, PRC and cv. Azam were planted on 5 dates i.e. 17 March, 30 April, 17 May, 21 June, and 26 July. Days to tasseling, silking, maturity, grain yield and harvest index were significantly affected by sowing dates, landraces and their interaction. Days to tasseling and silking enhanced as the planting was delayed. Days to maturity decreased when sowing was delayed from March to June, however further delay in sowing increased number of days to maturity. Azam gave maximum grain yield (4569 kg ha^{-1}) followed by landrace SWB sown on 26th July. Maximum harvest index was recorded by Azam when planted on 21st June and 26th July.

Key Words: **Sweet corn, planting date, phenology, yield, Peshawar.**

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INTRODUCTION

Maize (*Zea mays* L.) is the third most important source of calories for mankind after rice and wheat, and will most likely become the most important crop by 2020 (Rosegrant *et al.,* 2001). Sweet corn (*Zea mays saccharata*) differs from field corn in terms of its genetic makeup rather that it's systematic or taxonomic characterization (Marshall, 1987). Sweet corn is grown for local markets in Azad Jammu and Kashmir and several areas of Khyber Pukhtunkhwa including Mingora, Swabi and Mansehra.

Potential yield of sweet corn can be achieved through optimum use of inputs and agronomic practices. Planting date and variety selection are the major factors affecting maize production in addition to soil fertility, temperature regimes and irrigation (Ramankutty *et al.,* 2002). For optimization of yield, planting at the appropriate time is very critical (Anapalli *et al.,* 2005). Photoperiod and temperature influence the time from sowing to tassel initiation with appreciable genetic differences in relative sensitivity to these factors (Ellis *et al.,* 1992). Earlier planting of corn is preferable because of utilization of the entire growing season, achieving physiological maturity before frost, and proper drying; thereby increasing profit through reduced drying costs (Lauer *et al.,* 1999) while delays in sowing date reduced individual kernel weight (Cirilo and Andrade, 1996). High yielding varieties are of primary importance for potential yield. Yield can be increased to a greater extent provided high yielding varieties are identified and planted at proper time (Khan *et al.,* 2009; and Arif *et al.,* 2001). Highest grain yield with optimum planting time has been reported by Martiniello (1985) and Albus *et al.* (1990). Khan *et al.* (2004) reported significant effects of varieties on days to tasseling and grain yield of corn. Maize landraces have the highest genetic variation and adaptation to the natural and anthropological environment where they have evolved. Surveying both qualitative and quantitative morphological traits of existing landraces may be useful in maintaining their genetic diversity and preserving them from genetic erosion (Lucchin *et al.,* 2003). The present study was therefore initiated to evaluate phenology and yield of sweet corn landraces planted on different dates in Peshawar region.

MATERIALS AND METHODS

Experiment was carried out at New Developmental Farm, Agricultural University Peshawar, Pakistan during 2008. Experimental field is located in Peshawar valley at 34° N latitude, 71.3° E longitude and 350 m above sea level (Khan *et al.,* 2004). The soil of experimental site was analyzed for organic matter (Nelson and Sommer, 1982), pH (McClean, 1982), EC (Ryan, J. 2000), P and K (Soltanpour and Schwab, 1977). Soil was low in organic matter (0.87 %), alkaline in reaction (pH 8.2), having EC (0.74 dSm^{-1}), total N (0.04 %), AB-DTPA extractable P (1.15 mg P_2O_5 kg^{-1}) and high in exchangeable K (506 mg K_2O kg^{-1}). Temperature, humidity, and precipitation recorded during the period of experiment are given in Table I.

Table I *Monthly climatic data during 2008 in Peshawar*

Months	Temperature (°C)			Mean Relative Humidity (%)	Total precipitation (mm)
	Maximum	Minimum	Mean		
March	28.94	13.42	21.18	47.81	0
April	29.57	16.27	22.92	52.03	16.8
May	37.55	21.03	29.29	41.97	0
June	38.83	26.27	32.55	62.73	16
July	37.74	27.39	32.57	72.45	27
August	36.94	25.65	31.29	75.61	150.9
September	36.63	21.33	28.98	69.9	16.7
October	32.15	16.78	24.46	65.07	0
November	27.43	9.93	18.68	56.37	0
December	16.96	6.59	11.78	45.56	10.4

Four sweet corn landraces i.e. Mingora (MNG), Mansehra (MNS), Swabi (SWB), Parachinar (PRC) and cv. Azam (control) were planted on five dates i.e. 17 March, 30 April, 17 May, 21 June, and 26 July. The landraces were named and abbreviated against the names of the places from where they were collected. They were collected from districts of Mingora, Swabi and Mansehra (Khyber Pukhtunkhwa province) and Parachinar (Tribal area). Mingora falls in northern mountainous zone having sub–humid climate with mild summer and freezing winter. The average annual rainfall is more than 600 mm. In Mansehra, sweet corn is grown in low–land having humid climate with hot dry summer and mild winter. The mean annual rainfall exceeds 800 mm. District Swabi falls in central valley plains. Its climate is sub–tropical, sub–humid and continental with mean daily maximum (summer) temperature 40 to 44 °C and minimum (winter) 4 to 6 °C. Mean annual rainfall varies from 450 to 750 mm with more rains (about 60%) in summer months. Parachinar falls within western dry mountains. Its climate is diversified, mostly semi–arid with mild summer and harsh winters. Treatments were replicated three times according to randomized complete block design with split plot arrangements. Planting dates were allotted to main plots while landraces were maintained in sub-plots. A subplot size of 4m × 3.6m having 6 rows, 60 cm apart and 4m long was used. Treatments were randomized in main and sub-plots. Plant population of 11667 plants ha^{-1} was maintained by thinning at the early vegetative stages of the crop. A basal dose of 120:70 kg N: P_20_5 ha^{-1} was used. Urea and Single Super Phosphate were used as sources of N and P_2O_5, respectively. The crop was irrigated at two weeks interval. Furadan (Carbofuran 3%) @ 19.76 Kg ha^{-1} was applied in the early stages of growth to control attack of stem borers. Weeds were manually eradicated. Standard agronomical practices were followed throughout the growing season. Data were recorded on days to tasseling, days to silking, days to maturity and grain yield.

Days to tasseling and silking were counted from sowing till 50% of the plants in each subplot produced tassels and silk, respectively. Days to maturity were counted from sowing till maturity. The appearance of black layer in the grains of the mid portion of the ear was considered as physiological maturity (Daynard and Duncan, 1969). Two central rows of each subplot were harvested, sun dried and threshed to record grain yield $plot^{-1}$ and then converted into grain yield ha^{-1} using the following formulae.

$$\text{Grain Yield (kg per ha)} = \frac{\text{Yield per plot x (10000)}}{\text{No. of rows harvested (2) x r – r distance (60 cm) x row length (4m)}}$$

Harvest index was calculated as follows:

$$\text{Harvest Index (\%)} = \frac{\text{Grain Yield}}{\text{Biological Yield}} \text{ X 100}$$

The data were statistically analyzed, using analysis of variance technique in MSTAT-C. Means were compared using least significant difference (LSD) test (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

Days to Tasseling

Days to tasseling were significantly affected by planting date (D), landraces (L) and D×V interaction Table II. Sweet corn planted on 17th March took more days to tasseling (63). Days to tasseling decreased with delay in planting and minimum days (51.4) were noted for 26th July planted crop. Variety Azam and landrace MNG took fewer days while landrace SWB took more days to tasseling. Landrace SWB planted on 17th March took maximum days to tasseling (65.67), whereas MNG took fewer days to tasseling planted on 26th July. Since, tassel initiation is correlated with maturity of genotype and late maturing genotype will take more days to tasseling (Lejeune and Bernier, 1996) and vise versa. Azam belongs to medium maturity group (Khan *et al.*, 2004) hence it took significantly less days to tasseling. Days to tasseling decreased with delay in sowing from March to July. The possible reason for this decrease may be the presence of differences in photoperiod and temperature among sowing dates. Photoperiod and temperature can influence the timing of development events in maize (Aitken, 1977 and Allison and Daynard, 1979) and influence days to tasseling in maize with appreciable genetic differences in relative sensitivity to these factors (Ellis *et al.*, 1992). These results are also supported by Khan *et al.* (2009), Khan *et al.* (2004), Shaw (1988), and Daughtry *et al.* (1984) who reported dependence of tasseling duration on temperature and variety.

Table II ***Days to tasseling of sweet corn as affected by sowing dates and landraces***

Sowing date	Control	Landraces				Mean
	Azam	MNG	MNS	SWB	PRC	
17th March	60	62	65	66	63	**63 a**
30th April	59	60	62	60	62	**60.67 b**
17th May	57	59	59	59	61	**58.87 c**
21st June	55	55	57	57	58	**56.47 d**
26th July	53	49	50	51	53	**51.40 e**
Mean	**56.80 c**	**57 c**	**58.67 b**	**58.53 b**	**59.40 a**	

LSD for sowing dates at P<0.05 = 0.35
LSD for landraces at P<0.05 = 0.38
LSD for D×L interaction at P<0.05 = 0.84

Days to Silking

Days to silking were significantly affected by planting date (D), landraces (L) and D×L interaction Table III. Mean values of planting dates showed that sweet corn planted on 17th March took more days to silking (72.2). Delay in sowing decreased days to silking and minimum days (56.73) were noted for 26th July planted crop. Landrace MNG and Azam took fewer days to silking while SWB and MNS took more days to silking. SWB planted on 17th March took maximum days to silking (76), whereas MNG took fewer days to silking planted on 26th July. This decrease in days to silking may be due to increase in mean temperature with delay in planting date. Significant effects of sowing date and landraces on days to silking in corn are reported (Khan *et al.*, 2009; Shafi *et al.*, 2006).

Table III ***Days to silking of sweet corn as affected by sowing dates and landraces***

Sowing date	Control	Landraces				Mean
	Azam	MNG	MNS	SWB	PRC	
17th March	68	70	75	76	73	**72.20 a**
30th April	64	65	66	66	67	**65.73 b**
17th May	62	63	63	63	65	**63.07 c**
21st June	60	59	61	62	63	**61.07 d**
26th July	57	54	57	57	58	**56.73 e**
Mean	**62.20 c**	**62.27 c**	**64.4 b**	**64.73 b**	**65.20 a**	

LSD for sowing dates at P<0.05 = 0.41
LSD for landraces at P<0.05 = 0.39
LSD for D×L interaction at P<0.05 = 0.87

Days to Maturity

Planting date (D), landraces (L) and D×L interaction showed significant effects on days to maturity Table IV. Sweet corn planted on 17th March took more days to maturity (116.6). Days to maturity decreased with delay in planting from March to June but further delay increased days to maturity. Variety Azam took fewer days while landrace PRC took more days to maturity. PRC planted on 17th March took maximum days to maturity (120), whereas Azam took fewer days to maturity (88) planted on 21st June. These results are supported by Khan *et al.* (2009) and Zaki *et al.* (1994) who reported decrease in days to maturity with delaying of sowing from April to July. As sowing date was delayed, growth occurred under greater temperatures, with associated reductions in duration of growing cycles (Otegui *et al.,* 1995). Low mean temperature and radiation at emergence and vegetative growth period may be the main reasons for taking more days to maturity by crop planted in March. Results also showed a slight increase in days to maturity when planting was further delayed to July. This delay in maturity may be result of high precipitation and lowering of mean temperature in the months of August, September and October. Zaki *et al.* (1994) also reported decrease in number of days to maturity when planting date was enhanced from April to June. While further delay in sowing to August, they noted an increase in number of days to maturity.

Table IV ***Days to maturity of sweet corn as affected by sowing dates and landraces***

Sowing date	Control	Landraces				Mean
	Azam	MNG	MNS	SWB	PRC	
17th March	111	117c	115	119	120	**116.6 a**
30th April	105	112	106	109	114	**109.4 b**
17th May	95	98	101	97	104	**99 c**
21st June	88	90	92	89	94	**90.73 e**
26th July	91	94	96.	92	98	**94.47 d**
Mean	**98.07 d**	**102.2 b**	**102.3 b**	**101.3 c**	**106.4 a**	

LSD for sowing dates at P<0.05 = 0.54
LSD for landraces at P<0.05 = 0.33
LSD for D×L interaction at P<0.05 = 0.74

Grain Yield

Grain yield is the function of integrated effect of all individual yield components and interaction between the genetic makeup and plant environment during the growing period. Statistical analysis of the data revealed that grain yield of sweet corn was significantly affected by planting date (D), landraces (L) and D×L interaction Table V. Sweet corn planted on 26th July produced more yield (2960 kg ha^{-1}) while 17th May planting gave lowest grain yield (1690 kg ha^{-1}). Azam gave more grain yield (3673 kg ha^{-1}) followed by landrace SWB (2759 kg ha^{-1}). Azam planted on 26th July gave maximum grain yield (4569 kg ha^{-1}) whereas landrace PRC yielded minimum (1229 kg ha^{-1}) when planted on 17th May. Since landrace SWB was collected from an area whose climatic conditions are more or less same to Peshawar, resulting in better performance than other landraces. Grain yield increased from March sowing to April sowing then considerably decreased in May sowing and again increased in June sowing to reach maximum in July sowing. Proper growth and development conditions for July sowing and genetic makeup of the crop may be resulted in higher grain yields. July planting got rainfall of about 156.6 mm (Table I) during its early growth stage which may be one of the main factors, along with others, responsible for high yield. Thompson (1969, 1986 and 1988) found total July precipitation to be the most important climatic variable influencing yield. He also reported that decrease in yield by above normal summer temperatures. Planting date and landraces showed significant effects on final grain yield of sweet corn (Khan *et al*., 2009). Herbek *et al.* (1986) and Zaki *et al.* (1994) reported decrease in grain yield when sowing delayed from April to May and then increased in June sowing. Khan *et al.* (2004), Khan *et al*. (1999) and Aziz *et al*. (1992) reported that genetically different varieties significantly differed in their grain yield performance in corn.

Table V ***Grains yield (kg ha^{-1}) of sweet corn as affected by sowing dates and landraces***

Sowing date	Control	Landraces				Mean
	Azam	MNG	MNS	SWB	PRC	
17th March	3875	1910	2139	2889	1736	**2510 c**
30th April	4000	1938	2257	2938	1743	**2575 b**
17th May	2576	1306	1438	1903	1229	**1690 e**
21st June	3347	1444	1951	2688	1319	**2150 d**
26th July	4569	1903	3118	3375	1833	**2960 a**
Mean	**3673 a**	**1700 d**	**2181 c**	**2759 b**	**1572 e**	

LSD for sowing dates at P<0.05 = 60.20
LSD for landraces at P<0.05 = 72.79
LSD for D×L interaction at P<0.05 = 163

Biological Yield

Planting date and landraces significantly affected biological yield (BY) of sweet corn, during both years Table VI. Significant interaction between planting dates and landraces was also observed. Highest BY (15778 kg ha^{-1}) was recorded in 17th March planting, while minimum BY (10611 kg ha^{-1}) was recorded in 17th May planting.

These results illustrated that early sowing resulted highest BY. Delay in sowing decreased BY through May planting, while further delay showed an increase in BY. Higher BY in early plantings may be attributed to more days to maturity (Table IV), higher plant height (unpublished data) and extended growth and development period. Khan and Zada (1990) also found higher stalk yield from early planting in Peshawar. Garcia *et al.* (2009) observed decrease in aboveground biomass when planting date was delayed from early March to mid-May in three different maturity group sweet corn hybrids. Kim *et al.* (2007) found negative correlation between total above ground biomass and growth temperature. Landrace SWB recorded highest BY (14014 kg ha^{-1}) followed by MNS (13681 kg ha^{-1}), while Azam produced lowest BY (13028 kg ha^{-1}). Higher BY observed in landraces (SWB and MNS) may be attributed to higher leaf area (unpublished data) achieved by them which produced more dry matter through increased light interception. SWB × mid-March planting produced highest BY (16875 kg ha^{-1}), while minimum BY (9722 kg ha^{-1}) was attained from Azam × 21st June planting.

Table VI ***Biological yield (kg ha^{-1}) of sweet corn as affected by sowing dates and landraces***

Sowing date	Control	Landraces				Mean
	Azam	MNG	MNS	SWB	PRC	
17th March	15625	16250	16459	16875	13681	**15778 a**
30th April	15278	15764	16250	16111	13195	**15320 b**
17th May	11250	10069	10486	11111	10139	**10611 e**
21st June	9722	11458	11389	11597	10278	**10889 d**
26th July	13264	13681	13819	14375	12986	**13625 c**
Mean	**13028 d**	**13444 c**	**13681 b**	**14014 a**	**12056 e**	

LSD for sowing dates at P<0.05 = 267.32
LSD for landraces at P<0.05 = 170.49
LSD for D×L interaction at P<0.05 = 381.2

Harvest Index (HI)

HI of sweet corn were significantly affected by planting date (D), landraces (L) and D×L interaction Table VII. Mean values of planting dates showed that 26th July planting gave more HI value (21.71 %) while 17th May planting gave lowest HI value (15.77 %). Azam resulted in higher HI value (28.57 %) whereas landrace MNG gave lower HI value (12.70 %). Values regarding D×L interaction maximum HI (34.48 %) was observed for Azam planted on 26th July, which was not statistically different from HI values observed for 21st June planting. Lowest HI value (11.75 %) was noted for MNG when planted on 17th March. HI is dependent on grain and biological yields of the crop and it changes with change in grain and biological yields. Similar results of significant effects of sowing dates and landraces were reported by Khan *et al.* (2009).

Table VII ***Harvest index (%) of sweet corn as affected by sowing dates and landraces***

Sowing date	Control	Landraces				Mean
	Azam	MNG	MNS	SWB	PRC	
17th March	24.82	11.75	13.00	17.12	12.69	**15.88 d**
30th April	26.20	12.29	13.89	18.23	13.21	**16.76 c**
17th May	22.92	12.97	13.71	17.14	12.13	**15.77 d**
21st June	34.42	12.60	17.14	23.19	12.84	**20.04 b**
26th July	34.48	13.91	22.57	23.47	14.11	**21.71 a**
Mean	**28.57 a**	**12.70 d**	**16.06 c**	**19.83 b**	**13 d**	

LSD for sowing dates at P<0.05 = 0.744
LSD for landraces at P<0.05 = 0.62
LSD for D×L interaction at P<0.05 = 1.38

CONCLUSION AND RECOMMENDATIONS

Summarizing the main findings of the present study it is concluded that sweet corn landrace SWB produced higher grain yield compared with other landraces when planted on 26th July. Results also suggest that two crops of sweet corn can be earned if planted in mid-March and late July from same piece of land in one year. Early planting may be done for fodder use as early planting produced higher biological yields. It is however recommended that farmers in Peshawar valley may plant sweet corn landrace SWB in the last week of July for obtaining higher yield.

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REFERENCES

Aitken, Y. 1977. Evaluation of maturity genotype-climate interactions in maize (*Zea mays* L.). Pflanzenzuecht. 78: 216-237.

Albus, W.L., J. Weigel and H. Sayfikar. 1990. The effect of planting date on irrigated corn in North Dakota. N.D. Farm Res. 48(2):22-25.

Allison, J.C.S. and T.B. Daynard. 1979. Effect of change in timing of flowering induced by altering photoperiod and temperature on attributes related to yield in maize. Crop Sci. 19: 1-4.

Anapalli, S.S., L. Ma, D.C. Nielsen, M.F. Vigil and L.R. Ahuja. 2005. Simulating planting date effects on corn production using RZWQM and CERES-Maize models. Agron. J. 97:58–71.

Arif, M., Ihsanullah, S. Khan, F. Ghani and H.K. Yousafzai. 2001. Response of maize varieties to different planting methods. Sarhad J. Agric. 17: 159-163.

Aziz, A., M. Saleem, H. Rehman and F. Muhammad. 1992. Performance of maize hybrids under irrigated conditions. Sarhad J. Agric. 8 (5): 509-512.

Cirilo, A.G. and F.H. Andrade. 1994. Sowing date and maize productivity: I. Crop growth and dry matter partitioning. Crop Sci. 34:1039-1043.

Daughtry, C.S.T., J.C. Cochran and S.E. Holinger. 1984. Estimating silking and maturity dates of corn for large areas. Agron. J. 76:415-420.

Daynard, T.B. and W.G. Duncan. 1969. The black layer and grain maturity in corn. Crop Sci. 9:473-476.

Ellis, R.H., R.J. Summerfield, G.O. Edmeades and E.H. Roberts. 1992. Photoperiod, temperature, and the interval from sowing to tassel initiation in diverse cultivars of maize. Crop Sci. 32:1225-1232.

Garcia, A.G., L.C. Guerra and G. Hoogenboom. 2009. Impact of planting date and hybrid on early growth of sweet corn. Agron. J. 101:193–200.

Herbek, J.H., L.W. Murdock and R.L. Blevins. 1986. Tillage system and date of planting effects on yield of corn on soils with restricted drainage. Agron. J. 78: 824-826.

Khan, A.Z., P. Shah, S.K. Khalil and B. Ahmad. 2004. Yield of soybean cultivars as affected by planting date under Peshawar valley conditions. Nucleus. 41 (1-4): 93-95.

Khan, M.A., S. Akbar, K. Ahmad and M.S. Baloch. 1999. Evaluation of corn hybrids for grain yield. Pak. J. Biol. Sci. 2(2):413-414.

Khan, M.T. and K. Zada. 1990. Stability of harvest indices of maize varieties as affected by planting dates under different environments. M.Sc (Hons) Thesis, Deptt. Agron. Agric. Univ. Peshawar, Pakistan.

Khan, Z.H., W.A. Shah, J. Bakht, M. Shafi and M.A. Khan. 2004. Performance of maize varieties under different seed rates. Sarhad J. Agric. 20(2): 183-189.

Khan, Z.H., S.K. Khalil, S. Nigar, I. Khalil, I. Haq, I. Ahmad, A. Ali and M.Y. Khan. 2009. Phenology and yield of sweet corn landraces influenced by planting dates. Sarhad J. Agric. 25(2): 153-157.

Kim, S., D.C. Gitz, R.C. Sicher Jr, J.T. Baker, D.J. Timlin and V. Reddy. 2007. Temperature dependence of growth, development, and photosynthesis in maize under elevated CO_2. Env. Exp. Bot. 61:224–236.

Lucchin, M., G. Barcaccia and P. Parrini. 2003. Characterization of a flint maize Italian landrace: I. Morpho-phenological and agronomic traits. Genet. Resour. Crop Evir. 50(3): 315-327.

Lauer, J.G., P.R. Carter, T.M. Wood, G. Diezel, D.W. Wiersma, R.E. Rand and M.J. Mlynarek. 1999. Corn hybrid response to planting date in the Northern Corn Belt. Agron. J. 91:834-839.

Lejeune, P. and G. Bernier. 1996. Effects of environment on the early steps of ear initiation of maize (*Zea mays* L.). Plant, Cell & Envir. 19:217–224.

McLean, E.O. 1982. Soil pH and lime requirement. *In* Page, A.L., R.H. Miller and D.R. Keeney (eds.) Methods of soil analysis. Part 2 - Chemical and microbiological properties. (2nd Ed.). Agron. 9:199-223.

Marshall, S.W. 1987. Sweet corn. p. 431-445. *In*: A.W. Stanley and P.E. Bamstad (Ed.) Corn Chem. & Technol.. Amer. Assoc. Cereal Chemists, Inc. St. Paul, Minnesota, USA.

Martiniello, P. 1985. Recurrent visual selection in S_1 progenies for early vigor in maize. Maydica. 30:301-308.

Nafziger, E.D. 1994. Corn planting date and plant population. J. Prod. Agric. 7: 59-62.

Nelson, D.W. and L.E. Sommer. 1982. Total carbon, organic carbon and organic matter. *In*: A.L. Page, R.H. Miller and D.R. Keenay (ed), Methods of Soil Analysis, Part II (2^{nd} ed). Amer. Soc. Agron. 9: 539-577.

Otegui, M.E., M.G. Nicolini, R.A. Ruiz and P.A. Dodds. 1995. Sowing date effects on grain yield components for different maize genotypes. Agron. J. 87:29-33.

Ramankutty, N., J.A. Foley, J. Norman and K. McSweeney. 2002. The global distribution of cultivable lands: Current patterns and sensitivity to possible climate change. Global Ecol. Biogeogr. 11:377–392.

Rosegrant, M.W., M.S. Paisner, S. Meijer and J. Witcover. 2001. Global food projections to 2020: emerging trends and alternative futures. Intl. Food Policy Res. Instt. Washington, DC. 206:1–24.

Ryan, J. 2000. Soil and plant analysis in the Mediterranean region: limitations and potential. Commun. Soil Sci. Plant Anal. Marcel Dekker Inc. Monticello, New York. 31 (11/14) :2147-2154.

Shafi, M., Z.H. Khan, J. Bakht, M.J. Khan and S. Anwar. 2006. Performance of maize varieties under different seed rates. Sarhad J. Agric. 22(1): 23-26.

Shaw, R.H. 1988. Climate requirement. *In*: G. F. Sprague and J.W. Dudley (Ed.) Corn and corn improvement. 3^{rd} ed. No. 18, ASA, Madison, Wisconsin.

Soltanpour, P.N. and A.P. Schawab. 1977. A new soil test for simultaneous extraction of macro & micronutrients in alkaline soil. Commun. Soil Sci. Pl. Anal. 8:195-207.

Steel, R.G.D. and J.H. Torrie. 1984. Principles and procedures of statistics. McGraw Hill Book Co., New York.

Thompson, L.M. 1969. Weather and technology in the production of corn in the U.S. Corn Belt. Agron. J. 61:453-456.

Thompson, L.M. 1986. Climate change, weather variability and corn production. Agron. J. 78:649-653.

Thompson, L.M. 1988. Effects of changes in climate and weather variability on the yields of corn and soybeans. J. Prod. Agric. 1:20-27.

Zaki, M.S., P. Shah and S. Hayat. 1994. Effect of date of sowing on maize and non-flooded land rice. Sarhad J. Agric. 10(2): 191-199.