INTEGRATION OF NITROGEN FERTILIZER AND HERBICIDES FOR EFFICIENT WEED MANAGEMENT IN MAIZE CROP

NOOR WALI KHAN,NAEEM KHANand IJAZ AHMAD KHAN

Department of Weed Science, Agricultural University, Peshawar – Pakistan.
E-mail: nk_khandr@yahoo.com

ABSTRACT

Investigating the response of maize plants to nitrogen levels and herbicides, a field trial was undertaken in 2006 at the Malakandher Research Farm, Agricultural, University Peshawar, Pakistan. The trial was carried out under randomized complete block design with split plot arrangements and each treatment having four replications. Three levels of nitrogen (N) fertilizer in urea form (viz. 80, 120 and 160 kg ha^{-1}) and three herbicides (viz. Stomp 330 EC, Atrazine 38 SC and 2,4-D ester) were applied in the trial. A control plot was maintained with each treatment for comparison. The N levels were assigned to the main plots and the herbicides were assigned to the sub plots. For all the N levels, their half N dose was applied after 10 days of seed germination while the second half N dose was applied after 45 days of the crop germination. Stomp 330 EC @ 0.75 and Atrazine 38 SC @ 1.00 kg ha^{-1} (both applied as pre-emergent) at the time of sowing and 2,4-D (ester) @ 0.80 kg ha^{-1} was applied as post emergent after 25 days of sowing the crop. Results have shown the lowest weed density (30.83 weeds m^{-2}) and the lowest dry weed biomass (6.80 g m^{-2}) in plots that were sprayed with atrazine while the highest weed density (54.33 weeds m^{-2}) and the highest dry weed biomass (10.83g m^{-2}) was found in control plots. In case of plant height, herbicides did not significantly affect the maize plant height; however, the N levels had significantly affected the maize plant height and the tallest plants were recorded under 120 and 150 kg ha^{-1} N levels (i.e. 164.8 and 163.5 cm, respectively) followed by 90 kg ha^{-1} N level (161.3 cm). The shortest plants of maize were found in the control plots. The maximum cob length (12.33 cm) was recorded in the stomp and in the atrazine treated plots while the minimum cob length (9.83 cm) was found in the control plots. Maize gave the greatest grain yield (1.47 t ha^{-1}) in the atrazine treated plots and the lowest grain yield (1.24 t ha^{-1}) was realized in the control. In addition, the greatest grain yield of maize (1.5 t ha^{-1}) was found under the 160 kg ha^{-1} N level. The interaction of all the herbicides with 160 kg ha^{-1} N level had produced the best grain yield of maize. As over all, atrazine was found to be the best herbicide for weed control in maize and the 160 kg ha^{-1} N level was found to be the best for increasing productivity of the crop.

***KeyWords*: Herbicides, integration, nitrogen fertilization, maize crop, weed management.**

Citation: Khan, N., N.W. Khan and I.A. Khan. 2012. Integration of nitrogen fertilizer and herbicides for efficient weed management in maize (*Zea mays*) crop. Sarhad J. Agric. 28(3):457-463

INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal crops of Pakistan. It belongs to the family Poaceae and is an annual cross pollinated, determinate and having C_4 carbon fixation pathway. The maize plant possesses an erect stem which bears alternate leaves. Maize produce tassel at the top and axillary female inflorescence “ear” in the middle. The stalk is composed of nodes and internodes. Its internodes are straight and cylindrical in the upper part of the plant, but alternately grooved on the lower part.

Maize is a multipurpose crop (e.g. used as human food, animal’s and poultry feed, and in industrial products) (Bibi*et al*., 2010). It contributes 6.4% to the total grain production in the country and occupies an important position in the national economy; as it is a good source of food for people, feed for poultry and fodder for livestock. The maize grain containing protein (10.4%), fat (4.5%), starch (17.8%), vitamins and minerals (Chaudhry, 1994). Maize also produces raw materials for starch industry and is also used in the preparation of other products.

Although maize is grown in all of the four provinces of Pakistan, however, the major growing provinces are Punjab, Sindh and Khyber Pakhtunkhwa (KPK). In Pakistan, in 2008-2009, maize was cultivated on an area of 981.8 thousand hectares which produced 2797.0 thousand tons with 2849 kg ha^{-1} average grain yield (MINFAL, 2008-2009). The major maize growing district(s) of KPK province includes Peshawar, Kohat, Mardan, D.I. Khan, Bannu and Swat, and Hazara and Malakand divisions etc. The total cultivated area under maize in KPK, during 2008-2009 was 509.5 thousand hectares which produced 957.9 thousand tons grains with an average yield of 1880 kg ha^{-1} (MINFAL, 2008-2009).

A number of nutrients are essential for growth and development of maize plants, among which N is the most important one which can effect growth and production of the crop. The agricultural lands of Pakistan are poor in major nutrients especially N due to which their crop productivity is significantly poor (Rashid, 1994). In addition, the unbalanced application of synthetic fertilizers is also responsible for poor crop growth (Anonymous, 2006). This is because the reduced quantity of N in soils causes stunted growth, small grain size and reduced yield of maize crop and its overall competition with weeds. The growth of plants primarily depends on sufficient extractable N quantity in soil in solution form. However, the access enrichment of soil with N beyond the crop need could be utilized by various weeds infesting the crop and could promote weed infestation and make them more competitive against the crop plants and hence, increase production losses to the maize crop.

The average maize crop production in Pakistan is comparatively lower to most of the other maize growing countries. Various factors are responsible for this lower production, among which various weeds infestation is a more important factor. Only in KPK province, maize crop is facing ca. 20-40% production losses due to various weeds infestation (Anonymous, 2001) and if not managed properly in time, the yield losses may reach to 35-70% (Ford and Pleasant, 1994; Teasdale, 1995). More than 200 different types of weeds have been found to be infesting various crops in KPK with varying densities. The most harmful weeds, infesting maize crop and causing its yield losses in KPK are thought to be *Echinocloa crus-galli*(L.) P. Beauv., *Leptochloa* sp., *Cyperusrotundus*L., *Sorghum helepense*(L.) Pers., *Cynodondactylon*(L.) Pers., *Digiteriasanguinalis*(L.) Scop., *Convolvulus arvensis*L., *Tribulusterrestris*L., *Digeramuricata* (L.) Mart. and *Portulacaolereacea* L. (Ullah*et al*., 2008; Hassan *et al*., 2010).

Several weed management measures may be useful for managing weeds in maize crop, such as sowing of improved maize cultivars (Hassan *et al*., 2010) and other cultural practices (Begna*et al*., 2001), hand weeding (Abouziena*et al*., 2008), and biological control. However, most of these management measures possess several limitations; e.g. the improved competitive and high yielding maize cultivars seed is expensive, hand weeding is laborious and costly especially in bigger fields and also weather dependent, and is not feasible during the monsoon rains (Chaudhry, 1994). Biological control of weeds is not feasible as the bio-control agents require optimal environmental and climatic conditions to reproduce, to establish and to increase their population sizes, and is not feasible in a short period of time. In such a circumstance, additional weed management measures are needed that are easy to be applied and also economical to minimize the production losses in maize crop. The utilization of herbicides and N fertilizers might be additional weed management measures for maize crop which could provide a better solution to the weed problem in maize and could be able to minimize production losses due to weeds. Many studies have shown the usefulness of herbicidal weed control in maize (e.g. Hassan *et al*., 2010) have found herbicidal control of weeds as one of the most effective control measure in maize. Miller and Libby (1999) and Ali *et al*. (2003) have also recommended herbicidal weed control for getting higher maize yield. In addition, maize yield reduction was reported to be minimum due to weeds in soils with sufficient N contents than under soils deficient in N (Rajcan and Swanton, 2001) and N fertilizer had increased the growth of maize plants (Bibi*et al*., 2010). Thus, the integration of N fertilization and herbicides might be useful in managing weeds in maize crop as fertilization of maize plants with N could promote growth of the crop plants and make them more competitive against weeds, and the application of herbicides could kill the weeds in maize crop. Thus, keeping in mind the usefulness of herbicides and N fertilization, this present trial was undertaken to find out the most effective herbicides for weed control in maize, to find out the optimum N application level for promoting growth of maize plants against the weeds and better integration of herbicides and N fertilizer for achieving maximum yield.

MATERIAL AND METHODS

A trial was undertaken on the response of maize to different N fertilizer rates and herbicides at Malakander Research Farm, KPK Agricultural University Peshawar (710-27' and 720-47' E and 330-40' and 340-31' N) during the summer season of the year 2006. Peshawar has a sub-tropical climate with mean maximum temperature of 40^{o}C and mean minimum temperature of 4^{o}C, where the mean annual rainfall was ca. 365 mm; however the mean summer rainfall was less than the mean winter rainfall. The trial was laid out using Randomized Complete Block (RCB) design with split plot arrangement and having three N-rates (i.e. in form of urea) in the main-plots while three herbicides and a control in the sub-plots (each measuring 3m x 5m). Each treatment was having four rows (75cm apart from each other) and each treatment was replicated four times. Prior to sowing, the field site was three times ploughed approximately 30cm deep using a cultivator to destroy all types of the growing vegetation and then planking was done to prepare fine seed bed for sowing the seed. The maize variety "Azam" was sown at its recommended seeding rate (40 kg ha^{-1}) using drill method. The trial was irrigated when required.

The N (in urea form) was hand broad-casted onto the assigned experimental plots uniformly @ 80, 120 and 160 kg ha^{-1} in two split doses (i.e. the first dose after 10 days of germination and the second dose after 45 days of germination) while did not applied to the control plot. In addition, the herbicidal treatments (i.e. Stomp 330 EC @ 0.75 and Atrazine 38 EC @ 1.00) were applied as pre-emergence while 2,4-D 72 (ester) @ 0.80 kg a.i ha^{-1} was applied as post emergence after 25 days of sowing the crop. The N levels (80, 120 and 160 kg ha^{-1}) were assigned to the main plots while the herbicidal treatments (Stomp 330 EC @ 0.75, Atrazine 38 SC @ 1.00, 2,4-D 72 (ester) @ 0.80 and Control (0) kg a.i. ha^{-1}) were kept in sub-plots.

Parameters were recorded on weed density (m^{-2}), dry weed biomass (m^{-2}), maize plant height (cm), maize cob length (cm) and maize grain yield (kg ha^{-1}). The weed density was recorded by placing a quadrate of 0.25 m^2 three times randomly in all the experimental plots after 30 days of sowing the crop and all the weeds occurring inside the quadrate were identified, visually counted and recorded, and then subsequently converted into weed density m^{-2}. To record dry weed biomass data, in all experimental treatments a quadrate of 0.25 m^2 was randomly landed 3 times inside all plots and the weeds surrounded by the quadrates were cut through a manual cutter, placed separately in marked paper bags, dried in an oven at 72 ± 3°C for 48 hours and weighed to record their dry biomass (g) using an electronic balance. Finally, the data was converted on m^{-2} basis. To measure maize plant height, 10 randomly selected mature plants of maize at harvest maturity (102-days after sowing) from each replicated plot were measured from the soil surface level to the tip of the plants with the help of a measurement rod. To measure cob length, 10 plants were randomly selected inside each replicated plot at harvest maturity; all cobs were removed from the selected plants, measured their length (cm) and subsequently computed their means. To record maize grain yield, from each replicated plot, the central two rows were harvested using a pair of manual shears, dried under the sun light for ca. 4-days, removed all the cobs from all plants, threshed all the grains from all the cobs, their weight (kg) was measured and converted into tons ha^{-1}, i.e.

$$\text{grain yield (t ha}^{-1}\text{)} = \frac{\text{Grain yield (kg) from net plot}}{\text{Area harvested (m}^2\text{)}} \times 10000$$

Statistical Analysis of Data

All the parameters recorded were subjected to the analysis of variance (ANOVA) technique using MSTATC statistical software followed by means separation for their significant differences using the least significance (LSD) test as has been demonstrated by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Weed Density

Statistical analysis of the data showed that different levels of N had a non-significant effect and the herbicides applied had significant affect while their interaction had non-significant effect on the weed density in maize crop Table I. The lowest weed density (30.83 weeds m^{-2}) was recorded in plots which were sprayed with atrazine 30 SE Table III followed by Stomp 330 EC and 2,4-D (ester) both achieving statistically at par weed control (i.e. 38.00 and 37.17 weeds m^{-2}, respectively; Table III. The highest weed density (54.33 weeds m^{-2}) was observed in the control plots which did not receive the herbicides spray Table III. The highest weed density (41.38 weeds m^{-2}) was recorded in those plots that received 160 kg ha^{-1} N while the minimum weed density (38.875 weeds m^{-2}) were noted in plots that were fertilized with 80 kg ha^{-1} N Table III. Similar results have been reported by Khan *et al*. (2003), Abdullah (2007) and Hassan *et al*. (2010) by stating that herbicides have significantly reduced the weed density in maize crop and Devender*et al*. (1998) have found atrazine as the most effective herbicide for reducing weed density in maize. However, Ullah*et al*. (2008) have found stomp to be more effective in controlling weeds in maize crop. Conversely Hussein *et al*. (2007) found hand-hoeing to be the most efficient weed control measure.

Table I ***Mean squares for weed density and dry weed biomass as affected by nitrogen levels applied and herbicides sprayed for weed control in maize***

Source of variation	Mean Squares		
	Degree of freedom	Weed density (m^{-2})	Dry weed biomass (g m^{-2})
Replication	3	233.833	0.831
Nitrogen levels	2	25.083 NS	0.449 NS
Error	6	16.083	0.761
Herbicides	3	1205.889*	35.341*
Interaction	6	15.139 NS	0.517 NS
Error	27	21.741	0.467
CV (%)	-	11.63	7.75

*= Significant at p<0.05
NS= Non-significant

Table II ***Mean squares for plant height, cob length and grain yield as affected by nitrogen levels applied and herbicides sprayed for weed control in maize***

Source of variation	Mean Squares			
	Degree of freedom	Plant height (cm)	Cob length (cm)	Grain yield (t ha^{-1})
Replication	3	96.250	5.278	0.032
Nitrogen levels	2	50.021*	0.583 NS	0.093*
Error	6	3.688	2.028	0.007
Herbicides	3	11.639NS	18.000*	0.094*
Interaction	6	3.410 NS	0.917NS	0.004NS
Error	27	5.542	1.111	0.013
CV (%)	-	1.44	9.04	27.77

*= Significant at p<0.05
NS= Non-significant

Table III ***Weed density (m^{-2}) as affected by different nitrogen levels, different herbicides and their interaction***

Herbicides	Nitrogen Levels (kg ha^{-1})			Herbicides Means
	80	120	160	
Stomp330 EC	35.50	39.50	36.50	37.17b
Atrazine 38 SC	31.50	28.75	32.25	30.83c
2,4-D 72 (ester)	37.00	37.25	39.75	38.00b
Control	51.50	54.50	57.00	54.33a
Nitrogen levels Mean	38.87	40.00	41.38	-

Means in the columns having different alphabets are significantly different (at 0.05 level of significance).

Dry Weed Biomass

Statistical analysis undertaken on the weeds dry biomass data had showed significant effect of the applied herbicides against weeds in maize crop Table I as the minimum weed dry biomass (6.80 g m^{-2}) was found in the atrazine treated experimental plots while the maximum weeds dry biomass (10.83 g m^{-2}) was recorded in control plots Table IV. Stomp and 2,4-D were noted to be the second and third effective herbicides as to reduce weeds dry biomass by 8.24 and 9.42 g m^{-2}, respectively as compared to the control plots (10.83 g m^{-2} weeds dry biomass; Table IV. The N levels and the interaction of herbicides and N levels did not affect the weeds dry biomass significantly Table II, however, the highest weeds dry biomass was recorded for 160 and 120 kg ha^{-1} N level (i.e. 8.93 and 8.90 g m^{-2}, respectively) and the lowest weeds dry biomass (8.63 g m^{-2}) was recorded for 80 kg ha^{-1} N level Table IV. The results are in line with the findings of Balyan*et al*. (1994), who also stated that herbicidal applications had significantly decreased the dry matter accumulation of weeds. The more recently undertaken studies by Ullah*et al*. (2008) and Hassan *et al*. (2010) have also found the pre-emergence herbicides (viz. atrazine and stomp) to be highly effective in reducing the weed biomass in maize crop.

Table IV ***Dry weed biomass (g m^{-2}) as affected by nitrogen levels, herbicides and their interaction***

Herbicides	Nitrogen Levels (kg ha^{-1})			Herbicides Means
	80	120	160	
Stomp330 EC	8.15	8.02	8.54	8.24c
Atrazine 38 SC	6.73	7.03	6.65	6.80d
2,4-D 72 (ester)	8.96	9.33	9.97	9.42b
Control	10.68	11.25	10.58	10.83a
Nitrogen levels mean	8.630	8.905	8.933	-

Means in the columns having different alphabets are significantly different (at 0.05 level of significance).

Plant Height

Plant height is a function of the genetic as well as the environmental condition. Statistical analysis indicated that the different N levels had a significant and herbicides had non-significant effects upon the plant height of maize plants while their interaction was found non-significant on the plant height of maize (Table II). The tallest plants of maize (164.82 cm) were recorded for 160 kg ha^{-1} N level treated plots, while the shortest maize plants (161.31 cm) in plots which were fertilized at 80 kg ha^{-1} N level (Table V). Although herbicides did not showed significant effect on plant height of maize, but the tallest plants (164.17 cm) were noticed in plots sprayed with 2, 4-D (ester) and the smallest maize plants (161.83 cm) were seen in the control plots (Table V). The plant height increase in the plants of maize may have been occurred due to sufficient availability of N for the maize plants. In addition the application of the herbicides had possibly reduced competition by the weeds with the maize plants. These results can be justified with the results shown by Uhart and Andrade (1995) and Akma*et al*. (2010) who have found higher growth rate of maize plants when supplemented with N fertilizer application. In addition, Nawab*et al*. (1999) and Hassan *et al*.

(2010) have said that the maize plant height was comparatively high in plots which were sprayed with herbicides for weed control than the control plots where no herbicide was sprayed.

Table V ***Plant height (cm) of maize as affected by nitrogen levels, herbicides and their interaction.***

Herbicides	**Nitrogen Levels (kg ha^{-1})**			**Herbicides Means**
	80	**120**	**160**	
Stomp330 EC	161.25	163.00	166.25	163.50
Atrazine 38 SC	161.25	163.25	165.50	163.33
2,4-D 72 (ester)	162.75	164.75	165.00	164.17
Control	160.00	163.00	162.50	161.83
Nitrogen levels mean	161.31bc	163.50ab	164.82a	-

Means in the columns having different alphabets are significantly different (at 0.05 level of significance).

Cob Length

Analysis of the data indicated that the cob length of maize was significantly affected by the herbicides treatment while the nitrogen levels and the interaction of herbicides and N levels did not possess significant effect over the cob length of maize ($p<0.05$; Table II). All of the three herbicides applied for weed control in maize had achieved statistically similar cob length; however, the longest cob length (13.25 cm) was gained by plots which were sprayed with atrazine while the shortest cob length (9.75 cm) was observed in the control plots (Table VI). Our results are in great agreement with those reported by Kamal *et al*. (1983) and Ali *et al*. (2003). They have reported the promotion of cob length when appropriate weed controlled treatments including herbicidal weed control was applied for weed control in maize crop. The non-significant effect of the N levels on the cob length of maize may have been associated with the sufficient availability of N for the maize plants under the no or reduced weed competition achieved by the herbicidal application for weed control in the maize crop as has been reported by Akmal *et al*. (2010) where maize plants have shown statistically similar response to 120 and 150 kg ha^{-1} N fertilization in terms of growth rate promotion of the maize plants.

Table VI ***Cob length (cm) of maize as affected by nitrogen levels, herbicides and their interaction***

Herbicides	**Nitrogen Levels (kg ha^{-1})**			**Herbicides Means**
	80	**120**	**160**	
Stomp330 EC	12.50	12.00	12.50	12.33a
Atrazine 38 SC	11.75	12.00	13.25	12.33a
2,4-D 72 (ester)	12.00	12.50	12.00	12.17a
Control	9.75	10.00	9.75	9.83b
Nitrogen levels mean	11.50	11.63	11.88	

Means in the columns having different alphabets are significantly different (at 0.05 level of significance).

Grain Yield

The grain yield of maize was statistically analyzed and shown to be significantly affected by the N levels and that by the herbicides treatments while interaction of both was found to be non-significant on the grain yield of maize infested with weeds (Table II). For nitrogen levels, the greatest and statistically similar grain yield of maize was obtained in plots which were supplemented with 160 and 120 kg ha^{-1} N levels by 1.50 and 1.40 tons ha^{-1}, respectively) while the lowest grain yield (1.35 t ha^{-1}) was recorded in plots that received 80 kg ha^{-1} N fertilization (Table VII). Although, all of the three herbicides used for weed control in maize had showed statistically equal efficiency against the weeds, but yet the highest grain yield (1.47 t ha^{-1}) was recorded for atrazine (Table VII). The lowest value (1.24 t ha^{-1}) of grain yield was recorded for the control plots (Table VII). This indicate that herbicidal application had killed the weeds in maize crop while the N fertilization had provided sufficient nutritional requirements for the maize plants to rapidly grow and hence promoted its grain production. Our results can be supported by the results of many researchers such as Khan (2002) and Subhan *et al*. (2007). All of them have indicated increased grain yield of maize crop by controlling weeds with the application of herbicides. Similarly, Abbas *et al*. (2003), Akmal *et al*. (2010) and Bibi*et al*. (2010) have found higher grain yield of maize when supplemented with sufficient quantity of N fertilizers.

Table VII ***Grain yield (t ha^{-1}) of maize as affected by nitrogen levels, herbicides and their interaction***

Herbicides	Nitrogen Levels (kg ha^{-1})			Herbicides Means
	80	120	160	
Stomp330 EC	1.39	1.42	1.55	1.46a
Atrazine 38 SC	1.37	1.47	1.55	1.47a
2,4-D 72 (ester)	1.42	1.40	1.55	1.46a
Control	1.20	1.31	1.34	1.24b
Nitrogen levels mean	1.35b	1.40ab	1.50a	-

Means in the columns having different alphabets are significantly different (at 0.05 level of significance).

CONCLUSION AND RECOMMENDATION

As overall, Atrazine 38 SC had proved to be the best solution for weed management in maize crop followed by Stomp 330 EC which also achieved desirable weed control results. In addition, the application of 160 kg ha^{-1} N level was found to be the best in maize which could sufficiently promote the growth of maize crop against the weeds, enable the crop to strongly compete with the weeds and subsequently give higher production.

REFERENCES

Abbas, M., M.Z. Rizwan, A.M. Maqsood and M. Rafiq. 2003. Maize response to split application of nitrogen. J. Agric. Biol. 5:19-21.

Abdullah. 2007. Effect of planting methods and herbicides on yield and yield components of maize. M.Sc(Hons) Thesis, Agric. Univ. Peshawar, Pakistan.

Abouziena, H.F., I.M. El-Metwally, E.R. El-Desoki. 2008. Effect of plant spacing and weed control treatments on maize yield and associated weeds in sandy soils. Amer. Eurasian J. Agric. &Envir. Sci. 4(1):9-17.

Ali, R., S.K. Khalil, S.M. Raza and H. Khan. 2003. Effect of herbicides and row spacing on maize (*Zea mays* L.). Pak. J. Weed Sci. Res. 9(3-4):171-178.

Akmal, M., Ur-Rehman, H., Farhatullah, M. Asim and H. Akbar. 2010. Response of maize varieties to nitrogen application for leaf area profile, crop growth, yield and yield components. Pak. J. Bot. 42(3):1941-1947.

Anonymous. 2001. Losses in different crops due to weeds. Plant Physiol. Section, Agric. Res. Instt.Tarnab, Peshawar, Pakistan.

Anonymous. 2006. The impact of deregulation on the fertilizer sector and crop productivity inPakistan. pp.46-47.

MINFAL.2008-2009. Agricultural Statistics of Pakistan.Ministry of Food Agric.&Livest. (MINFAL), Govt. of Pakistan, Islamabad.

Balyan, R.S., R.K. Mali, R.S. Dhankar and S.M. Singh. 1994. Effect of time and method of isoproturon application on weeds in maize. Haryana Agric. Univ. Res. 24 (4):158-162.

Begna, H.S., R.I. Hamilton, L.M. Dwyer, D.W. Stewart, D. Cloutier, L. Assemat, K.Foroutan-pour and D.L. Smith. 2001. Morphology and yield response to weed pressureby corn hybrids differing in canopy architecture. Europ. J. Agron. 14(4):293-302.

Bibi, Z., N. Khan, M. Akram, Q. Khan, M.J. Khan, S. Batool and K. Makhdum. 2010. Integrating cultivars with reduced herbicides rates for weed management in maize. Pak. J. Bot. 42(3):1923-1929.

Chaudhry, F.M. 1994. Kharif cereal crops. In: Elena, B. and Robyn, B. (Eds.), Handbook of Crop Production. Sigma Press, Rawalpindi, Pakistan.pp.261-269.

Devender, S., R.C. Tyagi, S.K. Agarwal and D. Singh. 1998. Weed control methods in spring maize. Haryana Agric. Univ. J. Res. 28(1):21-25.

Ford, G.T., M.J. Pleasant. 1994. Competitive abilities of six corn (*Zea mays* L.) hybrids with four weed control practices. Weed Tech. 8:124-128.

Hassan, G., S. Tanveer, N. Khan and M. Munir. 2010. Integrating cultivars with reduced herbicides rates for weed management in maize. Pak. J. Bot. 42(3):1923-1929.

Hussein F., Abouziena, M.F. El-Karmany, M. Singh and S.D. Sharma. 2007. Effect of nitrogen rates and weed control treatments on maize yield and associated weeds in sandy soils. Weed Tech. 21(4):1049-1053.

Kamal, M.S., M.S.Abdel-Raouf, E.A. Mahmoud and S. Amer. 1983.Response of two maize varieties to different plant densities in relation to weed control treatments. Ann. Agric. Sci. 19:79-93

Khan, S.A., N. Hussain, I.A. Khan, M. Khan and M. Iqbal. 1998. Study on weed control in maize. Sarhad J. Agric. 14(6):581-586.

Khan, M.A. 2002.Efficacy of different herbicides on the yield and yield components of maize.M.Sc (Hons) Thesis, Agric. Univ. Peshawar, Pakistan.

Khan, B.M., N. Khan and I.A. Khan. 2003. Efficacy of different herbicides on the yield and yield componentsof maize. Asian Net. Sci. Info. 3(2):300-304.

Miller, T.W. and C.R. Libbey. 1999. Response of three sweet corn cultivars to several herbicides. Res. Prog. Report.Western Soc. Weed Sci. Colorado Springs, USA.pp.57-58.

Nawab, K., M. Hatam, B.A. Khan, K. Rashid and M. Mansoor. 1999. Study of some morphological characters in maize as affected by time of weeding and plant spacing. Sarhad J. Agric. 15(1):21-24.

Rajcan, I. and C.J. Swanton. 2001. Understanding maize-weed competition: resource competition, light quality and the whole plant. Field Crops Res. 71(2):139-150.

Rashid, A. 1994.Annual report of micronutrient project. Land Resources Res. Instt.(LRRI), NARC, Islamabad, Pakistan.

Spandl, E., T.L. Rabaey, J.J. Kells and R.G. Harvey. 1997. Application timing for weed controlin corn (*Zea mays*) with dicamba tank mixtures. Weed Tech. 11(3):602-607.

Steel, R.G.D. and J.H. Torrie. 1980. Principle and procedures of statistics (2nd Ed.). McGraw Hill book Co. Inc., New York. pp.232-251.

Subhan, F., N. Ud-Din, A. Azim and Z .Shah. 2007. Response of maize crop to various herbicides. Pak. J. Weed Sci. Res. 13(1-2):9-15.

Teasdale, J.R. 1995. Influence of narrow/high population corn (*Zea mays* L.) on weed control and light transmittance. Weed Tech. 9:113-118.

Uhart, S.A. and F.H. Andrade. 1995. Nitrogen deficiency in maize. 1. Effect on crop growth, development, dry matter partitioning and kernel set. Crop Sci. 35:1376-1383.

Ullah, W., M.A. Khan, M. Sadiq, H. Rehman, A. Nawaz and M.A. Sher. 2008. Impact of integratedweed management on weed and yield of maize. Pak. J. Weed Sci. Res. 14(3-4):141-151.