INTEGRATING CULTIVARS WITH REDUCED HERBICIDE RATES FOR WEED MANAGEMENT IN MAIZE-II.

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ABSTRACT

A field experiment to study the integration of cultivars with reduced herbicide rates for weed management in maize (Zea mays L) was conducted at the University of Agriculture, Peshawar Pakistan. The crop was sown during June, 2007 in a triplicated randomized complete block (RCB) design with a split plot arrangement. Two local open pollinated maize cultivars (Azam and Pahari) were assigned to the main plots, three herbicides (full recommended 1x) and reduced doses (½x)) were kept into sub-plots. The herbicides included pendimethaline, s-metolachlor and atrazine @ 1.32 and 0.66, 1.57 and 0.78 and 1.44 and 0.72 kg a.i. ha^{-1}, respectively and weedy check. Each sub-plot measured 5.6 x 3 m^{2}. The data for each character were subjected to ANOVA technique and the significant means were separated by LSD test. For the main effects of cultivars, weed density at 60 days after treatment and harvesting were significant (P≤0.05), while highly significant for leaves plant^{-1} and kernels cob^{-1}. For herbicides, significant differences were recorded in all parameters studied except leaves plant^{-1} and harvest index. While, varieties × herbicides interaction was non-significant for all the traits except germination %. Cultivar Azam under s-metolachlor at full and reduced dose (1.44 and 0.72 kg a.i.ha^{-1}) offered best control of weeds, higher kernels cob^{-1} and gave the highest biological yield of maize while variety Pahari was evaluated as more competitive with weeds. For the economic and environmental significance, it is recommended that reduced dose of s-metolachlor may be integrated with cv. Azam for the sustainability of the agr-ecosystems.

Keywords: Weed management, pre-emergence herbicides, reduced herbicide rates, maize cultivars.

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INTRODUCTION

Maize (*Zea mays* L.) is a tall, deep rooted, warm season, annual, short day and cross pollinated crop belonged to family Poaceae (Tribe Maydeae). Maize production in Pakistan was 6.130 million tons from an area of 1.334 million ha during 2016-2017 which increased from 0.626 million tons in 1968 to 6.130 million tons in the year 2017, growing at an average annual rate of 17. 94%. The mean yield realized in Pakistan was 4549 kg ha^{-1}. Whereas, the yield realized in Khyber Pakhtunkhwa province is only 41% of the national average and 31% of theother province i.e. Punjab. Despite such an enormous annual increase, still we are harvesting only 38% of the potential yield of 12 tons ha^{-1} at the national level (Anonymous, 2019). The gap between the harvested yield and the potential yield could be bridged through adopting the suitable genotypes; hybrids rather than open pollinated cultivars (OPVs) and the proper address of the biotic like pests including weeds and abiotic stresses on maize crop.

Based on the cultivated area and the staple food, maize ranks the third largest cereal crop preceded by wheat and rice in Pakistan like many other regions in the world. Maize crop is highly infested with weeds both in irrigated as well as rainfed areas at its early growth stages till the canopy closure. Weeds reduce the crop yield from 20-40% depending upon weed species and density (Hussain, 1983; Safdar *et al.,* 2015). Haroorn ur Rashid *et al.* (2017) recommended in their findings that allelopathic plants surface mulches could reduce weed density which ultimately increased the 1000 kernel weight and other agronomic parameters of maize crop.

Chemical weed control in maize has meager attention in Pakistan and specifically in Khyber Pakhtunkhwa (Shah, 1998). Latre *et al.* (2015) conducted a seven year study and concluded that a better planned weed control based on actual infestation in combination with a carefully thought-out choice of herbicides is also an IPM– approach.

However, the weed population below threshold level can be rather beneficial to the crop as it provides sustenance and habitat for beneficial organisms (Millington *et al.,* 1990). Whereas, the weed flora exceeding thresholds, weed significantly reduce the crop yield as well as quality (Cussans, 1968). Herbicides increase the maize yield 150% more than the weedy check (Becker and Staniforth, 1981), Jehangeri *et al.* (1984), Abid *et al.* (1991) and Miller and Libby (1999). Please delete very old refrences Cavero and Zargoz Susu Pardo (2002) reported that maize yield was decreased by 14–63% when competing with *Datura stramonium.* . Later studies showed that *Xanthium strumaium* was even more competitive with maize than *Datura stramonium (*Karimmojeni *et al.,* 2010). Similarly Safdar *et al.* (2015) evaluated the response of maize to the most noxious weed parthenium. Maize grain yield was reduced from 21 to 50% due to competition of 5 to 20 parthenium plants m^{-2} (Safdar *et al.*, 2015).

Tall maize cultivars were not found effective in suppressing weeds as compared to some shorter modern cultivars (Cosser *et al.,* 1997). Eisele and 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 differences in plant height , 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 affect production of weed seeds. Enough research has not been conducted to determine if production package could be altered to minimize the losses due to weeds sustainably. Hence, a study was conducted to decipher the influence of two maize cultivars on weed suppression integrated with reduced doses of herbicides on weeds and yield and yield components 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 the University of Agriculture, Peshawar. Crop was sown during mid June, 2007 in a randomized complete block (RCB) design with three replications in 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 reduced doses (½x) were used as the sub-plots viz., pendimethalin @ 1.32 and 0.66 kg, s-metolachlor @ 1.44 and 0.72 and atrazine @ 1. 57 and 0.78 kg a.i ha^{-1} and a weedy check. Each sub-plot measured 5.6 × 3 m^2. All the recommended cultural practices and inputs including fertilizers and pest control were applied for all the experiment from sowing till to the harvesting. The crop was grown under uniform conditions (except herbicides application) to minimize environmental variability to the maximum possible extent.

RESULTS AND DISCUSSION

Weed density m^{-2} 60 days after herbicide application

Statistical analysis of the data revealed that varieties and herbicides have significant effect on weed density m^{-2} (Table-1), while interaction effect was non-significant (P>0.05). Significantly lower weed density was recorded for Pahari cultivar (12.17) as compared to 12.60 weeds m^{-2} in Azam. (Table-1). Different herbicides have also affected the weed density significantly (P=0.000). The lowest density was recorded in metolachlore (1x) treatment (8.58) followed by pendimethaline (1x) (10.59) and metolachlor (½x) (10.83). The highest weed density was recorded in the weedy check Plot (19.10). Interaction of herbicides and varieties was non-significant (P>0.05) statistically. Numerically lowest density was recorded in metolachlor (1x) (8.05) under Pahari cultivar. While among the interactions, highest weed density was recorded in Pahari under weedy check (19.21). It could be inferred from the result that application of metolachlor (1x) for weed control in Pahari is the best among the herbicides, but it was closed followed by pendimethaline Full dose and Half dose of metolachlore. These results are in a great analogy with those reported by Gregory *et al.* (2000) also concluded that erect leaf hybrids were effective in suppressing weeds better than the horizontal leaf hybrids. Earlier studies of Jehangeri *et al.* (1984) also reported that application of selective herbicides provided 65 to 90% weed control of weeds and gave 100-150% more maize yield as compared to weedy check.

Table-1. Effect of varieties, herbicides, and their interaction on weed density m^{-2} 60 days after herbicide application.

Cultivar	Herbicides							Cultivar Mean
	pendimethalin (1x)	pendimethalin (½x)	s-metochlor (1x)	s-metochlor (½x)	atrazine (1x)	atrazine (½x)	Weedy check	
Pahari	9.75	12.21	8.05	10.77	11.88	13.33	19.21	12.17b
Azam	11.44	12.66	9.10	10.88	11.77	13.33	18.99	12.60a
Herbicide Means	10.59d	12.44bc	8.58e	10.83d	11.82cd	13.33b	19.10a	

CV= 8.47% LSD$_{0.05}$ for herbicides= 1.25.

Weed density m^{-2} at harvesting Please use cultivar instead of variety

Statistical analysis of data revealed that varieties and herbicides have statistically significant effect (P<0.05) on weed density m^{-2} at harvesting (Table-2), while their interaction effect is non-significant (P>0.05). The lower weed density was recording in Pahari (14.51) as compared to Azam (15.64) (Table-2). Different herbicides have affected the weed density significantly (P=0.000). The lowest weed density was recorded in metolachlor (1x) treatment (11.44) followed by the same herbicide at reduced dose (½x) (13.21). The later treatment was however, statistically at par with pendimethaline (1x) (14.22). The highest weed density was recorded in the weedy check (21.84). Interaction of herbicides x varieties was non-significant (P>0.05) statistically, while among interactions, minimum numerical density was recorded in metolachlor (1x)(10.99) under Pahari variety and the highest weed density was recorded in the weedy check under (22.48) [Table-2]. Our findings are supported with the previous work of Ihasanullah *et al* (2003) and Abid *et al*. (1991) who reported that different weed species infesting their experiment were *Cyprus rotundus, Sorghum halepense, Cynodon dactylon, Leptochloa* sp., *Echinochloa crussgalli, Tribulus terrestris, Convolvulus arvensis and Portulaca oleracea.* Hassan *et al.* (2010) have also reported similar results 30 days after application of treatments. Conclusively, weed density was significantly affected by different herbicides which decreased the weed population by 67.8% and increased crop yield by 26-62% as compared to weedy check. Dogan *et al.* (2005) have also advocated the worth of reduced rates for weed management in maize.

Table-2. Effect of varieties, herbicides and their interaction on weed density m^{-2} recorded at harvesting.

Cultivar	Herbicides							Cultivar Means
	pendimethalin (1x)	pendimethalin (½x)	s-metochlor (1x)	s-metochlor (½x)	atrazine (1x)	atrazine (½x)	Weedy check	
Pahari	12.88	14.66	10.99	12.33	13.99	15.55	21.20	14.51b
Azam	15.55	16.27	11.88	14.10	14.11	15.10	22.48	15.64a
Herbicides Means	14.22bc	15.47b	11.44d	13.21c	14.05bc	15.33b	21.84a	

CV= 8.20% $LSD_{0.05}$ for herbicides= 1.654

Dry Weed Biomass g m^{-2}

Statistical analysis of the data revealed that herbicides had highly significant effect on dry weed biomass (Table-3), while varieties (P>0.05) and their interaction (P=0.137) effect is non-significant statistically. The effect of varieties in weed suppression was non-significant statistically, yet the higher weed biomass was recorded in Azam variety (221.18 g m^{-2}) as compared to Pahari (217.88 g m^{-2}) (Table-3). Different herbicides have affected dry weed biomass highly significantly (P=0.000). The lowest biomass was recorded in metolachlor (1x) (178.3 g m^{-2}), which was followed by the reduced rate (½x) of the same herbicide (195.6) and pendimethaline at the full rate (1x) (196.8). The highest weed biomass was recorded in weedy check (304.5 g m^{-2}). Interaction of varieties x herbicides was non-significant (P=0.137) as depicted in Table-3, yet numerically highest weed biomass was recorded in Pahari under weedy check (314.18 g m^{-2}) and the lowest for metolachlor (1x) (173.14 g m^{-2}) in Pahari variety. It is concluded that metolachlor (1x) and 1(½x) in Azam showed best control in weed biomass. These results are in agreement with Tesfay *et al.* (2014) and Khan *et al* (2016) who reported that dry weight of all weed species were significantly reduced under all treatments as compared to the weedy check.

Table-3. Effect of varieties, herbicides and their interaction on on dry weed biomass g m^{-2}.

Cultivar	Herbicides							Cultivar Means
	pendimethalin (1x)	pendimethalin (½x)	s-metochlor (1x)	s-metochlor (½x)	atrazine (1x)	atrazine (½x)	Weedy check	
Pahari	194.42	209.45	173.14	184.23	217.21	232.55	314.18	217.88
Azam	199.26	215.75	183.54	206.96	219.63	228.34	294.78	221.18
Herbicides Means	196.8d	212.6c	178.3e	195.6d	218.4bc	230.5b	304.5a	

CV=5.37% $LSD_{0.05}$ for herbicides= 14.04

Germination percentage of crop

Statistical analysis of data revealed that herbicides and their interaction with varieties has highly significant effect ($P<0.01$) effect on germination of maize, while varieties main effect is non-significant ($P>0.05$) statistically. Among varieties, the higher germination was recorded in Pahari (87.04) as compared to Azam (86.61) (Table-4). Different herbicides have affected germination significantly ($P=0.000$). The highest germination was recorded in metolachlor (1x) (95.83) followed by the same herbicide at reduced rate (½x). The lowest germination was recorded in Weedy Check Plot (78.16) followed by atrazine (½x) (81.83). Interaction of herbicides and varieties was highly significant ($P=0.002$). Among interactions, the highest germination was recorded for Pahari treated with metolachlor (1x)(97.33) followed by metolachlor(1x) in Azam (94.33) and the lowest in the Weedy Check (75.33) in Pahari. In Weedy Check where weeds were in greater number, the germination percentage was little affected by delaying the germination of maize seeds. It might be due to the competition between maize seeds and weed seeds for available space, moisture and nutrients etc. The higher germination in herbicides might be the hormesis of these chemicals in inducing germination. These results are in analogy with those reported by Trevor *et al.* (2006) indicating a strong linear relationship between the seed number in the soil (including grassy, broadleaf weeds) and seedling numbers affecting maize germination in the field.

Table-4. Effect of varieties, herbicides and their interaction on germination percentage (%).

Cultivar	Herbicides							Cultivar Means
	pendimethalin (1x)	pendimethalin (½x)	s-metochlor (1x)	s-metochlor (½x)	atrazine (1x)	atrazine (½x)	Weedy check	
Pahari	89.66de	86fg	97.33a	93.66bc	85gh	82.33hi	75.33j	87.04
Azam	88ef	85gh	94.33b	91cd	85.66fg	81.33i	81.0i	86.61
Herbicide Means	88.83c	85.50d	95.83a	92.33b	85.33d	81.83e	78.16f	

CV= 1.87% $LSD_{0.05}$ for Interaction= 2.733 $LSD_{0.05}$ for herbicides=1.932

No. of Leaves Plant^{-1}

The statistical analysis of data showed that varieties had highly significant effect on No. of maize, while herbicides and their interaction with varieties was non-significant statistically ($P>0.05$). It is thus clear that No. of leaves are statistically under getict ontrol and least affected by the microclimate. Highly statistically significant differences were evaluated between Pahari (9.32) and Azam (8.90) as far as the No. of leaves are concerned (Table-5). For the herbicides, although non-significant statistically, highest leaf number was recorded in atrazine (9.65), followed by Pendimethaline Full dose (9.33). Interaction of herbicides and varieties was non-significant ($P>0.05$). Among interactions, highest number of Leaves Plant^{-1} were recorded for Azam in atrazine (1x)(9.70) followed by atrazine(1x) (9.60) for Pahari, while least number of Leaves Plant^{-1} were produced in Pendimethaline (½x) in Azam (8.33) [Table-5]. Similar results have been reported by Cavero *et al.*(2002) showing increase inLeaves plant^{-1}during the exponential growth phase was faster in maize causing competition with weeds. Gregory *et al.* (1994) examined the differences in maize hybrids in suppression of velvetleaf depending on height. Tall and erect leaf hybrids were more successful in competing with the velvetleaf as compared to horizontal leaf hybrids.

Table-5. Effect of varieties, herbicides and their interaction on Number of leaves plant^{-1}.

Cultivar	Herbicides							Cultivar Means
	pendimethalin (1x)	pendimethalin (½x)	s-metochlor (1x)	s-metochlor (½x)	atrazine (1x)	atrazine (½x)	Weedy check	
Pahari	9.46	9.16	9.33	9.30	9.60	8.96	9.41	9.32a
Azam	9.20	8.33	8.83	8.80	9.70	8.86	8.56	8.90b
Herbicides Means	9.33	8.74	9.08	9.05	9.65	8.91	8.99	

CV= 8.10% $LSD_{0.05}$ for Interaction= 0.87 $LSD_{0.05}$ for Herbicides=1.244

Number of Cobs Plant^{-1}

Statistical analysis of the data revealed that herbicides had significant effect on number of cobs plant^{-1}, while varieties (P>0.05) and their interaction (P=0.20) with herbicides was non-significant statistically. Higher number of cobs Plant^{-1}were recorded in Pahari variety (1) as compared to Azam (0.99). The highest number of cobs Plant^{-1}were recorded in pendimethaline (1x) (1.05), followed by metolachlor (1x) (1.03), which however was statistically at par with all other herbicidal treatments while the lowest number of cobs Plant^{-1}were recorded in the Weedy check (0.90) [Table-6]. Although non-significant statistically, the numerically highest number of cobs Plant^{-1}were recorded in Azam with metolachlor (1x)(1.06) and pendimethaline(1x)(1.06) [Table-6] and the lowest cobs plant^{-1} were recorded in Weedy Check(0.83) involving Azam variety. Similar findings have been reported by Nawab *et al*. (1999) who reported that number of cobs plant^{-1} was increased by 14.9% in weed free plots as compared to the check plots, which were not weeded throughout the growing period of maize.

Table-6. Effect of varieties, herbicides and their interaction on Number of cobs plant^{-1}.

Cultivar	Herbicides							Cultivar Means
	pendimethalin **(1x)**	pendimethalin **(½x)**	**s-metochlor (1x)**	**s-metochlor (½x)**	**atrazine (1x)**	**atrazine (½x)**	**Weedy check**	
Pahari	1.03	1	1	1	1	1	0.96	1
Azam	1.06	1	1.06	1	1	1	0.83	0.99
Herbicides Means	1.05a	1a	1.03a	1a	1a	1a	0.90b	

C.V = 6.12% LSD$_{0.05}$ for herbicides= 0.076

Cob Length (cm)

Statistical analysis of the data revealed that herbicides had significant effect on cob length (P<0.05), while varieties and varieties x herbicides interaction (P>0.05) effect is non-significant statistically. For varieties, the higher cob length was recorded in Azam variety (11.87 cm) as against 11.66 cm in Pahari. Different herbicides have affected cob length significantly (P=0.000). The highest cob length was recorded in pendimethaline (1x) (12.98 cm) followed by metolachlore (1x) (12.75 cm), which in turn was statistically comparable with metolachlore ((½x) (12.23) [Table-7]. The lowest cob length was recorded under Weedy check (10.68 cm). Interaction of herbicides and varieties was non-significant (P=0.245) statistically. Among the interactions, the highest cob length was recorded in Pahari treated with Pendimethaline(1x)(13) and the numerically lowest cob length was measured under Weedy Check (10.33 cm) and atrazine(½x)(10.33 cm) involving Azam variety. Similar results were reported by Kamel *et al.* (1983). They concluded that weed control treatment improved cob length.

Table-7. Effect of varieties, herbicides and their interaction on cob length (cm).

Cultivar	Herbicides							Cultivar Means
	pendimethalin **(1x)**	pendimethalin **(½x)**	**s-metochlor (1x)**	**s-metochlor (½x)**	**atrazine (1x)**	**atrazine (½x)**	**Weedy check**	
Pahari	13	10.66	12.66	12.13	11.83	10.33	11.03	11.66
Azam	12.96	11.16	12.83	12.33	12.16	11.33	10.33	11.87
Herbicides Means	12.98a	10.91d	12.75ab	12.23bc	12c	10.83d	10.68d	

CV= 4.52% LSD$_{0.05}$ for herbicides= 0.63

Number of Kernels Cob^{-1}

Statistical analysis of the data revealed that herbicides and varieties have significant (P<0.05) effect on number of kernels cob^{-1}, while their interaction is non-significant statistically (P=0.209). The effect of varieties in weed suppression was non-significant statistically, yet the higher number of kernels cob^{-1}were recorded in Azam variety (307.09) as compared to Pahari (217.19). Different herbicides have affected the number of kernels cob^{-1}significantly (P=0.000). The highest number of kernels cob^{-1} were recorded in metolachlor (1x) (370.8) followed by metolachlore (½x) (337.2), it was however statistically at par with pendimethaline (1x) (315.3). The lowest number of kernels cob^{-1}were recorded under weedy check (184.2). Interaction of herbicides and varieties though non-significant statistically (P=0.209), highest number of kernels cob^{-1}were recorded in Azam treated with metolachlor (1x)(386.66) and lowest under weedy check (179.66) in Pahari variety (Table-8). Similarly findings were communicated by Hassan *et al*. (2010) while working on maize crop.

Table-8. Effect of varieties, herbicides and their interaction on kernels cob^{-1}.

Cultivar	Herbicides							Cultivar Mean
	pendimethalin (1x)	pendimethalin (½x)	s-metochlor (1x)	s-metochlor (½x)	atrazine (1x)	atrazine (½x)	Weedy check	
Pahari	273.66	251.66	355	311	265.33	262	179.66	217.19b
Azam	357	310	386.66	363.33	294.66	249.33	188.66	307.09a
Herbicides Means	315.3bc	280.8cd	370.8a	337.2ab	280cd	255.7d	184.2e	

CV= 10.96% LSD$_{0.05}$ for herbicides= 37.76

Biological Yield (t ha^{-1})

Statistical analysis of the data exhibited that herbicides had significant effect on biological yield, while varieties and their interaction with herbicides (P>0.05) effect is non-significant. Among varieties, the higher biological yield was recorded in Azam variety (7.52 t ha^{-1}) as against 7.36 t ha^{-1} in Pahari (Table-8). Different herbicides have affected biological yield significantly (P=0.000). The highest biological yield was recorded in metolachlore (1x) (9.47 t ha^{-1}) followed by metolachlore (½x) (9.47 t ha^{-1}) and pendimethaline (1x) (8.52 t ha^{-1}). Minimum biological yield was recorded in weedy check (4.24 t ha^{-1}), which is >50% from the top scoring treatments. Interaction of herbicides and varieties was non-significant (P=0.30). Among the interactions, the highest yield was recorded in Pahari treated with Metolachlore (1x)(9.86 t ha^{-1}) and lowest under Weedy Check (4.20 t ha^{-1}) in the same variety (Table-9). Similar results were reported by Miller and Libby (1999) who concluded that corn yield responded positively when weeds were controlled by herbicides. Becker and Staniforth (1981) also obtained higher yield in maize with weedicides as compared to cultural weed control. Our findings are also corroborated by the recent work of Khan *et al*. (2016) on maize. They evaluated the lowest weed density in metolachlor 960 EC treated plots. Similarly, plant height (247.188 cm) and grain yield (2.253 t ha^{-1}) was the maximum in maize hybrid P-3025 x metolachlore treated plots in their findings.

Table-9. Biological yield (t ha^{-1}) as affected by herbicides, varieties and their interaction.

Cultivar	Herbicides							Cultivar Means
	pendimethalin (1x)	pendimethalin (½x)	s-metochlor (1x)	s-metochlor (½x)	atrazine (1x)	atrazine (½x)	Weedy check	
Pahari	8.19	7.05	9.86	8.94	7.11	6.20	4.20	7.36
Azam	8.85	7.66	9.07	8.44	7.89	6.41	4.29	7.52
Herbicides Means	8.52b	7.36c	9.47a	8.69b	7.50c	6.30d	4.24e	

CV= 8.78% $LSD_{0.05}$ for herbicides=0.77

Harvest Index %

Statistical analysis of the data revealed that varieties, herbicides and their interaction (P>0.05) had non-significant effect on harvest index%. (Table-10). Though the herbicidal application didn't affect the varieties however, numerically higher harvest index% was recorded in Azam variety (25.95) in comparison to Pahari (24.28). Herbicides effect on harvest index was non-significantly (P=0.17), the maximum harvest index was recorded for metolachlore (1x) (27) followed by pendimethaline (1x) (27) and the lowest H.I. was recorded under Weedy Check (22.33) [Table-10]. Among the interactions, the numerically highest harvest index was recorded for Azam treated with metolachlor (½x) (28.66) and the lowest H.I (Table-10) was recorded under Weedy Check (20.33) involving Azam and Pendimethaline (½x)(20.33) for both Azam and Pahari variety. Similar results were also reported by Tesfay *et al.* (2014) also who also recorded the lowest weed density in plot treated with hand weeding and hoeing (3.12 m^{-2}) followed by nicosulfuron (18.67 m^{-2}) and Primagram (3.88 m^{-2}). Our results do not agree with the findings of Weidong *et al*. (2005) who showed the effect of crowding stress of weeds on harvest index of maize causing decrease in total grain yield, biological yield, while the use of pre-emergence herbicide could control the crowding stress of weeds.

Table-10. Harvest index (%) as affected by herbicides, varieties and their interaction.

Cultivar	Herbicides							Cultivar Mean
	pendimethalin (1x)	pendimethalin (½x)	s-metochlor (1x)	s-metochlor (½x)	atrazine (1x)	atrazine (½x)	Weedy check	
Pahari	26.33n.s	20.33	25.33	21.33	26	26.33	24.33	24.28n.s
Azam	27.66	20.33	28.66	32.33	25.66	26.66	20.33	25.95
Herbicides Means	27.00n.s	20.33	27	26.83	25.83	26.50	22.33	

n.s = non-significant at $P_{0.05}$.

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