Pak. J. Bot., 44(5): 1627-1632, 2012.

EFFECT OF COMMON COCKLEBUR DENSITY ON BIOLOGICAL YIELD OF MAIZE AT VARYING POPULATIONS

ZAHID HUSSAIN*, KHAN BAHADAR MARWAT, BAKHTIAR GUL, MUHAMMAD SAEED AND SHAHIDA BIBI

Department of Weed Science, KPK Agricultural University Peshawar, 25130 Pakistan
**Corresponding author's email: zhussainws@aup.edu.pk*

Abstract

Experiments were conducted in the Khyber Pakhtunkhwa Province, Peshawar, Pakistan during 2006 and 2007 to evaluate the impact of common cocklebur densities on leaf area, leaf area index, plant height and biological yield of maize using an open pollinated variety "Azam". Seven cocklebur densities (0, 2, 4, 6, 8, 10, and 12 plants m^{-2}) in maize planted at four densities (5, 7.5, 10, and 12.5 plants m^{-2}) were evaluated in a split plot experiment. Statistical analysis for both years indicated significant main effects and interactions for leaf area, LAI, plant height and biological yield of maize. The leaf area of maize was decreased with increase in maize density because of the intra-specific competition within the maize plants. Maize leaf area plant^{-1} at all the maize densities was decreased by the density of cocklebur; however, the magnitude of reduction in leaf area was dependent on maize density; the lower the maize density the higher was the magnitude of reduction in maize leaf area. Similarly, the maize LAI at alternating maize densities was linearly affected by steadily increasing the cocklebur density. Increasing cocklebur density and/or maize density increased maize plant height but at very high densities of either species the average maize plant height was decreased as a result of increased intra as well as interspecific competition period. The statistical analysis also showed that maize biomass declined linearly as weed density increased from 0 to 12 plants m^{-2}, with an increasing rate of decline for high maize densities and low maize densities. Results decide that the effect of common cocklebur interference on maize biomass and other parameters was associated with a change in distribution of resources, resulting in increased crop height at the expense of a reduction in LAI by the crop as weed density increased.

Introduction

Maize being the third most important cereal crop after wheat and rice in Pakistan and second after wheat in Khyber Pakhtunkhwa (KP) accounts for 4.8% of the total cropped area and 3.5% of the value of agricultural output of the country. The KP province contributes 57 and 68% of the total area and maize production, respectively (Anon., 2008). The area under maize cultivation was 1.0521 million ha in Pakistan and 0.5095 million ha in KP, with production of 3.593 and 0.9579 million t and average yield of 3415 and 1880 kg ha^{-1}, respectively (Anon., 2009).

Weed competition has always been a serious problem in maize in the agro-ecological conditions of the KP province. Generally an increase of one kilogram of weed growth corresponds to a reduction of one kilogram of crop growth (Rao, 2000; Zhang *et al*., 2011). Along with other problematic weeds of maize, common cocklebur (*Xanthium strumarium* L.) is an emerging noxious weed of maize crop in the province (Afzal *et al*., 1994). Globally it has been a serious weed in various crops throughout the world for many years in general (Bloomberg *et al*., 1982; Marwat & Nafziger, 1990) and inflicts severe yield losses in maize production in particular (Baldoni *et al*., 2000; Hussain *et al*., 2011) probably due to its allelopathic effects (David *et al*., 2005; Casini, 2004). Cocklebur species are more competitive because of their larger size causing severe yield reductions in maize (Royal *et al*., 1997). The maize seed germination its early growth, and fresh and dry biomass all are decreased by leachates of common cocklebur (Inam *et al*., 1987; Bhatt *et al*., 1994). Both the germination and vigor of maize seeds collected at harvest decrease with an increase in density of common cocklebur (Saayman *et al*., 1996). It was introduced to Pakistan from Afghanistan during the Afghan war in the early 1980s due to massive migration of Afghan people and their livestock (Hashim & Marwat 2002).

Crop competition with weeds can be enhanced by increasing the crop density in order to cover the soil surface and sequester more light and soil resources that might help suppress weeds like common cocklebur, as increase in weed density always reduced the biological yield of maize (Oljaca *et al*., 2007). Under high plant population of maize, its leaf area index increased (Berzsenyi & Dang, 2007) and total biological yield was also greater but individual plant yield was higher at lower plant density (Randhawa, 1995). Thakur *et al.,* (1997) and Hammad *et al.*, (2011) reported improvement in growth and yield of single plant in lower maize density but did not compensate the total yield obtained under higher density. Therefore, optimum crop density is one of the key factors for enhancing maize competitiveness, weed suppression ability and achieving higher yields (Arif *et al.*, 2010; Shah *et al.*, 2011).

The local farmers that grow maize face stern economic restraints, as seed prices are going beyond the means of most growers. Also, the prices of chemicals and labor-based weed management continue to climb. Therefore, farmers require information on crop density and weed impacts in order to optimize both crop seed and weed management inputs. The objective of this study was to evaluate the impact of maize density and common cocklebur density on leaf area, leaf area index, plant height and biological yield of maize.

Materials and Methods

Field experiments were carried out at Agricultural Research Farm, Agricultural University Peshawar, in KP Pakistan during 2006 and 2007. The maize open-pollinated variety, Azam was used in the experiments.

Seeds of common cocklebur were collected by hand from an infested field at the Pakistan Forest Institute at Peshawar University. The study site had no history of cocklebur. The experimental variables were 4 maize densities and seven common cocklebur densities arranged in split plots within a randomized complete block design replicated three times. Maize densities of 5, 7.5, 10, and 12.5 plants m^{-2} were allotted to main plots whereas seven common cocklebur densities of 0, 2, 4, 6, 8, 10, and 12 plants m^{-2} were assigned to the sub plots. Each sub-plot (experimental unit) was 12 m^2 in size having 4 rows of maize, each 4m long and 75cm apart. Maize was planted in June 2006 and 2007 with the help of dibbler to facilitate seed sowing by hand and to maintain the required plant-to-plant distance. The N and P fertilizers were surface applied at planting at a rate of 100 and 60 kg ha^{-1} in the form of urea and single super phosphate, respectively. An additional application of N was side dressed at a rate of 60 kg ha^{-1}, one month after sowing. The common cocklebur seeds were sown on the same day of crop sowing, in a 10-cm band over the crop row. To avoid the risk of germination failure, two to three common cocklebur seeds were sown at each target site. Emergence of maize and common cocklebur was observed 15 days after planting and stands thinned to the appropriate density. Occasionally, common cocklebur seedlings were transplanted to attain the required density; other weeds were removed manually throughout the maize crop season on weekly basis. All the other agronomic practices were kept uniform for all the treatments from sowing to harvest.

The data reported here were collected at maize physiological maturity. All crop and weed plants were harvested separately from the central 2 rows of each experimental unit. Data were subjected to ANOVA using the MSTAT statistical analysis program. Due to variation in weather, data from each year were analyzed separately. Where appropriate, the significant differences among means were determined using the LSD test (Steel & Torrie, 1980). Regression analyses were carried out to determine the trends for the relevant parameter(s). Linear and quadratic models were generated to describe the relationship between measure dependent variables and maize or weed density as the independent variable, as appropriate.

Results and Discussion

Leaf area plant^{-1} of maize (cm): Statistical analysis of the data showed that maize densities had a significant effect on the leaf area plant^{-1} during the two years. The leaf area plant^{-1} of maize during 2006 were (0.303, 0.292, 0.286, and 0.244 m^2) recorded at maize densities of 5, 7.5, 10, and 12.5 plants m^{-2}, respectively; however, the leaf area at maize density of 5, 7.5, and 10 plants m^{-2} were statistically similar (Table 1). Thus, the maize density of 7.5, 10, and 12.5 plants m^{-2} showed leaf area plant^{-1} as 0.274, 0.264, and 0.259 m^2, respectively, at par with each other and decreased progressively with increasing the crop density. The results signified that maize leaf area was decreased because of the intra-specific competition within the maize plants. The common cocklebur density also had a significant ($P \leq 0.05$) effect on maize leaf area in the two trials. In both years, maize leaf area plant^{-1} across all the common cocklebur densities was significantly different from each other. Increasing the weed density significantly decreased maize leaf area with maximum reduction at common cocklebur density of 12 plants m^{-2}. As the canopy coverage (leaf area and vegetative growth) of common cocklebur was more than that of maize, presumably it captured more sunlight, depriving the crop plants of light and, to some extent, of space. Saccol & Estefanel (1995) reported a reduction in crop leaf area, plant height, stem diameter, and leaf area index as a result of increased weed competition. Mishra (2000) reported that the chlorophyll status of both the crop and the weed decreased with increasing weed density. For the interaction effect of the crop and weed density on crop leaf area, the regression lines showed that during both the years, the leaf area plant^{-1} decreased linearly with common cocklebur at all the maize densities (Fig. 1a & b). The maize leaf area plant^{-1} at all the maize densities was decreased by the density of common cocklebur; however, the magnitude of reduction in leaf area was dependent on maize density; the lower the maize density the higher was the magnitude of reduction in maize leaf area.

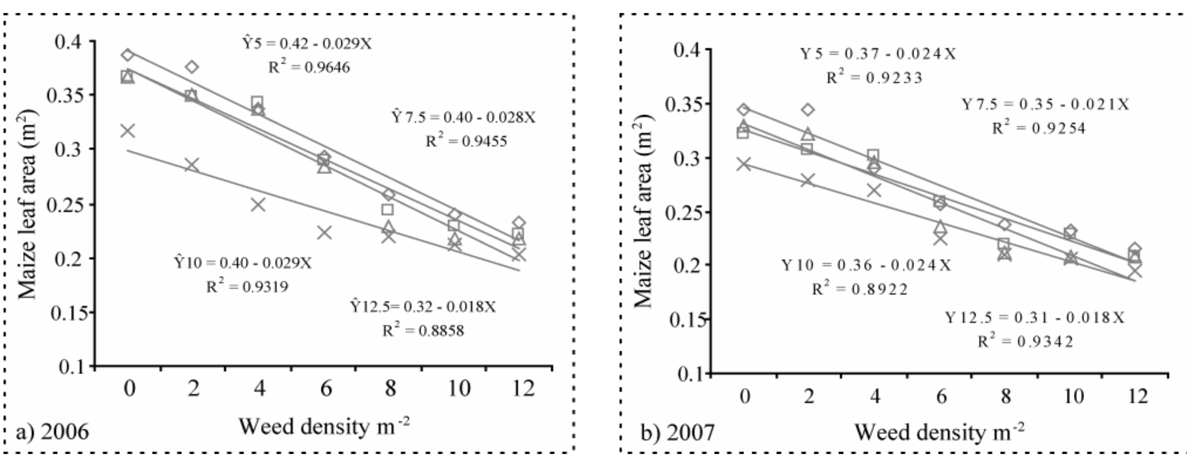

Fig. 1. Effect of maize density (◊ = 5, □ = 7.5, Δ = 10, x = 12.5 plants m^{-2}) and common cocklebur density on leaf area (m^2) of maize during a) 2006 and b) 2007.

Table 1. Biological yield of maize (kg ha^{-1}), maize plant height (cm), leaf area plant^{-1} of maize (m^2) and leaf area index of maize as affected by maize density and common cocklebur density during 2006 and 2007.

	Maize biological yield (kg ha^{-1})		Maize plant height (cm)		Maize leaf area plant^{-1} (m^2)		Leaf area index of maize	
	2006	2007	2006	2007	2006	2007	2006	2007
Maize density (m^{-2})								
5.0	8222 c	7540 d	163.8 b	159.1 bc	0.303 a	0.274 a	1.52 d	1.37 d
7.5	8700 b	7884 c	170.0 a	161.8 ab	0.292 a	0.264 ab	2.19 c	1.98 c
10.0	9005 ab	8112 b	172.6 a	164.2 a	0.286 a	0.259 b	2.86 b	2.58 b
12.5	9287 a	8295 a	162.4 b	156.5 a	0.244 b	0.240 c	3.05 a	3.00 a
LSD Values	404	155	5.0	3.8	0.02	0.01	0.12	0.15
Weed density (m^{-2})								
0	9969 a	9214 a	164.5 cd	158.2 c	0.359 a	0.323 a	3.08 a	2.80 a
2	9774 a	8973 a	172.4 ab	160.3 bc	0.340 b	0.313 b	2.89 b	2.68 b
4	9479 b	8533 b	171.4 bc	163.3 b	0.317 c	0.289 c	2.69 c	2.51 c
6	8858 c	8023 c	176.3 a	169.1 a	0.272 d	0.244 d	2.32 d	2.10 d
8	8279 d	7558 d	167.0 c	163.0 b	0.238 e	0.220 e	2.04 e	1.90 e
10	7766 e	6923 e	162.1 d	157.2 c	0.225 f	0.218 e	1.94 ef	1.88 ef
12	7501 f	6478 f	156.6 e	151.7 d	0.218 f	0.207 f	1.88 f	1.79 f
LSD values	210	231	4.7	4.0	0.01	0.01	0.13	0.09
Interaction								
MD x WD	*	*	*	*	*	*	*	*

Means of the same category followed by different letters are significantly different at P≤0.05 level using LSD test.
MD = Maize Density, WD = Weed Density, * Significant at p≤0.05.

Leaf area index of maize: In our experiments, maize density significantly affected maize LAI in both years. Maize LAI values observed at maize density of 5, 7.5, 10, and 12.5 plants m^{-2} were 1.52, 2.19, 2.86, and 3.05 in 2006 and 1.37, 1.98, 2.58, and 3.00 in 2007, respectively. Thus during both years the LAI at maize density of 5 plants m^{-2} was minimum and at maize density of 12.5 plants m^{-2} was maximum (Table 1). These values indicate that the apparent increase in maize LAI with progressive increase in maize density was actually due to the increase in mean leaf area with the respective maize density during the calculation process, even though the respective mean leaf area was significantly decreased with gradual rise in maize density. When cocklebur density increased, there was a decline in the maize LAI. The leaf area index at all the cocklebur densities was significantly different from the pure stand of maize during both years, however the LAI of maize at cocklebur density of 8, 10, and 12 plants m^{-2} were statistically at par during both years indicating the intraspecific competition among the cocklebur plants as well. This LAI reduction was progressive with the increasing cocklebur density. The results confirmed that maize LAI was density dependant; increasing density of either species significantly altered the LAI. Tollenaar *et al*., (1994) reported a significant effect of weed competition on maize LAI. The interaction effect on maize LAI was significant in both the experiments. The trend lines indicated that during both the years, the maize LAI at varying maize densities was linearly affected by progressively increasing the cocklebur density (Fig. 2a & b). The intercepts showed that at lower maize density, the LAI was lower and increased with increase in maize density up to 10 plants m^{-2} which was obviously due to the fact that with increase in plant population per unit area there was an increase in LAI but at maize density of 12.5 plants m^{-2}, the intra-specific competition decreased the maize LAI. The R^2 values expressed that there was a close relationship between maize LAI and cocklebur density during both the years. The LAI is used to predict the photosynthetic primary production and as a reference tool for crop growth.

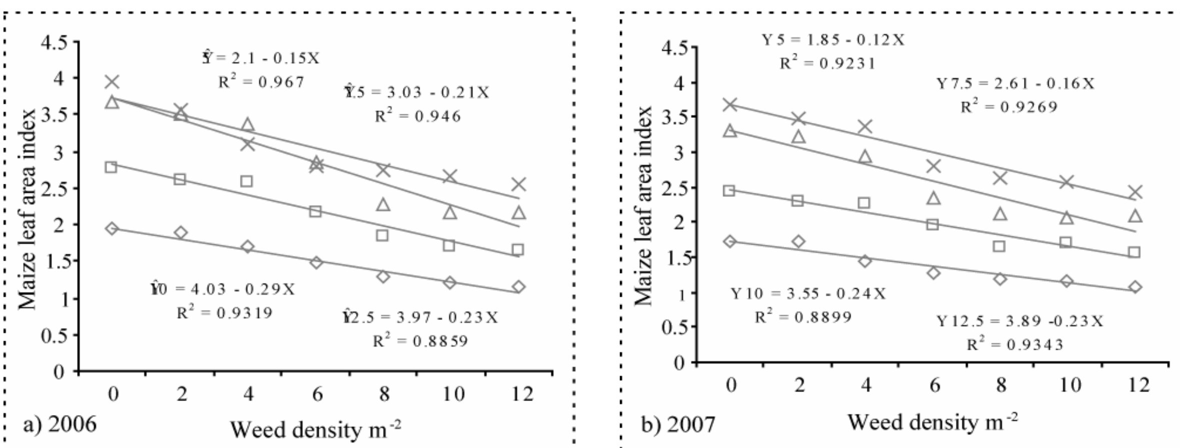

Fig. 2. Effect of maize density (◊ = 5, □ = 7.5, Δ = 10, x = 12.5 plants m^{-2}) and common cocklebur density on leaf area index of maize during a) 2006 and b) 2007.

Plant height of maize (cm): The data analyses showed that maize densities had a significant effect on plant height of maize. At the lower density of 5 plants m^{-2}, maize was prone to interspecific competition which negatively influenced the crop growth and development. Similarly, at the very high density of 12.5 plants m^{-2}, maize was in fact vulnerable to both the intra and interspecific competition. Thus the growth and development of maize plants were restricted both at lower and very high densities contrary to the medium densities of 7.5 and 10 plants m^{-2} which were not that much vulnerable to either mode of competition. Therefore, it was observed in both the years that with increasing maize density from 5 to 10 plant m^{-2} plant height was increased but at maize density of 12.5 plants m^{-2} plant height of maize was reduced (Fig 3a & b).. The results were in line with those reported by Hassan (2000) and Noor-ul-Akbar (1998). The plant height of maize was significantly altered by common cocklebur density as well. Means of the data showed that increasing cocklebur density from 0 to 6 plants m^{-2}, maize plant height progressively increased (Table 1). The canopy coverage of common cocklebur was more than maize crop due to which the crop plants gradually grew higher in competition with cocklebur up to cocklebur density of 6 plants m^{-2} in order to avoid competition for light but at cocklebur density of 8, 10 and 12 plants m^{-2}, the maize plant height was diminished progressively. The results were in line with those reported by David and Kovacs (2007) who stated that higher cocklebur density reduced maize plant height by 33% in weedy control plots compared to weed free plots. Our findings suggested that increasing cocklebur density and/or maize density increased maize plant height but at very high densities of either species the average maize plant height was decreased as a result of increased intra as well as inter-specific competition period (Mishra, 2000). Increased yield loss due to weed competition was associated with reduced plant height and light interception (Coleman & Gill, 2005; Baldoni *et al*., 2000). Plant height was a key factor that contributed significantly to maize biological yield.

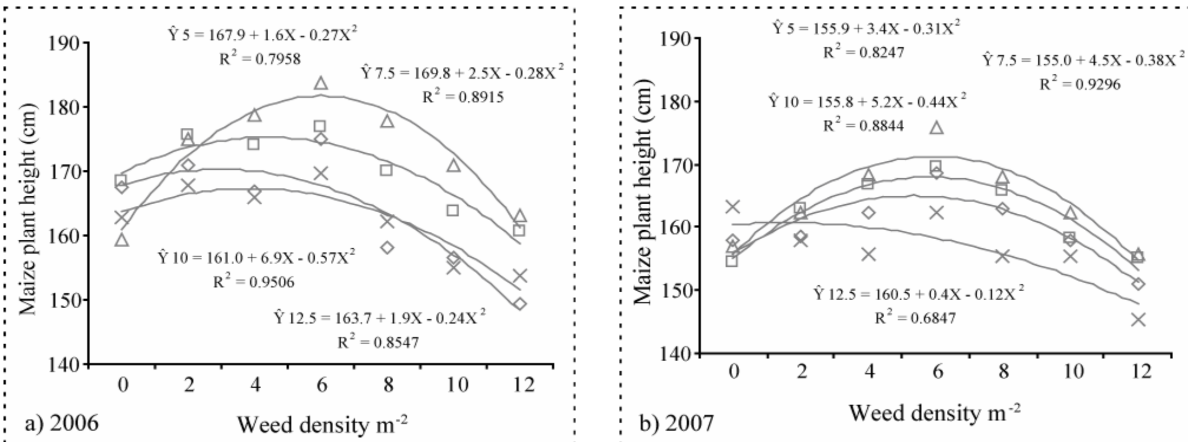

Fig. 3. Effect of maize density (◊ = 5, □ = 7.5, Δ = 10, x = 12.5 plants m^{-2}) and common cocklebur density on plant height (cm) of maize during a) 2006 and b) 2007

Biological yield of maize (kg ha^{-1}): Biological yield is the weight of net photosynthetic material which contributes significantly to the economic yield. In case of maize, it includes both the cob and stover weights. The analysis of the data showed that varying maize densities had significant effect on the biological yield of maize. Maximum biological yield was observed at maize densities of 12.5 plants m^{-2} however it was at par with the biological yield of maize at density of 10 plants m^{-2} during 2006 (Table 1). These results showed that at lower maize density the inter-specific competition and at higher maize density intra-specific competition eventually decreased the crop biomass. At medium maize density of 7.5 and 10 plants m^{-2} the crop was able to produce more biomass in terms of input cost. Therefore, an increase in maize density progressively increased the biological yield of maize crop on an area basis as one would expect (Hashemi *et al*., 2005). Akbar *et al*., (1996) reported that the biological yield of maize crop increased with increase in the crop density but not beyond 100,000 plants ha^{-1}. Common cocklebur density significantly decreased the biological yield of maize. Increasing cocklebur density, the biological yield of maize progressively decreased (Cavero *et al*., 1999). As all the qualitative and quantitative traits of maize were decreased by cocklebur density, therefore the same trend could be expected for biological yield. Maize biomass was declined by increase in weed competition (Saayman & Van-de-Venter, 1997). Table 1 further described that the interaction effect of the varying crop and weed densities on maize biological yield was also significant. The regression lines depicted that maize biological yield at all maize densities was linearly affected by the cocklebur density. The intercepts showed that the biological yield of maize increased with increase in maize density (Fig 4a & b). The linear relationship between biological yield and cocklebur density at varying maize densities during both the years indicated that the greater vegetative growth of cocklebur reduced the biomass accumulation in maize. Generally an increase in one kilogram of weed growth corresponds to a reduction in one kilogram of crop growth (Rao, 2000). Baldoni *et al*., (2000) reported a significant correlation between cocklebur density and biological yield of maize.

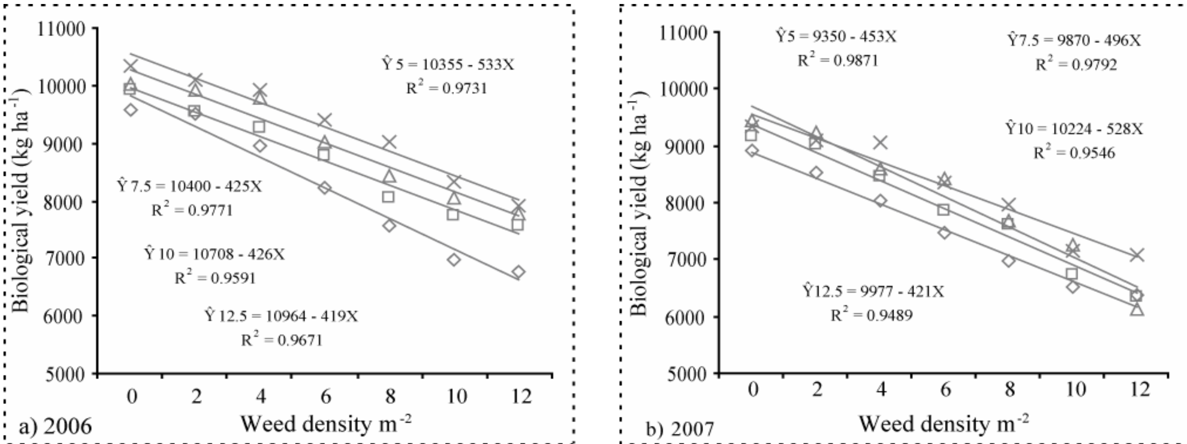

Fig. 4. Effect of maize density (◊ = 5, □ = 7.5, Δ = 10, x = 12.5 plants m^{-2}) and common cocklebur density on biological yield (kg ha^{-1}) of maize during a) 2006 and b) 2007.

References

Afzal, S., A. Din and M.R. Awan. 1994. Preliminary studies on the distribution of maize weeds of Abbottabad and Haripur (NWFP). *Pak. J. Weed Sci. Res*., 7(1-2): 13-17.

Akbar, H., S. Paigham, A.Z. Khan, S. Hamad and M. Munir. 1996. Biomass, grain yield and harvest index, a criteria for comparing corn types at different nitrogen levels and planting densities. *Sarhad J. Agric*., 12(3): 261-267.

Anonymous. 2008. http://www.pakissan.com, allabout/crops/maize. Pakistan Agriculture Research Council, Islamabad.

Anonymous. 2009. Agricultural Statistics of Pakistan 2007-08. Ministry of Food, Agriculture and Livestock (Economic Wing), Islamabad, pp. 18-19.

Arif, M., I. Amin, M.T. Jan, I. Munir, K. Nawab, N.U. Khan and K.B. Marwat. 2010. Effect of plant population, nitrogen levels, and methods of application on ear characters and yield of maize. *Pak. J. Bot*., 42(3): 1959-1967.

Baldoni, G., P. Viggiani, A. Bonetti, G. Dinelli and P. Catezone. 2000. Classification of Italian *X. strumarium* complex based on biological traits, electrophoretic analysis and response to maize interference. *Weed Res*., 40(2): 191-204.

Berzsenyi, Z. and Q.L. Dang. 2007. Study of the effect of plant density on the growth of maize (*Zea mays* L.) hybrids using the Richards function. *Acta Agronomica Hungarica*, 55(4): 417-436.

Bhatt, B.P., D.S. Chauhan and N.P. Todaria. 1994. Effect of weed leachates on germination and radicle extension of some food crops. *Indian J. Plant Physiol.*, 37(3): 177-179.

Bloomberg, J.R., B.L. Kirkpatrick and L.M. Wax. 1982. Competition of common cocklebur with soybean. *Weed Sci*., 30: 507-513.

Casini, P. 2004. Allelopathic influences of common cocklebur (*Xanthium italicum* Moretti) on maize. *Allelopathy J*., 13(2): 189-200.

Cavero, J., Zaragoza and S. Pardo. 1999. Competition between maize and *Datura stramonium* in an irrigated field under semi-arid conditions. *Weed Res.,* 39(3): 225-240.

Coleman, R. and G. Gill. 2005. Trends in yielding ability and weed competitiveness of Australian wheat cultivars. *Proc. Aust. Agron. Conf. Aust. Soc. Agron*., www.regional.org.au.

David, I. and I. Kovacs. 2007. Competition of three noxious weeds with row crops. *Cereal Res. Communic*., 35(2): 341-344.

David, I., V.M. Borbely and L. Radocz. 2005. Changing of amounts of allelochemicals in Italian cocklebur (*X. italicum* Mor.) during the growing season**.** *Novenyvedelem,* 41(9): 397-403.

Hammad, H.M. A. Ahmad, F. Azhar, T. Khaliq, A. Wajid, W. Nasim and W. Farhad. 2011. Optimizing water and nitrogen requirement in maize (*Zea mays* L.) under semi arid conditions of Pakistan. *Pak. J. Bot*., 43(6): 2919-2923.

Hashemi, A.M., S.J. Herbert and D.H. Putnam. 2005. Yield response of corn to crowding stress. *Agron. J.,* 97: 839-846.

Hashim, S. and K.B. Marwat. 2002. Invasive weeds a threat to the biodiversity: a case study from Abbotabad district, N-W Pakistan. *Pak. J. Weed Sci. Res*., 8(1-2): 1-12.

Hassan, A.A. 2000. Effect of plant population density on yield and yield components of Egyptian corn hybrids. Bulletin Faculty Agric. Univ. Cairo. 51: 1-16.

Hussain, Z., K.B. Marwat and J. Cardina. 2011. Common cocklebur competition in forage maize. *Weed Technol.,* 25(1): 151-158.

Inam, B., F. Hussain and F. Bano. 1987. Allelopathic effects of Pakistani weed, *X. strumarium* L. *Pak. J. Sci. Indust. Res.,* 30(7): 530-533.

Marwat, K.B. and E.D. Nafziger. 1990. Cocklebur and velvetleaf interference with soybean grown at different densities and planting patterns. *Agron. J.,* 82(3): 531-534.

Mishra, G.N. 2000. Crop weed competition under varying densities of jungle rice (*Echinochloa colona*) in upland rice. *Indian J. Agric. Sci.,* 70(4): 215-217.

Noor-ul-Akbar. 1998. *Response of corn varieties to various levels of Nitrogen and plant populations*. M.Sc. (Hons) Thesis, Dept. Agron. NWFP Agric. Univ. Peshawar.

Oljaca, S., S. Vrbnicanin, M. Simic, L. Stefanovic and Z. Dolijanovic. 2007. Jimsonweed (*Datura stramonium* L.) interference in maize. *Maydica*, 52(3): 329-333.

Randhawa, M.A. 1995. *Effect of plant spacing and weeds infestation on different agro-physiological traits of maize*. Ph.D Thesis. Dept. Agron. Uni. Agric. Faisalabad-Pakistan.

Rao, V.S. 2000. Harmful effects caused by weeds. *Principles of Weed Science*. Oxford and IBH publishing Co. Pvt. Ltd. New Delhi & Calcutta, pp. 1-2.

Royal, S.S., B.J. Brecke and D.L. Calvin. 1997. Common cocklebur (*X. strumarium*) interference with peanut (*Arachis hypogaea*). *Weed Sci.,* 45: 38-43.

Saayman, A.E.J. and H.A. Van-de-Venter. 1997. Influence of weed competition on subsequent germination and seed vigor of *Zea mays*. *Seed Sci. Technol.,* 25(1): 59-65.

Saayman, A.E.J., H.A. van-de-Venter, H. Brown and G.W. Cussans. 1996. Influence of weed competition on the germination and seed vigour of the produced caryopses of *Zea mays*. Proc. 2nd Inter. Weed Cont. Cong., Copenhagen, Denmark, 25-28 June 1996, 1-4: 101-106.

Saccol, A.V. and V. Estefanel. 1995. Competition between barnyard grass and soybean cultivated in hydromorphic soil. Effect on some agronomic characteristics. *Pesquisa Agropecuaria Brasileira*, 30(3): 327-338.

Shah, A., R. Gohar, S. Khalid and M. Akmal. 2011. Seminal root of maize varieties in relation to reduction in the substrate moisture content. *Pak. J. Bot*., 43(6): 2897-2902.

Steel, R.G.D. and J.H. Torrie. 1980. *Principles and procedures of statistics*. A biometrical approach. 2nd Edition. McGraw Hill, Book Co. Inc. USA.

Thakur, D.R., O.M. Prakash, P.C. Kharwara and S.K. Bhalla. 1997. Effect of nitrogen and plant spacing on growth, yield and economics of baby corn (*Zea mays*). *Indian J. Agron.,* 42(3): 479-483.

Tollenaar, M., A.A. Dibo, A.Aguilara, S.F. Weise and C.J. Swanton. 1994. Effect of crop density on weed interference in maize. Agron. J., 86: 591-595.

Zhang, L., K. Wang, X. Zhang, L. Lu, Y. Li, M. Gao, C. Wang, J. Hu and Z. Liang. 2011. Role of nitrate nutrition in alleviation of the adverse effects of drought stress on maize cultivars: biomass production and antioxidative capacity. *Pak. J. Bot*., 43(6): 2869-2874.

(Received for publication 2 September 2011)