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HERBICIDAL CONTROL OF PARTHENIUM WEED IN MAIZE

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Abstract

Two years experiments were conducted using randomized complete block (RCB) design, having eight treatments, replicated four times to find their impact on maize, parthenium and associated weeds. The treatments consisted of 6 herbicides, viz., Aatrax (atrazine) @ 1.0, Buctril super (bromoxynil+MCPA) 60 EC@ 0.80, Dual gold (s-metolachlor) 960 EC @ 1.92, Sencor extra (metribuzin) @ 2.0, Primextra gold 720 SC (atrazine+s-metolachlor), @ 1.50 Stomp (pendimethalin) 330 EC @ 1.50 kg. a.i. ha^{-1}, hand weeding and a control. Data showed that weed density was significantly influenced by application of various herbicides in maize. Fresh weed biomass (g m^{-2}) was reduced in plots where Primextra gold and Dual gold were sprayed followed by hand weeding. Weed mortality (%) was significantly influenced by application of different herbicides, whereas year effect remained similar for weed mortality. Higher weed mortality was observed in Primextra gold treated plots, followed by hand weeding and Dual gold which were statistically at par. Long stature maize plants were recorded in hand weeding and Primextra gold treated plots, whereas short stature plants were found in control plots. Number of grains ear^{-1} was significantly increased by application of herbicides and higher numbers of grains were recorded in Primextra gold and hand weeded plots. Thousand grain weight was significantly increased by herbicides and hand weeding. Application of herbicides significantly influenced biological and grain yields of maize. The effect of year was found non-significant for both grain and biological yields. Control plots resulted in lower grain and biological yield. Overall results indicated that application of Primextra gold as pre-emergence could provide good control of parthenium weed and associated weeds in maize.

Introduction

Maize (*Zea mays* L.) a member of family Poaceae, is an important spring as well as summer crop, grown both as a fodder and grain crop. Generally, it has been thought in the past that maize originated form teosinte, a wild grass originated in Mexico and Central America. It was introduced to subcontinent in the era of the Mughal Emperor Jehangir and brought to Pakistan area from Central America (Anon., 2007).

Maize being the highest yielding cereal crop in the world is of significant importance for countries like Pakistan, where rapidly increasing population has already out stripped the available food supplies. In Pakistan, maize is 3rd important cereal after wheat and rice, and accounts for 4.8% of the total cropped area and 3.5% of the value of agricultural output. Maize was grown on area of 974.2 thousand hectares with production of 3707 thousand tons having an average national yield of 3805 kg ha^{-1}, while in Khyber Pakhtunkhwa, the area under maize crop was 422.9 thousand hectares which produced 740.5 thousand tons with an average yield of 1751 kg ha^{-1}. Khyber Pakhtunkhwa, accounting for 57% of the total area and 68% of the total production (Anon., 2010-11).

There are several reasons responsible for lower yield of maize in Pakistan among them high weed infestation and poor weed management practices are very imperative. Maize crop is highly infested with several weeds. They shrink the crop yield from 20-40% depending on weed species and density (Ashique *et al.*, 1997). Among the crops, maize has been perceived to be more severely affected by parthenium weed in the Khyber Pakhtunkhwa Province (Khan *et al.*, 2013). Parthenium is a weed of national significance in Pakistan. Although infesting many districts of Khyber Pakhtunkhwa province, but more affected districts are Swabi, Mardan, Charsadda and Peshawar where it is highly invasive and invaded most of the open spaces like roadsides, water channels, pastures and crops and thus threatening the local biodiversity (Khan *et al.*, 2012; 2014). Parthenium weed has infested almost all field crops and if left uncontrolled, it can reduce crop yields by 40-97% (Tamado & Milberg, 2004). In India (Kamble *et al.*, 2005; Sharma & Gautam, 2003) reported parthenium weed as a major weed in maize crop.

Parthenium weed has been found in some of the most important rangelands (Swat & Potohar valley) in the country as well as in fodder crops such as maize, sorghum, persian clover and Egyptian clover (Shabbir & Bajwa, 2006). The degree of yield losses depends on nature, intensity, stage and duration of competition with weeds. Weeds density and the weed-free periods relative to the crop are two important aspects of weed interference (Bosnic & Swanton, 1997). These features can be fairly unpredictable for parthenium weed as it can emerge, grow and flower over a broad range of soil condition, temperatures and photoperiods (Williams & Groves, 1980) and it can be noticed in crop fields at densities ranging from a few plants to 370 plants m^{-2} in Eastern Ethiopia (Tamado & Milberg, 2000).

Manual and mechanical methods for controlling parthenium weed are not effective (Muniappa *et al.*, 1980). Manual cutting results in rapid regeneration, which is quickly followed by flowering with abundant seed production (Dhawan & Dhawan, 1996). Besides this, manual control method is tedious, not safe, labor intensive and expensive compared to chemical control. Alternative method of weeds control is required to prevent potential crop losses and increase maize crop productivity. Herbicides are a cheaper option and more effective against parthenium weed than manual control. Successful control of parthenium weed has been achieved by several herbicides (Ahmad *et al*., 2013; Balyan *et al*., 1996; Yadav *et al.*, 1997). Field trials showed that herbicides controlled weeds and produced 15% more maize yield than the weedy check (Abid *et al*., 1991).

Several studies on the control of parthenium weed with herbicides in different crops have been carried out worldwide. However, the information on the use of herbicides for parthenium weed control in maize in Pakistan and particularly in Khyber Pakhtunkhwa Province is almost lacking. Keeping in view the importance of the parthenium and associated weeds in maize, field experiments were conducted with the objectives to appraise the efficacy of herbicides for the control of weeds dominated by parthenium weed in maize crop.

Materials and Methods

Experimental site description: Field experiments were conducted to evaluate the herbicidal control of parthenium weed and associated weeds in maize in Swabi district, Khyber Pakhtunkhwa, Pakistan during summer 2009 and was repeated in 2010. The study site is situated at 72°28'0.39" East longitude and 34° 7'0.00" North latitude and at an elevation of 1089 ft. The experiments were conducted on a farmer’s field, heavily infested with parthenium weed. The farmer had abandoned the field for several years because of the severe weeds infestation. The soil was loamy having 7.4 pH, 0.89% organic matter content, 5% $CaCO_3$, 0.04% N, 7.80 P ppm and 373 K ppm (Anon., 2009).

Experimental layout and design: The experiments were laid out in randomized complete block (RCB) design, replicated four times with eight treatments. Herbicides used in the experiments were; Aatrax @ 1.0, Buctril super 60 EC @ 0.80, Dual gold 960 EC @ 1.92, Sencor extra @ 2.0, Primextra gold 720 SC @ 1.50 Stomp 330 EC @ 1.50 kg. a.i. ha^{-1}, hand weeding and a no-herbicide control (Table 1). The size of experimental unit was 5x4.5m. There were 6 rows of maize in each treatment, spaced 0.75 m apart. Measurements were made on individual plants present in central 3 rows. Recommended doses of all pre-emergence herbicides were applied on 18 June, 2009 and 22 June 2010. Control treatment remained weedy for the whole season. The weeded plots were kept weed free through hoeing.

Agronomic treatments: Field was prepared by plowing and harrowing. The soil was fertilized with 100 kg ha^{-1} N in the form of Urea and 60 kg ha^{-1} P in the form of single super phosphate (SSP) just before maize sowing. A complementary application of 60 kg ha^{-1} N was applied one month after sowing. The maize variety ‘Azam’ (widely cultivated in KPK) at seed rate of 50 kg ha^{-1} was planted in June 22, 2009 and June 26, 2010 with the help of dibbler. The crop was irrigated 4 times in 2009 due to sufficient rainfall and 6 times in 2010. All other agronomic practices were kept uniform for all the treatments from sowing to harvest.

The data on weed density (m^{-2}) was recorded after four weeks of herbicidal application with the help of 0.5x0.5 m quadrate. For fresh weed biomass (g m^{-2}) each treatment was weeded out thoroughly and weeds inside quadrate were harvested. The data recorded on weeds mortality (%) was based on visual rating of each treatment compared to control treatment. Scale of 1-5 was used for recording weeds mortality (%), where 1 means 0-20, 2 means 20-40, 3 means 40-60, 4 means 60-80 and 5 means 80-100 % weed mortality caused by the herbicides.

Maize plant height (cm) was recorded at the time of crop physiological maturity. Ten plants were randomly selected from each treatment and their height was measured from base to the top of the plant, then averages were computed. For number of grains ear^{-1} in each treatment, 10 ears were randomly selected from the maize plants and then the number of grains was counted for each ear. Thousand grain weight (g) was taken from the grain lot of each treatment and weighed by using electronic digital balance. For recording biological yield (kg ha^{-1}) maize plants of two central rows of each treatment were harvested at maturity. Bundles were tied, air-dried and weighed by spring balance and the values were converted to kg ha^{-1} by the formula:

Data on grain yield were recorded by cutting two central rows of 4 m length of each subplot. The cobs were then husked, dried, shelled and converted into kg ha^{-1} by the formula:

$$\text{Biological yield (kg ha}^{-1}) = \frac{\text{Biological weight (kg) x 10000 m}^2}{\text{Row length (m) x R-R distance (m) x No. of rows harvested}}$$

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{Grain weight (kg) x 10000 m}^2}{\text{Row length (m) x R-R distance (m) x No. of rows harvested}}$$

Harvest index was calculated by using the formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (kg ha}^{-1}) \text{ x 100}}{\text{Biological yield (kg ha}^{-1})}$$

Statistical analysis: The data recorded individually for each parameter were analyzed statistically combined over years using analysis of variance techniques appropriate for randomized complete block design. Means were compared using LSD test at 0.05 level of probability, when the F-values were significant (Steel & Torrie, 1980). The statistical software GenStat release 8.1 (GenStat, 2005) was used for analysis of the data.

Table 1. Details of herbicides treatments used in the experiment during 2009-10.

S. No.	Treatments	Common name	Time of application	Rate kg/L ha^{-1}
1.	Aatrax	Atrazine	Pre-emergence	1.0
2.	Buctril Super 60 EC	Bromoxynil + MCPA	Pre-emergence	0.80
3.	Dual Gold 960 EC	S-metolachlor	Pre-emergence	1.92
4.	Sencor Extra	Metribuzin	Pre-emergence	2
5.	Primextra Gold 720 SC	Atrazine + S-metolachlor	Pre-emergence	1.50
6.	Stomp 330 EC	Pendimethalin	Pre-emergence	1.50
7.	Hand Weeding	-----	------	------
8.	Weedy Check	-----	------	------

Table 2. Weed density of *A. viridis, C. arvensis, C. dactylon, C. rotundus* and *D. sanguinalis* as affected by herbicides during 2009-2010.

Year (Y)	*Amaranthus viridis*	*Convolvulus arvensis*	*Cynodon dactylon*	*Cyperus rotundus*	*Digiteria sanguinalis*
2009	4.16	3.69	8.69	8.66	6.34
2010	3.53	3.56	5.13	7.22	4.84
Significance	Ns	Ns	*	*	Ns
Treatments					
Aatrax	5.25 b*	5.63 b	8.75 b	9.13 b	3.75 c
Buctril Super 60 EC	3.38 c	3.88 cd	6.88 bc	6.38 c	8.88 b
Dual Gold 960 EC	1.25 de	2.00 e	4.13 cd	3.50 de	1.13 de
Sencor Extra	2.63 cd	2.50 de	4.00 cd	5.50 cd	3.25 cd
Primextra Gold 720 SC	1.50 de	0.38 f	2.13 d	2.88 e	0.13 e
Stomp 330 EC	6.25 b	4.38 bc	9.25 d b	9.63 b	7.88 b
Hand Weeding	0.75 e	2.00 e	2.63 d	4.75 cde	1.75 cde
Weedy Check	9.75 a	8.25 a	17.50 a	21.75 a	18.00 a
LSD	1.76	3.09	3.09	2.62	2.48

*Means for each categories (column) followed by different letters are significantly different from each other at 5% level of probability. Ns = Non significant

Results

Weeds flora: Data regarding weeds flora in various treatments are presented in (Tables 2, 3). Application of different herbicides considerably reduced the densities of weeds species. The densities of *Amaranthus viridis, Convolvulus arvensis, Digiteria sanguinalis, Parthenium hysterophorus, Portulaca oleracea, Trianthema portulacestrum* and *Xanthium strumarium* were not considerably different during both the years, whereas year effect was significant for *Cynodon dactylon, Cyperus rotundus* and *S. halepense*. Densities of *Cynodon dactylon, Cyperus rotundus* and *Digiteria sanguinalis* were higher in 2009 as compared to 2010. Weeding was found highly effective in reducing *A. viridis* and *C. arvensis* which were similar to the application of Primextra gold and Dual gold followed by Sencor extra and Buctril super treated plots. Likewise in case of *Cyperus rotundus* and *Digiteria sanguinalis*, their densities was lower in plots where Primextra gold was applied, however it was at par with hand weeded plots and these were followed by Sencor extra and Dual gold sprayed plots. Aatrax was more effective in reduction of *D. sanguinalis* than *Cyperus rotundus*. In case of parthenium weed, Preimextra gold and Dual gold equally reduced their densities. Similarly, Primextra gold, hand weeding and Dual gold effectively reduced *P. oleracea* density followed by Sencor and Aatrax. The densities of *X. strumarium, T. portulacestrum* and *S. halepense* were comparatively reduced with the application of Primextra gold, hand weeding and Dual gold. Similarly, Aatrax was also effective in the reduction of their densities. In control plots, higher densities of all weeds were found.

Weed density (m^{-2}): Data (Table 4) of weed density m^{-2} was significantly influenced by the application of various herbicides. Year was also found significant. The overall weed density m^{-2} was higher in 2009 as compared to 2010. It was obvious from the mean values indicated that all herbicides effectively reduced number of weeds as compared to control plots. Less number of weeds were found in plots where Primextra gold was sprayed (14.1), however it was at par with plots where hand weeding was practiced (19.1) and Dual gold was sprayed (21), followed by the plots where Sencor extra was sprayed (42.8). The remaining herbicides were moderate in reducing number of weeds in maize field. Higher weed density was recorded in control plots (156.9 m^{-2}).

Table 3. Weed densities of *P. hysterophorus, P. oleracea, S. halepense, T. portulacestrum* and *X. strumarium* as affected by herbicides during 2009-2010.

Year (Y)	*Parthenium hysterophorus*	*Portulaca oleracea*	*Sorghum halepense*	*Trianthema portulacestrum*	*Xanthium strumarium*
2009	9.44	5.59	4.00	5.28	3.03
2010	7.78	6.00	3.44	6.34	2.81
Significance	Ns	Ns	*	Ns	Ns
Treatments					
Aatrax	7.13 c*	3.38 d	1.88 de	3.63 de	2.00 cd
Buctril Super 60 EC	10.25 bc	5.50 c	5.38 b	6.00 b	4.13 b
Dual Gold 960 EC	2.63 d	2.50 de	1.75 de	2.00 de	0.13 ef
Sencor Extra	10.00 bc	4.00 cd	2.88 cd	4.75 cd	3.25 bc
Primextra Gold 720 SC	1.63 d	0.88 e	1.63 de	1.50 de	1.50 de
Stomp 330 EC	11.00 b	7.63 b	4.50 bc	7.00 bc	5.63 a
Hand Weeding	2.63 b	2.50 de	0.25 e	1.88 e	0.00 f
Weedy Check	23.63 a	20.00 a	11.50 a	19.75 a	6.75 a
LSD	3.27	2.01	1.92	2.01	1.37

*Means for each categories (column) followed by different letters are significantly different from each other at 5% level of probability. Ns = Non significant

Table 4. Weed density, fresh weed biomass and weed mortality as affected by herbicides during 2009-2010.

Year (Y)	Weed density (m^{-2})	Fresh weed biomass (gm^{-2})	Weed mortality (%)
2009	58.9	313.3	67.5
2010	50.7	301.8	68.4
Significance	*	Ns	Ns
Treatments			
Aatrax	50.5 d*	285.9 d	67.5 a
Buctril Super 60 EC	60.6 c	334.6 c	62.5 e
Dual Gold 960 EC	21.0 f	104.6 f	91.3 b
Sencor Extra	42.8 e	258.1 e	72.5 c
Primextra Gold 720 SC	14.1 f	86.3 f	98.8 a
Stomp 330 EC	73.1 b	498.0 b	60.0 e
Hand Weeding	19.1 f	100.1 f	91.3 b
Weedy Check	156.9 a	792.8 a	0.0 f
LSD	7.38	27.43	3.7

*Means for each categories (column) followed by different letters are significantly different from each other at 5% level of probability. Ns = Non significant

Fresh weed biomass (g m^{-2}): Data regarding fresh weed biomass as shown in Table 4 depicted that various herbicides significantly influenced fresh weed biomass. The effect of year was found not substantial on fresh weed biomass. Fresh weed biomass was less (86.3 g m^{-2}) in plots where Primextra gold was sprayed which was statistically similar to the hand weeding and Dual gold treated plots followed by plots where Sencor extra (285.9 g m^{-2}) was applied. Whereas higher fresh weed biomass was found in control plots (792.8 g m^{-2}) which were followed by Stomp 330 EC having higher fresh weed biomass (498 g m^{-2}).

Weed mortality (%): Weed mortality (%) was significantly influenced by the application of different herbicides, whereas year remained similar for weed mortality (Table 4). Higher weed mortality (98.8 %) was observed in plots where Primextra gold was applied, followed by hand weeding and Dual gold which were at par with each others. These were followed by Sencor extra (72.5%). Stomp 330 EC and Buctril super had comparatively lesser weed mortality as compared to the above used herbicides.

Maize plant height at maturity (cm): Data regarding plant height (cm) of maize is given in (Table 5). Perusal of the data revealed that the effect of different herbicide was significant on plant height of maize crop. Long statured plants were recorded in hand weeding plots (176.6 cm) which was similar to plots where Primextra Gold was sprayed (176.4 cm) followed by plots where Dual Gold was sprayed (171 cm) whereas short stature plants (153.7 cm) were found in control plots.

Table 5. Plant height, number of grains ear^{-1} and thousand grain weight of maize as affected by herbicides during 2009-2010.

Year (Y)	Plant height (cm)	No. of Grains ear^{-1}	(1000) grain weight (g)
2009	166.5	368.1	229.1
2010	167.3	368.7	223.8
Significance	Ns	Ns	*
Treatments			
Aatrax	163.4 de*	341.4 d	214.4 e
Buctril Super 60 EC	165.4 cd	332.4 d	212.3 e
Dual Gold 960 EC	171.0 b	441.3 b	244.9 b
Sencor Extra	166.2 c	374.6 c	230.6 c
Primextra Gold 720 SC	176.4 a	458.8 a	258.9 a
Stomp 330 EC	162.7 e	369.6 c	223.5 d
Hand Weeding	176.6 a	444.1 ab	246.5 b
Weedy Check	153.7 f	185.1 e	180.9 f
LSD	2.6	15.48	5.48

*Means for each categories (column) followed by different letters are significantly different from each other at 5% level of probability. Ns = Non significant

Number of grains ear^{-1}: Number of grains ear^{-1} was significantly increased by application of different herbicides, whereas year did not alter number of grains ear^{-1} (Table 5). Mean value of the data showed that higher grains ear^{-1} (458.8) were recorded in plots where Primextra gold was sprayed, which was statistically similar to hand weeding (444.1) plots. These were followed by Aatrax (441.4) and Dual gold sprayed plots (441.3). Herbicides like Sencor extra and Stomp were in similar range for grains ear^{-1} with 374.6 and 369.6 grains ear^{-1}. Lower number of grains ear^{-1} (185.1) was recorded in control plots.

Thousand grain weight (g): Thousand grain weight was significantly altered by using different herbicides in maize crop. The years also influenced thousand grain weight (Table 5). Grains were heavier during 2009 (229.1 g) than the 2010 (223.8 g). It is obvious from the data that heavy grains were recorded in plots where Primextra gold was sprayed (258.9 g), followed by hand weeded plots (246.5 g) which was statistically at same level with the plots where Dual gold was applied (244.9 g), whereas lighter grains were obtained in control plots (180.9 g).

Biological yield (kg ha^{-1}): Statistical analysis of the data revealed that the effect of year was found non-significant for biological yield of maize. Higher biological yield was produced in Primextra gold sprayed plots (9860 kg ha^{-1}) followed by Dual gold applied plots (9582 kg ha^{-1}) which was at par with hand weeded plots (9489 kg ha^{-1}). Control plots resulted in lower biological yield (6023 kg ha^{-1}).

Grain yield (kg ha^{-1}): Data relating grain yield of maize are shown in Table 6. Grain yield was significantly enhanced by the application of different herbicides in maize crop. The effect of year was found not significant for grain yield of maize. Plots where Primextra gold was sprayed resulted in higher grain yield (3703 kg ha^{-1}) which was statistically at par with hand weeded plots (3694 kg ha^{-1}). It was followed by Dual gold sprayed plots (3519 kg ha^{-1}). Lower grain yield (2160 kg ha^{-1}) was recorded in control plots.

Harvest index (%): Data regarding harvest index are presented in Table 6. Harvest index was significantly affected by using various herbicides, whereas the effect of year was not significant. Higher harvest index (34.9%) was recorded in plots where Primextra gold was sprayed followed by hand weeded plots (34%). Dual gold ranked third with (33.3%) and Sencor extra fourth with 32.3 % each harvest indices. Lower harvest index was observed in control plots (29%).

Table 6. Biological yield, grain yield and harvest index of maize as affected by herbicides during 2009-10.

Year (Y)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
2009	8556	3108	31.6
2010	8628	3153	31.7
Significance	Ns	Ns	Ns
Treatments			
Aatrax	8407 d*	2925 d	30.3 e
Buctril Super 60 EC	8574 d	2980 d	29.8 f
Dual Gold 960 EC	9582 b	3519 b	33.3 c
Sencor Extra	9008 c	3372 c	32.3 d
Primextra Gold 720 SC	9860 a	3703 a	34.9 a
Stomp 330 EC	7795 e	2690 e	29.6 f
Hand Weeding	9489 b	3694 a	34.0 b
Weedy Check	6023 f	2160 f	29.0 g
LSD	252	101.2	0.49

*Means for each categories (column) followed by different letters are significantly different from each other at 5% level of probability. Ns = Non significant

Discussion

Densities of *Cynodon dactylon*, *Cyperus rotundus* and *Digiteria sanguinalis* were higher in 2009 as compared to 2010. Weeding and application of Primextra gold and Dual gold were most considerable in reducing *A. viridis* and *C. arvensis*. Density of *Cyperus rotundus* and *D. sanguinalis* were lower in Primextra gold and hand weeded plots followed by Sencor extra and Dual gold 960 EC sprayed plots. Aatrax was also effective in reduction of *D. sanguinalis* than *Cyperus rotundus*. In case of *P. hysterophrous*, Primextra gold and Dual gold application equally reduced its densities. In same manner, Primextra gold, hand weeding and Dual gold effectively reduced *P. oleracea* density followed by Sencor and Aatrax. The densities of *X. strumarium, T. partulacastrum* and *S. halepense* was comparatively reduced with the application of Primextra gold, hand weeding and Dual gold. Similarly, Aatrax was also effective in the reduction of their densities. Plots where no herbicides were sprayed resulted in higher densities of all weeds which indicated the effectiveness of the application of these herbicides. As the above mentioned weeds are the major weeds in the maize fields in this area therefore the better results of the tested herbicides can be used for weed management in maize to get higher grain yield.

Weed density m^{-2} was significantly influenced by application of various herbicides. Year was also found significant. The overall weed density m^{-2} was higher in the 1st year (2009) as compared to 2nd year (2010). It was obvious from the mean values that all herbicides effectively reduced number of weeds as compared to weedy check. Less number of weeds was found in plots where Primextra gold was sprayed, however it was at par with plots where hand weeding was practiced and Dual gold was sprayed. Our findings are in-line with (Khan *et al.*, 2012; Navie *et al*., 1996) who affirmed that herbicides, either as pre- or post-emergence application, can provide effective control of parthenium weed in crops. Khan *et al*., (1991) also reported decrease in weed density with the use of pre-emergence herbicides viz. metolachlor plus atrazine, pendimethalin and cyanazine plus atrazine.

Fresh weed biomass (g m^{-2}) was reduced in plots where Primextra gold was sprayed which were similar to the hand weeding and Dual gold followed by plots where Sencor extra was sprayed. Whereas higher fresh weed biomass was found in control plots which was followed by Stomp. Weed mortality (%) was significantly influenced by application of different herbicides, whereas year remained similar for weed mortality. Higher weed mortality was observed in plots where Primextra gold was sprayed, followed by hand weeding and Dual gold which were statistically at par with each other. Comparatively lesser weed mortality was recorded in Stomp and Buctril super plots. These results are similar to Jacob (2003) who reported reduced weed biomass due to use of selective pre-emergence herbicides. Successful control of parthenium weed has been attained by several herbicides (Balyan *et al*., 1996; Yadav *et al*., 1997). Best weed control was reported with pre-emergence use of the herbicides Primextra in maize crop (Olunuga & Objimi, 1983).

The effects of different herbicides were significant on plant height of maize crop. The effect of year was found insignificant. Long stature plants were recorded in hand weeding plots which were similar to plots where Primextra gold was sprayed, whereas short stature plants were found in control plots. Our results were supported by Oljaca *et al.*, (2007) who reported major decrease in maize plant height due to the weeds invasion. While yield losses due to weed competition were linked with reduced plant height and light interception (Coleman & Gill, 2005).

Number of grains ear^{-1} was significantly increased by application of different herbicides, whereas year did not alter number of grains ear^{-1}. Higher grains ear^{-1} was recorded in plots where Primextra gold was sprayed, which was statistically similar to hand weeding plots. Lower number of grains ear^{-1} was found in control plots. Thousand grain weight was significantly altered by using different herbicides. The years also influenced thousand grain weight. Grains were heavier during 2009 than 2010. It is obvious from the data that heavy grains were recorded in plots where Primextra gold was sprayed, followed by hand weeded plots which was statistically at same level with the plots where Dual gold was applied, whereas lighter grains were obtained in control plots. Gregory (1997) also observed that increase in yield was mainly due to increased grain size which is due to effective weed management through herbicides.

Application of different herbicides significantly influence biological and grain yields of maize. The effect of year was found non-significant for both grain and biological yields. Higher biological yield was produced in Primextra gold sprayed plots followed by Buctril super applied plots and hand weeded plots. Control plots resulted in lower biological yield. In case of grain yield, Primextra gold sprayed and hand weeded plots resulted in higher grain yield followed by Dual gold sprayed plots. Lower grain yield was recorded in control plots. The instant findings depicted that weed management increased all the yield related traits of maize. Thus weed management by using the herbicides is recommended to control parthenium and other associated weeds.

Harvest index was significantly affected by using various herbicides, whereas the effect of year was not significant. Higher harvest index was recorded in plots where Primextra gold was sprayed followed by hand weeded plots. Lower harvest index was observed in control plots. Our results are supported by Cavero *et al.*, (2002) who claimed that maize biomass was declined by increase in weed competition. Our results are also in line with Khan & Hassan (2003) who reported excellent weed control and significant yield increases with herbicides application in maize crop.

Conclusion

No phytotoxic effects of herbicides were noticed on maize crop. Weed density, fresh weed biomass and weed mortality were significantly influenced by the application of Primextra gold 720 SC. While higher plant height, number of grains ear^{-1}, thousand grain weight, biological yield, grain yields and harvest index were recorded due to use of Primextra gold. It is concluded that parthenium weed is highly sensitive to photosynthesis inhibitors compared to herbicides with other modes of action. For obtaining higher grain yield of maize, Primextra gold 720 SC (atrazine+S-metolachlor) as pre-emergence application can provide best control of parthenium weed and other associated weeds under the agro-ecological condition of Swabi, Khyber Pakhtunkhwa-Pakistan.

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