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Effect of herbicides on productivity and weed control efficiency in Maize (*Zea mays* L.)

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Abstract
The experiment was conducted in randomized block design with ten weed management treatments involving various herbicides (acetochlor @ 1.125, 2.25 and 4.5 kg a.i. ha^{-1}, atrazine @ 1.0 kg a.i. ha^{-1}, pendimethalin @ 0.5 kg a.i. ha^{-1} + atrazine @ 0.5 kg a.i. ha^{-1}, alachlor @ 0.5 kg a.i. ha^{-1} as pre-emergence and 2,4-Diethyl ester @ 0.6 kg a.i. ha^{-1} and topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} as post-emergence including weed free and weedy check replicated thrice. Among the weed control treatments, post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} coupled with atrazine @ 0.25 kg a.i. ha^{-1} recorded significantly lower weed index and higher weed control efficiency. Weed free treatment recorded significantly higher grain and stover yields than weedy check. Weed free treatment recorded significantly higher grain and stover yields (83.1 and 140.4 q ha^{-1}) and was significantly superior over rest other herbicide treatments except topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} and acetochlor @ 4.5 kg a.i. ha^{-1} which exhibited statistical parity among themselves. Yield attributing parameters of maize also followed the similar trends, in which topramezone @ 0.04 kg a.i. ha^{-1} coupled with atrazine @ 0.25 kg a.i. ha^{-1} exhibited parity with acetochlor @ 4.5 kg a.i. ha^{-1}. From the results of the present study, it can be concluded that application of topramezone @ 0.04 kg a.i. ha^{-1} coupled with atrazine @ 0.25 kg a.i. ha^{-1} both as post-emergence herbicides can be recommended in winter maize for enhancing crop yield and yield attributes, more weed control efficiency and less weed index.

Keywords: Herbicide, yield, weed control efficiency, weed index

Introduction
Maize is grown all year in all states for a different purpose, like grain, fodder, green cobs, sweet corn, baby corn, and popcorn in peri-urban areas. The predominant maize growing states that contributes more than 80% of the total maize production are AP (20.9%), KN (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), UP (6.1%), MP (5.7%), HP (4.4%). In Uttar Pradesh, maize is cultivated mainly in the upper Gangetic plain in the state. In U.P., maize is grown in as many as 25 districts Bulandshahar, Jaunpur, Etawah, Ghaziabad, Bahraich, Farrukhabad, and Gonda is the main maize producing districts. In Uttar Pradesh the total area of maize was 62374 (ha) in 2016-17, total production of maize was 110903 (metric tonnes), and productivity 17.78 q/ha in 2016-17 (Directorate of Economics & Statistics, (DAC & FW) 2016-17.

The yield reduction of maize due to weeds has been reported to the extent of 40 per cent (Lal and Saini, 1985). The weedy environment from 30 days after swoing and up to 50 days after sowing is harmful to maize crop and causes severe yield losses (Porwal, 1998) [2]. Pests, plant diseases, and weeds all contribute to significant maize output losses. Maize is subjected to severe weed competition, which results in yield losses ranging from 28-100%, depending on the intensity of the weed competition and its origin, crop stages, and length of infection. (Patel *et al*., 2006) [3]. Ashique *et al*.(1997) [4] and Oerke & Dehne, (2004) [5] Weeds were shown to be the most significant agricultural production limiting factor, lowering crop output by 20-40% depending on weed species and density. Weed competition has resulted in yield losses of up to 35%. (Oerke, 2005) [6]. Furthermore, weeds serve as an additional host for insects and plant disease organisms, increasing production costs. Weed management strategies must be prioritised in order to retain the vulnerable crop's competitive competitiveness by reducing weed interference during crop growth phases. The kind of weed interference has a considerable effect on the selection of weed management strategies.

To reduce weed losses, several strategies are available, including mechanical, cultural, biological, and chemical management methods. Cultural approaches are still beneficial in general, but they are becoming costlier, arduous, and time consuming. As a result, farmers are turning to alternate weed management methods. As a result, chemical weed management is an essential option that is rapid, more effective, efficient, and saves time and labour. Chemical weed control method is suggested by many researchers (Khan and Haq, 2004 and Toloraya *et al*., 2001) [7, 8]. Knezevic *et al*. (2003) reported that grain yield has significantly improved by the use of herbicides in maize. These findings are in agreement with those of Rout and Satapathy (1996) [10]. The success of chemical control measures is determined by various aspects, including weed emergence pattern, timing of application, and crop stage. Herbicide application timing is critical for optimal weed control and increasing herbicide efficacy. Herbicidal weed management appears to be a competitive and promising method of controlling weeds during the early phases of crop development. Weed losses can be decreased by using selective herbicides, but they might be prohibitively expensive for many farmers if the herbicide-treated weeds are not herbicide resistant. (Mehmeti *et al.*, 2012) [11]. To manage the dynamic and complex weed flora in maize, there is need to evaluate different herbicides alone and in combination to have a broad spectrum weed control this research was conducted the objective 1. to find out the effect of herbicide on yield and yield attributing character and productivity of maize, 2. to find out the effect of herbicide on weed dynamics in maize

Material and Methods

Experimental Site

The experiment was carried out at Agricultural Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur, during the *Kharif* season of 2021-22. The Geographical location of Kanpur comes under central Plain Zone agro-climatic zone of Uttar Pradesh. It located at a latitude of 26.4499° N, longitude of 80.3319° of 126 meters above the mean sea level in the old alluvial plain zone falling under the Central Plain Zone. The topography and soil at the experimental site is the land was fairly leveled and well drained. The soil is medium textured category as silt loam with soil reaction falling in the neutral range. Fertility status of the experimental plots as envisaged through organic carbon, available nitrogen was low and phosphorus and potash was in medium range during 2021-22.

Climatic condition of site

The climate of Kanpur is subtropical, with a rainy season that runs roughly from mid-June to early October, due to the monsoon, and a dry season from mid-October to early June. In winter, from mid-November to late February or early March, nights are cool, and sometimes even cold. In addition, from November to February, fog can form at night and in the early morning. The fog usually dissolves during the day, however, in these situations, it can sometimes be cool even during the day, with highs of 15/16 °C (59/61 °F), and sometimes even below. From mid-March to mid-June, before the monsoon, it is very hot. In the hottest periods, the temperature can reach or exceed 45 °C (113 °F). The rainfall amounts to 885 millimeters (34.8 inches) per year: so, it is at an intermediate level. It ranges from 3 mm (0.1 in) in the driest month (November) to 280 mm (11 in) in the wettest one (August). The average annual rainfall of this locality is around 1100 mm of which 80-85 per cent is received during four monsoon months (June to September), late arrival and early cessation of monsoonal rains are common. The normal rainfall is about 1207 mm (10 years' average) which is unimodal type mostly precipitating during middle of June to middle of October, where potential evapo-transpiration is lower than the precipitation.

Experimental Details

The experiment was laid out in randomized block design, comprising ten weed management treatments especially herbicide dose including weed free and weedy check replicated thrice and thirty numbers of plots with net plot size was 3.8×3 m^2. Maize variety DKC-9081 was used as seed, recommended dose of fertilizer NPK as 120:75:50 kg ha^{-1} through source of Urea (46% N), DAP (18% N & 46% P_2O_5) and MOP (60% K_2O) were used as experimental material during the experiment and sowing date was 21 June 2021. The details of the treatment description are presented in Table 1

Table 1: Treatment Details

S. No.	Treatments	Dose (kg a.i. ha^{-1})	Time of application
T_1	Weedy check	-	-
T_2	Weed free	-	-
T_3	Acetochlor 90% EC	1.125	Pre-emergence
T_4	Atrazine 50% WP	1.00	Pre-emergence
T_5	Pendimethalin 30% EC + Atrazine 50% WP	0.50 0.50	Pre-emergence Pre-emergence
T_6	Topramezone 33.6% SC + Atrazine 50% WP	0.04 0.25	Post-emergence
T_7	Acetochlor 90% EC	2.25	Pre-emergence
T_8	Alachlor 50% WP	0.50	Pre-emergence
T_9	2,4- Diethyl ester 38% EC	0.60	Post-emergence
T_{10}	Acetochlor 90% EC	4.50	Pre-emergence

Result and Discussion

Effect of different weed control treatments on yield attributing characters

Among the yield attributes, number of grains per cob, cob length and test weight were higher in weed free treatment (385.7 grains cob^{-1}, 17.3 cm and 363.2 g, respectively). However, among the weed control treatments, post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} (T_6) recorded significantly higher number of grains per cob (382.3) which might be attributable to improved metabolite translocation for grain development. It was largely due to reduced weed competition in these treatments and was at par with rest of the herbicide treatments except weedy check (T_1) which exhibited lower value. Likewise decrease in number of grains per cob was noticed with increase in weed competition (Thakur and Sharma, 1996). Cob length and test weight also varied significantly with weed control treatments. Significantly higher cob length was recorded under post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} (T_6) followed by acetochlor @ 4.5 kg a.i. ha^{-1} (T_3), atrazine @ 1.0 kg a.i. ha^{-1} (T_4), pendimethalin 0.5 kg a.i ha^{-1} + atrazine @ 0.5 kg a.i. ha^{-1} (T_5) and 2, 4-Diethyl ester @ 0.6 kg a.i. ha^{-1} (T_9). Whereas, test weight was recorded higher with post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} +

atrazine @ 0.25 kg a.i. ha^{-1} (T_6) and found significantly higher test weight (362.8 g) as compared to rest of the treatments (Table 2). The differences in various yield attributes of maize, which led to the significant yield differences among weed control treatments could be tracked back to differences in growth parameters.

Higher grain production in these treatments might be ascribed to better yield components such as increased number of grains per cob, cob length, and test weight. This increase in yield components was caused by enhanced growth factors such as increased total dry matter production and dispersion in different sections, as well as a greater leaf area index. As a result of decreased crop-weed competition, crop consumption of nutrients, moisture, light, and space shifted in favour of crop. These results are in agreement with the findings of Bially (1995) [12].

Yield

Yield is the net effect of several interactions, including soil characteristics, meteorological conditions, crop-weed competition, leaf area, and metabolic and biochemical interactions that occur during crop growth. Maize grain yield is further regulated by dry matter buildup in various sections, particularly in reproductive areas, and yield components, which are the result of interactions between the foregoing characteristics.

The highest grain yield of maize (83.1 q ha-1) was obtained from weed free treatment. This is most likely due to the establishment of a changed physical micro-climate for mechanical soil manipulation and lower crop-weed competition under weed free treatment, which may have resulted in improved yield components and therefore higher yield. (Mundra *et al.*, 2003) [3]. Persistence and broad-spectrum weed control keep the weed population in check by arresting or inhibiting weed seed germination and arresting weed growth and development, resulting in a weed-free environment for the crop, better manifestation of growth and yield attributes, and, ultimately, increased crop yield. These findings are consistent with those reported by Singh *et al*. (2005) [14]. The yield advantage related to various weed control treatments over weedy management was primarily attributed to improved yield characteristics, reduced weed population and biomass, and increased weed control efficacy. Low crop-weed competition throughout the crop growth phase allowed the crop to make the most use of nutrients, moisture, light, and space, all of which affected growth and yield components. The above results could be corroborated with the findings of Rout and Satapathy (1996) [10], and Sinha *et al.* (2000) [15]. Higher grain production in these treatments might be ascribed to better yield components such as increased number of grains per cob, cob length, and test weight. As a result of decreased crop-weed competition, crop consumption of nutrients, moisture, light, and space shifted in favor of crop. The result recorded in my experiment also favored by the results of Saini and Angiras (1998), Sreenivas and Satyanarayana (1994) and Kamble *et al.* (2005). Among the weed control measures/treatments, post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} (T_6) produced significantly higher grain yield to the tune of 17.9 per cent over weedy check. Acetochlor @ 4.5 kg a.i. ha^{-1} (T_{10}), pendimethalin @ 0.5 kg a.i ha^{-1} +atrazine @ 0.5 kg a.i. ha^{-1} (T_5), atrazine @ 1.0 kg a.i. ha^{-1} (T_4), 2,4-Diethyl ester @ 0.6 kg a.i. ha^{-1} (T_9) and acetochlor @ 2.25 kg a.i. ha^{-1} (T_7) produced similar grain yields (81.9, 80.0, 79.5, 79.1 and 78.6 q ha^{-1}, respectively). The increase in yield in these treatments was to the tune of 16.8, 14.1, 13.4, 12.8 and 12.1 per cent over weedy check (T_1), respectively (Table 3). The increased yield in these treatments was owing to higher weed control efficiency and increased crop growth and number of grains per cob. Acetochlor @ 1.125 kg a.i. ha^{-1} (T_3) and alachlor @ 0.5 kg a.i. ha^{-1} (T_8) exhibited statistical parity with each other in terms of lower grain yield among herbicides treatment and produced 9.2 and 10.4 per cent more yield than that of weedy check (T_1). Weed free treatment (T_2) also recorded highest stover yield (140.4 q ha^{-1}) followed by topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} (T_6) and acetochlor @ 4.5 kg a.i. ha^{-1} (T_{10}). The lowest stover yield was recorded in weedy check (T_1), however, statistical parity for stover yield was also found among acetochlor @ 1.125 kg a.i. ha^{-1} (T_3), alachlor @ 0.5 kg a.i. ha^{-1} (T_8) and acetochlor @ 2.25 kg a.i. ha^{-1} (T_7) noted lower value which was mainly due to reduced dry matter accumulation in plant. (Table 3). The lowest grain yield (70.1 q ha^{-1}) was noticed in weedy check (T_1) as a result of the largest loss of nutrients and moisture by weeds and extreme crop-weed competition, resulting in poor source and sink development with poor yield components and a higher weed index. Lowest grain yield under weedy check accounted for 15.53 per cent of yield loss as evident from weed index value. This was mainly due to lower dry matter accumulation, leaf area index, plant height, poor development of yield attributes and higher weed index

Weed control efficiency

Weed control efficiency worked out at 15, 30, 45 and 60 days after sowing on the basis of total weed dry weight in weedy check and herbicide treatment are presented in Table 4. At all the growth stages, weed free treatment (T_2) recorded maximum weed control efficiency (100 per cent) and zero value in weedy check (T_1). At 15 days after sowing, among the different herbicide treatments, acetochlor @ 4.5 kg a.i. ha^{-1} (T_{10}) recorded significantly higher weed control efficiency (72.2 per cent) as compared to rest of the treatments. At 30 days after sowing, among the different herbicide treatments, post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} coupled with atrazine @ 0.25 kg a.i. ha^{-1} (i.e. T_6) recorded significantly higher weed control efficiency (60.1 per cent) as compared to rest of the treatments but it was at par with (T_{10}), acetochlor @ 4.5 kg a.i. ha^{-1} (54.8 per cent). At 45 days after sowing, among the different herbicide treatments, post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} coupled with atrazine @ 0.25 kg a.i. ha^{-1} (T_6) recorded significantly higher weed control efficiency (52.5 per cent) as compared to all other treatments. At 60 days after sowing, among the different herbicide treatments, post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} coupled with atrazine @ 0.25 kg a.i. ha^{-1} (T_6) recorded significantly higher weed control efficiency (75.8 per cent) as compared to rest of the treatments but it was at par with (T_{10}), acetochlor 4.5 @ kg a.i. ha^{-1} (73.2 per cent). Lower weed count and weed dry weight might explain the improved weed management performance. These findings supported the findings of Kolage *et al*. (2004). However, weedy check had a worse weed control efficacy, which was mostly attributable to greater weed count and weed dry weight. These results supported by the findings of Saini and Angiras (1998) and Sreenivas and Satyanarayana (1996).

Weed index (%)

Weed index, which is a measure of yield reduction due to weed competition which was the maximum in weedy check because of competition attributed by unchecked growth of weed which compete for nutrients, moisture and light as indicated by poor growth and yield components. The significantly lower weed index was noticed with post-emergence application of topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} (T_6) which was at par with acetochlor @ 4.5 kg a.i. ha^{-1} (T_{10}) and pendimethalin 0.5 kg a.i ha^{-1} + atrazine @ 0.5 kg a.i. ha^{-1} (T_5). Significantly highest weed index was observed with weedy check (T_1). On the contrary to WCE, weed index was found zero value in weed free check (T_2). The weed control treatments, namely, weed free manually (T_2) and herbicide use such as topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} (T_6), acetochlor @ 4.5 kg a.i. ha^{-1} (T_{10}) and pendimethalin @ 0.5 kg a.i ha^{-1} + atrazine @ 0.5 kg a.i. ha^{-1} (T_5) were equally effective in regards of controlling weeds and herbicides had higher value of weed index than weed free check (T_2). This was mostly attributable to increased growth as a result of successful weed management and a reduction in crop-weed competition. This may have allowed the crop to absorb more nutrients.

Table 2: Effect of different weed control treatments on yield attributing characters.

Treatments		No. of cobs plant^{-1}	No. of grain rows cob^{-1}	No. of grains row^{-1}	Length of cob	Girth of cob	No. of grains cob^{-1}	1000-grain weight (g)
T_1	Weedy check	1.03	13.8	25.2	16.3	15.0	359.8	335.4
T_2	Weed free	1.32	14.7	27.7	17.3	15.8	385.7	363.2
T_3	Acetochlor @ 1.125 kg a.i. ha^{-1}	1.05	14.2	25.8	16.3	15.2	364.2	343.8
T_4	Atrazine @ 1.0 kg a.i. ha^{-1}	1.27	14.4	26.9	16.9	15.4	378.1	355.0
T_5	Pendimethalin @ 0.5 kg a.i.ha^{-1} + atrazine @ 0.5 kg a.i. ha^{-1}	1.28	14.4	27.3	16.8	15.4	378.5	358.9
T_6	Topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1}	1.30	14.7	27.6	17.2	15.8	382.3	362.8
T_7	Acetochlor @ 2.25 kg a.i. ha^{-1}	1.23	14.3	26.2	16.5	15.4	367.3	349.3
T_8	Alachlor @ 0.5 kg a.i. ha^{-1}	1.07	14.3	26.0	16.4	15.3	365.4	348.7
T_9	2,4-Diethyl ester@ 0.6 kg ai ha^{-1}	1.25	14.5	26.7	16.7	15.5	370.4	352.0
T_{10}	Acetochlor @ 4.5 kg a.i. ha^{-1}	1.28	14.6	27.5	17.2	15.8	381.6	360.7
SEm±		0.09	0.2	0.5	0.2	0.2	6.7	7.0
CD (P=0.05)		0.27	0.6	1.7	0.6	0.6	20.1	20.9

Table 3: Effect of different weed control treatments on grain, stover and stone yield (q ha^{-1}).

Treatments		Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Stone yield (q ha^{-1})
T_1	Weedy check	70.1	115.7	14.0
T_2	Weed free	83.1	140.4	18.3
T_3	Acetochlor @ 1.125 kg a.i. ha^{-1}	76.6	126.4	15.3
T_4	Atrazine @ 1.0 kg a.i. ha^{-1}	79.5	132.8	17.5
T_5	Pendimethalin @ 0.5 kg a.i.ha^{-1} + atrazine @ 0.5 kg a.i. ha^{-1}	80.0	134.4	17.6
T_6	Topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i.ha^{-1}	82.7	139.8	18.2
T_7	Acetochlor @ 2.25 kg a.i. ha^{-1}	78.6	131.3	16.5
T_8	Alachlor @ 0.5 kg a.i. ha^{-1}	77.4	128.5	16.3
T_9	2,4-Diethyl ester @ 0.6 kg a.i. ha^{-1}	79.1	132.1	16.6
T_{10}	Acetochlor @ 4.5 kg a.i. ha^{-1}	81.9	137.6	18.0
SEm±		1.1	1.9	0.3
CD (P=0.05)		3.3	5.8	1.1

Table 4: Effect of different weed control treatments on weed control efficiency and weed index (%).

Treatments		Weed control efficiency (%)				Weed index (%)
		15 DAS	30 DAS	45 DAS	60 DAS	
T_1	Weedy check	0.0	0.0	0.0	0.0	15.53
T_2	Weed free	100.0	100.0	100.0	100.0	0.00
T_3	Acetochlor @ 1.125 kg a.i. ha^{-1}	54.7	37.3	26.2	59.0	7.89
T_4	Atrazine @ 1.0 kg a.i. ha^{-1}	57.2	43.2	28.1	62.2	4.38
T_5	Pendimethalin @ 0.5 kg a.i.ha^{-1} + atrazine @ 0.5 kg a.i. ha^{-1}	56.9	45.4	31.2	64.9	3.72
T_6	Topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i.ha^{-1}	3.1	60.1	52.5	75.8	0.54
T_7	Acetochlor @ 2.25 kg a.i. ha^{-1}	59.2	40.6	30.8	64.2	5.45
T_8	Alachlor @ 0.5 kg a.i. ha^{-1}	56.2	40.6	25.4	59.4	6.95
T_9	2,4-Diethyl ester @ 0.6 kg a.i. ha^{-1}	1.7	46.0	35.6	70.8	4.83
T_{10}	Acetochlor @ 4.5 kg a.i. ha^{-1}	72.2	54.8	44.6	73.2	1.36
SEm±		3.0	1.8	1.4	1.1	1.3
CD (P=0.05)		9.0	5.6	4.2	3.3	3.8

Summary and Conclusion

Weed free check recorded significantly highest grain yield and was significantly superior over rest other herbicide treatments except topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} (T_6), acetochlor @ 4.5 kg a.i. ha^{-1} (T_{10}) and pendimethalin @ 0.5 kg a.i. ha^{-1}+ atrazine @ 0.5 kg a.i. ha^{-1} (T_5). Application of topramezone @ 0.04 kg a.i. ha^{-1} + atrazine @ 0.25 kg a.i. ha^{-1} (T_6) recorded significantly lower weed index and higher weed control efficiency and was at par with acetochlor @ 4.5 kg a.i. ha^{-1} (T_{10}).

From the results of the present study, it can be concluded that application of topramezone @ 0.04 kg a.i. ha^{-1} coupled with atrazine @ 0.25 kg a.i. ha^{-1} both as post-emergence herbicides can be recommended for maize in enhancing crop yield in terms of more growth, yield attributes and retards weed complex which leads to more weed control efficiency and less weed index. However, the results are of one season. Further experimentation is needed to have the right recommendation of herbicides for winter maize for a particular soil and climatic feature.

References

1. Lal S, Saini RS. Technology for increasing maize production. Indian Farming. 1985;35:5-9.
2. Porwal MK. Effect of graded levels of nitrogen on weeds in winter maize. Indian Journal of Weed Science. 1998;30(1&2):69-71.
3. Patel VJ, Upadhyay PN, Zala SU, Patel BD. Residual effect of herbicide applied as alone and mixture to kharif maize on succeeding *rabi* oat and mustard. Indian Journal of Weed Science. 2006;38(3/4):258-262.
4. Ashique M, Shah ML, Shafi M. Weeds of maize and their eradication. Zarat Nama. 1997;35:89.
5. Oerke EC, Dehne HW. Safeguarding production-losses in major crops and the role of crop protection. Crop Protection. 2004;23:275–285
6. Oerke EC. Crop losses to pest. Journal of Agricultural Science. 2005;143:1-13.
7. Khan MA, Haq NU. Effect of pre-emergence herbicides on weed control in maize grain yield. Sarhad Journal of Agriculture. 2004;9(5):415-421.
8. Toloraya TR, Malakanova VP, Akhtyrtsev MG. Effectiveness of dates, methods and doses of applying zinc sulfate and its combination with the selective herbicides (Titus) in maize sowings. Kukuruza I Sorgo. 2001; 2:5-7.
9. Knezevic M, Durkic M, Knezevic I, Loncaric Z. Effect of pre- and post-emergence weed control on weed population and maize yield in different tillage systems. Plant Soil Environment. 2003;49(5):223-229.
10. Rout D, Satapathy MR. Chemical weed control in rainfed maize (*Zea mays* L.). Indian Journal of Agronomy. 1996;41(1):51-53.
11. Mehmeti A, Adem D, Imri D, Halime R. Effect of post-semergence herbicides on weeds and yield of maize. Pakistan Journal of Weed Science Research. 2012;18(1):27-37.
12. Bially ME. Efficacy of atrazine with other herbicides used alone in sequence or as tank mix in maize. Annals of Agricultural Science. 1995;40:709-721.
13. Mundra SL, Vyas AK, Maliwal PL. Effect of weed and nutrient management on weed growth and productivity of maize (*Zea mays* L.). Indian Journal of Weed Science. 2003;35(1&2):57-61.
14. Singh M, Singh P, Nepalia V. Integrated weed management studies in maize based intercropping system. Indian Journal of Weed Science. 2005;37(3&4):205-208.
15. Sinha SP, Prasad SM, Singh SJ. Effect of integrated weed management on growth and yield attributes and yield of winter maize. Journal of Applied Biology. 2000;10(2):158-162.
16. Angiras NN, Chopra P, Kumar S. Weed seed bank and dynamics of weed flora as influenced by tillage and weed control methods in maize (*Zea mays* L.). Agricultural Science Digest. 2010;30(1):6-10.
17. Sreenivas G, Satyanarayan V. Nutrient removal by weeds and maize. Indian Journal of Agronomy. 1996;41(1):160-162.
18. Kamble TC, Kakade SU, Nemade SU, Pawar RV, Apotikar VA. A integrated weed management in hybrid maize. Crop Research. 2005;29(3):396-400.