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INTEGRATING CULTIVARS WITH REDUCED HERBICIDE RATES FOR WEED MANAGEMENT IN MAIZE

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Abstract

A field experiment to study the impact of integrating cultivars with reduced herbicide rates for the weed management in maize (*Zea mays* L) was conducted at NWFP Agricultural University, Peshawar. Crop was sown during mid of June, 2007 in a randomized complete block (RCB) design with three replications with split plot arrangement. Two local maize cultivars (Azam and Pahari) were used as main plots. The three herbicides as full recommended doses (1x) and their half doses (½x) used as sub-plots viz; pendimethalin (Stomp 330E) @ 1.32 and 0.66 kg a.i. ha^{-1}; s-metolachlor (Dual gold 960 EC) @ 1.44 and 0.72 kg a.i ha^{-1} and atrazine (Atrazine 38 SC) @ 1.57 and 0.78 kg a.i ha^{-1} and a weedy check. Each sub-plot measured 5.6 x 3 m^2. Data were recorded on weed density (after 30 days of herbicides application), fresh weed biomass, plant height, leaf area, 1000-kernel weight, kernel yield and phytotoxicity of herbicides on crop if any. For the main effects of cultivars, all the parameters were non-significant. For herbicides, significant differences were recorded in all parameters, while the interaction also manifested non-significant differences for all the traits except 1000 kernel weight. Cultivar Azam alongwith s-metolachlor with full dose (1x) followed by half dose (½x) and their interaction offered the best weed management in maize. It is thus recommended that half of the recommended dose of s-metolachlor integrated with cv. Azam may be used to harvest economic yield of maize while keeping the environment intact.

Introduction

Maize (*Zea mays* L.) is a tall, deep rooted, warm weather annual short day cross pollinated grass belongs to family Poaceae (Tribe Maydeae). Maize ranks the third largest cereal crop after wheat and rice on area basis in Pakistan. The maize crop was grown on an area of 1043.94 thousands hectares with a production of 2906.78 thousand tons with an average yield of 2784 kg ha^{-1}in Pakistan, while in province of NWFP the area under maize crop was 537.50 thousands hectares which produced 854.0 thousand tons with an average yield of 1589 kg ha^{-1} (Anon., 2007). There are several reasons for lower production of maize in our country, among them high weed infestation and their poor management and improper planting methods are common problems. Maize crop is highly infested with weeds both in irrigated as well as rainfed areas. They reduce the crop yield from 20-40% depending upon weed species and density (Hussain, 1983; Ashique *et al*., 1997).

Herbicides use for weed control in maize has received little attention in Pakistan and particularly in NWFP (Shah, 1998). However, low weed population can be beneficial to the crop as it provides food and habitat for a range of beneficial organisms (Millington *et al.*, 1990). Whereas, above the critical population thresholds, weed flora can significantly reduce the crop yield and quality also (Cussans, 1968). Herbicides use to manage weeds and harvest 150% more maize yield than the weedy check reported by Becker & Staniforth (1981), Jehangeri *et al*., (1984), Abid *et al*., (1991), Cavero *et al*., (2002) and Miller & Libby (1999). Effective weed control was reported with pre-emergence use of the herbicide Primextra 500 FW in maize crop (Olunuga & Objimi, 1983).

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Tall maize cultivars were not found effective in suppressing weeds as compared to some shorter modern cultivars (Cosser *et al*., 1997), and it also observed that tall cultivars are also not so much responsive to fertilizers. Eisele & Köpke (1997) indicated that tallness is not the only criterion for competitiveness, rather good overall shading ability is more important. It has been further confirmed that corn leaf area was directly correlated to corn grain yield variability caused by weed competition and interaction of corn with recommended and reduced rates of pre-emergent herbicides (Roggen and Gregory, 1997; Gregory, 1997). Gregory *et al*., (1994) in their earlier research on maize revealed that yield reduction occurred for all cultivars as herbicide rates decreased which conclude that herbicide rate directly affect the grain yield.

Modern corn hybrids exhibited difference in plant height and size, leaf area index, leaf angle and rate of early season growth. Therefore, it should be expected that some hybrids will shade weeds more and reach canopy closure at different times, thus differ in competitiveness with weeds and influence production of weed seeds. Little research has been conducted to determine if production practices could be altered to provide weed control with reduced herbicide rates or to reduce the risk associated with lower herbicide rates. Keeping in view the importance of weeds in maize crop, a study was conducted to evaluate the influence of different maize cultivars on weed suppression under reduced doses of herbicides with a consequent impact on growth and yield of maize.

Materials and Methods

Plant material and experimental design: A field experiment to study the impact of integrating cultivars with reduced herbicide rates for the weed management in *Zea mays* L. was conducted at NWFP Agricultural University, Peshawar. Crop was sown during mid of June, 2007 in a randomized complete block (RCB) design with three replications with split plot arrangement. Two local maize cultivars (Azam and Pahari) were used as main plots. The three herbicides as full recommended doses (1x) and their half doses (½x) used as sub-plots viz; pendimethalin (Stomp 330E) @ 1.32 and 0.66 kg a.i. ha^{-1}; s-metolachlor (Dual gold 960 EC) @ 1.44 and 0.72 kg a.i ha^{-1} and atrazine (Atrazine 38 SC) @ 1.57 and 0.78 kg a.i ha^{-1} and a weedy check. Each sub-plot measured 5.6 x 3 m^2. All the recommended cultural practices and inputs including fertilizer and pest control were applied for all the entries from sowing till the harvesting and the crop was grown under uniform conditions (except herbicides application) to minimize environmental variability to the maximum possible extent.

Traits measurement and statistical analysis: During the course of studies the data were recorded on weed density (after 30 days of herbicides application) and fresh weed biomass m^{-2}, plant height, leaf area (cm^2), 1000 kernel weight (g) and kernel yield (kg ha^{-1}). All the data were subjected to the analysis of variance (ANOVA) technique by using MSTATC computer software and means were separated by LSD test according to Steel & Torrie (1980).

Results and Discussion

Weed density (g m^{-2}): The weed species infesting the experiment were bermuda grass [*Cynodon dactylon* (L.) Pers.], false amaranth [*Digera muricata* (L.) Mart.], johnsongrass (*Sorghum halepense* L.), and common purslane (*Portulaca oleracea*). Statistical analysis of the data revealed that herbicides have significant effect on weed density m^{-2}, while cultivars and their interaction effects were nonsignificant ($p>0.05$). The infestation was numerically higher in cv. Pahari (7.84 m^{-2}) as compared to Azam (7.73 m^{-2}) (Table 1). Different herbicides have affected weed density significantly (p=0.000). The highest weed density was recorded in weedy check plot (11.46 m^{-2}) and the lowest density was recorded in Dual gold 1x (5.40 m^{-2}) followed by Dual Gold ½x (6.81 m^{-2}). Interaction of herbicides and cultivars was non-significant, however, among the interactions, the highest weed density was recorded in Pahari under weedy check (11.96 m^{-2}) and lowest in Dual gold 1x (5.06 m^{-2}) with same cultivar. Results manifested that Dual gold 1x and ½x under both cultivars has more capability of controlling weeds as compared to other herbicides. Similar results were also reported by Dogan *et al*., (2005) who concluded that weed density was significantly affected by herbicides which provided acceptable weed control during critical period. Khan *et al*., (2003) reported that significant reduction in weed density was obtained in herbicides treated plots as compared to weedy check and concluded that Dual gold proved to be the best herbicide and provided most economical weed management in maize.

Fresh weed biomass (g m^{-2}): The herbicides had significant effect on fresh weed biomass, while cultivars ($p \leq 0.05$) and their interaction ($p \geq 0.084$) effects were nonsignificant statistically (Table 2). However, the higher weed biomass was recorded in cv. Azam (609.71 g m^{-2}) as compared to Pahari (598.47 g m^{-2}). All the three herbicides and their two different doses have affected fresh weed biomass significantly (p=0.000). The highest weed biomass was revealed by weedy check (837.3 g m^{-2}), while the lowest biomass was recorded in Dual Gold 1x (490) followed by its ½x (540.7 g m^{-2}) and Stomp 1x (541.3 g m^{-2}). Interaction of herbicides and cultivars was non-significant (p=0.084), however, the highest weed biomass was recorded in Pahari under weedy check (864 g m^{-2}) and lowest in Dual Gold 1x (470.66 g m^{-2}) followed by its half dose (506.6 g m^{-2}) with cv. Pahari. The data further revealed that Dual Gold 1x, and its half dose (540.7 g m^{-2}) and Stomp 1x (541.3 g m^{-2}) offered the best weed control. These results are in a great analogy with those reported by Bezuidenhout & Reinhardt (2002) and Jacob (2003) who reported reduced weed biomass due to use of selective pre-emergence herbicides and the Dual Gold emerged as the best among pre-emergence herbicides for controlling different maize weed species. However, Olunuga & Objimi (1983) noted effective weed control with Primextra 500 FW (pre-emergence) in maize crop.

Plant height (cm): According to analysis of the data revealed that herbicides had significant effect on plant height, whereas cultivars (p=0.10) and their interaction ($P>0.05$) effects were nonsignificant. Among cultivars, the taller plants were recorded in cv. Azam (188.68 cm) followed by Pahari (158.95 cm) (Table 3). Different herbicides have affected the plant height significantly (p=0.0002). The tallest plants were recorded in Stomp 1x (188.7 cm), however it was found statistically at par with Dual Gold 1x (176.9 cm), Atrazine 1x (184.3 cm) and its ½x (176.6 cm). The lowest plant height was recorded in weedy check (146.5 cm). Among interactions, numerically the tallest plants were recorded for cv. Azam with Stomp 1x (203.5 cm) followed by Atrazine 1x (198.4 cm), Dual Gold 1x (190.1 cm) and its half dose (188.7 cm), and Atrazine½x (188.4 cm). The shorter plants were recorded in weedy check under cv. Pahari (167.1 cm). These results are in agreement with Sakhunkhu (1985) who also reported that weed control methods had nonsignificant effect on plant height in maize. Cosser *et al*., (1997) and Eisele & Köpke (1997) have also mentioned that tall maize cultivars were not always found the best cultivar for suppressing weeds as compared with medium tall cultivars.

Table 1. Weed density m^{-2} 30 days after application as affected by herbicides, cultivars and their interaction.

Cultivars	Herbicides							
	Stomp (1x)	Stomp (½x)	Dual gold (1x)	Dual gold (½x)	Atrazine (1x)	Atrazine (½x)	Weedy check	Cultivars means
Pahari	6.53	8.63	5.06	6.63	7.30	8.76	11.96	7.84
Azam	6.73	8	5.73	7	7.53	8.20	10.96	7.73
Herbicides means	6.63d	8.31bc	5.40e	6.81d	7.41cd	8.48b	11.46a	

$LSD_{0.05}$ for herbicides = 1.064; 1x = Recommended Dose; ½x = Half Dose

Table 2. Fresh weed biomass g m^{-2} as affected by herbicides, cultivars and their interaction 30 days after treatment.

Cultivars	Herbicides							
	Stomp (1x)	Stomp (½x)	Dual gold (1x)	Dual gold (½x)	Atrazine (1x)	Atrazine (½x)	Weedy check	Cultivars means
Pahari	534.66	576	470.66	506.66	597.33	640	864	598.47
Azam	548	593.33	509.33	574.66	604	628	810.66	609.71
Herbicides means	541.3d	584.7c	490e	540.7d	600.7bc	634b	837.3a	

CV = 5.28%, $LSD_{0.05}$ for herbicides = 37.98; 1x = Recommended Dose; ½x = Half Dose

Table 3. Plant height (cm) as affected by herbicides, cultivars and their interaction.

Cultivars	Herbicides							
	Stomp (1x)	Stomp (½x)	Dual gold (1x)	Dual gold (½x)	Atrazine (1x)	Atrazine (½x)	Weedy check	Cultivars means
Pahari	173.86	159.40	163.73	155.03	170.13	164.73	125.80	158.95
Azam	203.50	184.40	190.13	188.73	198.46	188.40	167.16	188.68
Herbicides means	188.7a	171.9b	176.9ab	171.9b	184.3ab	176.6ab	146.5c	

CV = 7.24%, $LSD_{0.05}$ for herbicides= 14.99, 1x = Recommended Dose, ½x = Half Dose.

Table 4. Leaf area per plant as effected by herbicides, cultivars and their interaction.

Cultivars	Herbicides							
	Stomp (1x)	Stomp (½x)	Dual gold (1x)	Dual gold (½x)	Atrazine (1x)	Atrazine (½x)	Weedy check	Cultivars means
Pahari	342.04	326.07	337.07	353.52	346.93	267.44	304.73	325.40
Azam	350.03	345.78	319.80	329.41	339.08	350.02	243.17	325.32
Herbicides means	346a	335.9a	328.4a	341.5a	343a	308.7ab	274b	

CV = 10.96%, $LSD_{0.05}$ for herbicides= 42.49; 1x = Recommended Dose; ½x = Half Dose

Leaf area (cm^2): Leaf is the basic photosynthetic machinery for synthesizing plant food; hence its size would directly affect the yield and yield contributing traits of the crop. Analysis of the data revealed that herbicides had significant effect on leaf area, while cultivars ($p \leq 0.05$) and their interaction ($p=0.06$) effects were non-significant. However, on average the leaf area was 325.40 cm^2 and 325.32 cm^2 in the cultivars Pahari and Azam, respectively (Table 4). Herbicides have affected leaf area significantly ($p \leq 0.01$) and the higher leaf area was recorded in Stomp 1x (346 cm^2). Although it was found statistically at par with all other herbicidal treatments. The least leaf area was recorded in weedy check (274 cm^2) which in turn was found statistically at par with Atrazine ½x (308.7 cm^2). Interaction of herbicides and cultivars was nonsignificant ($p \leq 0.05$). However, among interactions the highest leaf area was recorded in Pahari treated with Dual Gold ½x (353.52 cm^2) and minimum under weedy check (243.17 cm^2) in cv. Azam. Khan. (2002) have corroborated our inferences and reported maximum leaf area in weedicide treated plots as compared to weedy check having minimum leaf area. Leaf area has an immense role in the canopy closure of the crop and smothering the weeds; hence its size will directly affect the yield and yield components of crop and indirectly weeds also (Gregory *et al*., 1994; Roggen & Gregory, 1997).

Table 5. 1000 kernel weight (g) as affected by herbicides and cultivars and their interaction.

Cultivars	Herbicides							
	Stomp (1x)	**Stomp (½x)**	**Dual gold (1x)**	**Dual gold (½x)**	**Atrazine (1x)**	**Atrazine (½x)**	**Weedy check**	**Cultivars means**
Pahari	231.7bc	205cde	231.3bc	189.7def	200.3cde	180efg	154.7fg	198.95
Azam	224.7bcd	205.7cde	280a	258.3ab	257.7ab	204cde	148.3g	225.52
Herbicides means	228.2b	205.3bc	255.7a	224b	229b	192c	151.5d	

CV = 9.96%, $LSD_{0.05}$ for Interaction= 35.61; $LSD_{0.05}$ for Herbicides=25.18; 1x = Recommended Dose; ½x = Half Dose

Table 6. Kernel yield (t ha^{-1}) as affected by herbicides, cultivars and their interaction.

Cultivars	Herbicides							
	Stomp (1x)	**Stomp (½x)**	**Dual gold (1x)**	**Dual gold (½x)**	**Atrazine (1x)**	**Atrazine (½x)**	**Weedy check**	**Cultivars means**
Pahari	2.11	1.34	2.52	1.91	1.84	1.61	0.97	1.76
Azam	2.19	1.55	2.71	2.52	1.98	1.43	0.85	1.89
Herbicides means	2.15b	1.44c	2.62a	2.22b	1.91b	1.52c	0.91d	

CV = 16.96%, $LSD_{0.05}$ for herbicides=0.36; 1x = Recommended Dose; ½x = Half Dose

1000 kernel weight (g): Analysis of the data revealed that herbicides and their interaction with cultivars have a significant effect on 1000 kernel weight, while cultivars effect was non-significant (p=0.23). Among cultivars, the higher 1000 kernel weight was recorded in Azam (225.52 g) as against Pahari (198.95 g) (Table 5). The herbicides have affected 1000 kernel weight significantly (p=0.000) and the highest kernel weight was recorded in Dual Gold 1x (255.7 g) while lowest in weedy check (151.5 g). Interaction of herbicides and cultivars was also significant ($p \leq 0.01$) as depicted in Table 5. Among interactions, the highest 1000 kernel weight was observed in Azam treated with Dual Gold 1x (280 g) and its ½x (258.3 g) and Atrazine 1x (257.7 g). The lowest kernel weight was noticed in weedy check in Azam (148.3 g) followed by Pahari (154.7g). Gregory *et al.,* (1994) also observed that increase in yield was mainly due to increased kernel size which also due to effective weed management through herbicides.

Kernel yield (t ha^{-1}): Data revealed that herbicides have a significant effect on kernel yield, however, cultivars (p=0.29) and their interaction (p=0.42) effects were non-significant. Cultivars did not influence the yield yet the higher kernel yield was recorded in Azam (1.89 t ha^{-1}) followed by Pahari (1.76 t ha^{-1}) (Table 6). The herbicides and their two different doses have affected the grain yield significantly (P=0.000). The highest grain yield was recorded in Dual Gold 1x (2.62 t ha^{-1}) followed by its ½x dose (2.22 t ha^{-1}), 1x dose of Stomp 330E and Atrazine 38SC (1.91 t ha^{-1}). The lowest yield was recorded in weedy check (0.91 t ha^{-1}). Interaction of herbicides and cultivars was non-significant (p=0.42). However, among interactions, the highest grain yield was recorded in Azam treated with Dual Gold 1x (2.71 t ha^{-1}), followed by its half dose and full doses of Stomp and Atrazine involving the same cultivar. The lowest kernel yield was realized in the weedy check (0.85 t ha^{-1}) under the cv. Azam. Gregory *et al*., (1994) and Muhammad *et al*., (1999) also observed that maize average over herbicide rates, the yield reduction occurred for all cultivars as herbicide rates decreased which conclude that herbicide rate directly affect grain yield. Zafar *et al*., (1981), Rashid *et al*., (1993), Sharma *et al*., (1998), Khan (2002) and Ali *et al*., (2003) also reported that weed control treated plots increased yield as compared to check plots.

Conclusions

No phytotoxicity of herbicides was observed on maize crop. Dual Gold 960 EC (s-metolachlor) full dose followed by its half dose proved to be the best herbicide for weed control with higher maize yield. Interaction of cv. Azam and Dual Gold 960 EC full dose (s-metolachlor) followed by its half dose may be employed for harvesting optimum yields of maize under environmental conditions of Peshawar, Pakistan.

References

Abid, M.A., Z.A. Cheema, S. Ahmad, T. Mahmood and C.M. Akhtar. 1991. Corn and weed response to some selective herbicides *J. Agric. Res*., 29 (1): 35-40.

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.

Anonymous. 2007. *Agricultural Statistics of Pakistan.* Ministry of Food, Agriculture and Livestock (MINFAL), Government of Pakistan, Islamabad.

Ashique, M., M.L. Shah and M. Shafi. 1997. Weeds of maize and their eradication. *Zarat Nama* 35: 89.

Becker, B.L. and D.W. Staniforth. 1981. Cost benefits assessment of herbicides use. *Proc. North Cent. Weed Control Conf*., 36: 68-71.

Bezuidenhout, S.R. and C.F. Reinhardt. 2002. Using cover crops (maize) to suppress weed growth. *Combined Congress 2009, South African Soc. Crop Prod. and South African Weed Sci. Soc*.,

Cavero, Zaragoza, Suso and Pardo. 2002. Competition between maize and *Datura stramonium* in an irrigated field under semi-arid condition. *Weed Res.,* 39(3): 225-240.

Cosser, N.D., J.M. Godding and R.J.F. Williams. 1997. The impact of wheat cultivar, sowing date and grazing on the weed seedbank of an organic farming system. *Aspects Appl. Biol.,* 15(1): 429-432.

Cussans, F E. 1968. The growth and development of *Agropyron repens* (L.) Beauv. in competition with cereal, field beans and oilseed rape. *Proc. 9th British Weed Control Conf*., pp. 131-136.

Dogan, M.N., Ö. Boz and A. Ünay. 2005. Efficacies of reduced herbicide rates for weed control in maize (*Zea mays*) during critical period. *J. Agron.,* 4(1): 44-48.

Eisele, J.A. and U. Kopke. 1997. Choice of cultivar in organic farming: New criteria for winter wheat ideotypes. *Agric. Sci. J.,* 1(5): 19-24.

Gregory, J.R.K. 1997. Hybrid Selection for reducing herbicide rates in corn. *Ph.D. Dissert. Department of Agronomy, Univ. of Nebraska, Lincoln, Nebraska, USA*.

Gregory, J.R.K., C.M. Stephen and A.R. Martin. 1994. Velvetleaf (*Abutilon theophrasti*) and green foxtail (*Setaria viridis*) response to corn (*Zea mays*) hybrid. *Weed Tech.,* 14(2): 304-311.

Hussain, F. 1983. Biochemical inhibition (allelopathy a less understood ecological factor in agroecosystems. *Progr. Farming* (PARC), 3: 33-37.

Jacob, W. 2003. Applying plant population ecology - Increasing the suppression of weeds by cereal crops. *J. Agron*., 2(4): 8-10.

Jehangeri, G., Q.A. Sahibzada and M. Bashir. 1984. Effect of selective herbicides on yield of maize. *Frontier J. Agric. Res.,* 10(1-2): 67-76.

Khan, B.M., N. Khan and I.A. Khan. 2003. Efficacy of different herbicides on the yield and yield componentsof maize. *Asian Network for Scientific Information,* 3(2): 300-304.

Khan, M.A. 2002. *Efficacy of different herbicides on the yield and yield components of maize*. *M.Sc. Hons. Thesis, Deptt. of Weed Scienc, NWFP Agric. Uni. Peshawar*, *Pak.*

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

Millington, S., C.E. Stopes, L. Woodwatd and H. Vogtmann. 1990. Rotational design and the limits of organic systems. *Crop Prot.,* 19(1): 163-173.

Muhammad, A.N., I.U. Awan, M.A. Khan and K.W. Khan. 1999. Effect of post-emergence application of herbicides on weed control. *Pak. J. Biol. Sci.,* 2(4): 1455-1457.

Olunuga, B.A. and Objimi. 1983. Effect of some herbicides on the growth and yield of cassava and maize grown in mixture. *9th Ann. Conf. Weed. Sci. Nigeria*, pp. 93-96.

Rashid, A., M. Shad, Q. Chatha and H. Nawaz. 1993. Weed management studies in maize. *Pak. J. Agric*., 1(1): 44-49.

Roggen, K. and J. Gregory. 1997. Hybrid selection for reducing herbicide rates in corn. *University of Nebraska Absts.* pp. 2189.

Sakhunkhu, S.F. 1985. Effects of tillage system and methods of weed control on grain yield and some agronomic characteristics of corn. *Kastsart J.,* 19(2): 85-91.

Shah, A. 1998. Study on weed control in maize. *Sarhad. J. Agric.,* 14(6): 581-584.

Sharma, V., D.R. Thakur and J.J. Sharma. 1998. Effect of metolachlor and its combination with atrazine on weed control in maize (*Zea mays*). *Indian J. Agron.,* 43(4): 677-680.

Steel, R.G.D. and J.H. Torrie. 1980. *Principles and Procedures of Statistics*. Mc Graw Hill Book Co., Inc. New York. pp. 481.

Zafar, M.I., R. Anwar and A.R. Saleemi. 1981. Effectiveness of chemical weed in maize production. *Pak. J. Agric. Res.,* 2(1): 21-24.

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