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Research Article

Effect of weed control on yield and quality of malt barley *(Hordeum vulgare)*

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Abstract

The experiment was conducted at the Research Farm of the Khalsa College, Amritsar during Rabi seasons of 2013-14 and 2014-15 to study the weed control efficacy of different herbicides in barley. Minimum weed dry weight was recorded in clodinafop (60g) + metsulfuron (4g/ha), which was significantly lower than isoproturon (936 g) + metsulfuron (4 g/ha), isoproturon (936 g) + 2, 4-D (500 g/ha), pinoxaden (50 g/ha), fenoxaprop-p-ethyl (100 g/ha), isoproturon (936 g/ha), hand weeding and weedy check during both the years. Maximum plant height, , dry matter accumulation, effective tillers, ear length, numbers of grains per ear, test weight, grain yield and malt yield were recorded in clodinafop (60 g) + metsulfuron (4 g/ha) which was significantly higher than isoproturon (936 g) + metsulfuron (4 g/ha), isoproturon (936 g) + 2, 4-D (500 g/ha), pinoxaden (50 g /ha), fenoxaprop-p-ethyl (100 g/ha), isoproturon (936 g/ha), hand weeding and weedy check in both the years.

Keywords : Chemical Weed Control, Grain Yield, Malt Recovery and Malt Yield

1. Introduction

Barley (Hordeum vulgare) is one of the most important cereals of the world. It is valuable product for malt extracting industries which is utilized for brewing, distillation, baby foods, beer, whisky, brandy and in Ayurvedic medicines. Barley is the most preferred cereal crop for malt preparation, because its husk protects the acrospires during germination process and provides aid in filtration, firm texture of grains and higher amylase activity makes it unique amongst common cereals. In Punjab the area under the cultivation of barley is 13 thousand hectare with a production of 47 thousand tonnes in 2012-13 (Anonymous, 2014). Wheat is main Rabi crop which is susceptible to increasing weed infestation and yellow rust in recent years due to large scale cultivation of one or two varieties. Furthermore water requirement of Rice-Wheat rotation is also very high resulted in lowering down of underground water level. In this scenario, it is necessary to divert some area from wheat to barley. Further, considering the growing importance of barley among processing unit into variety of products, there is great need to increase not only the area but productivity of barley also. Among different factors, efficient weed control is the key factor for successful cultivation of barley. Weed control plays an active role in raising grain yield, since weeds cause great loss up to 48.9% in yield (Metwally et al., 2000). Use of herbicides is an economical and easy method for weed control in barley as compared to hand weeding. Herbicidal treatments increase grain yield as compared with unweeded and hand weeding treatments. The better grain yield realization is not possible without proper weed management in crop, because weed compete with the crop for nutrient, water, space and sunlight. Keeping in view the importance of chemical weed control in barley in present scenario and its yield loss due to competition offered by weeds, this field experiment was conducted under the agro climatic conditions of Punjab.

2. Materials and methods

The experiment was conducted at the Research Farm of the Khalsa college, Amritsar (31° 38' N, 72 ° 52' E; 236 m ASL), India during Rabi seasons of 2013-14 and 2014-15 to evaluate the weed control efficacy of different herbicides in barley (Hordeum vulgare). The soil of experimental field was sandy loam in texture and its chemical analysis showed neutral pH (7.8), low organic carbon content (0.46 %) and low alkaline KMnO4 -N (168 kg/ha), high Olsen's (0.5 M NaHCO3 extractable) P (18.1 kg/ha) and medium 1N ammonium acetate extractable K (316 kg/ha). All the herbicides were applied at 35 days after sowing (DAS) by knapsack sprayer. The treatments included alone application of isoproturon (936 g/ha), fenoxaprop -p-ethyl (100 g/ha) and pinoxaden (50 g/ha .); tank-mix combinations of clodinafop (60 g/ha) + metsulfuron (4 g/ha), isoproturon (936 g/ha) + metsulfuron (4 g/ha) and isoproturon (936 g/ha) + 2,4-D sodium salt (50 g/ ha) along with hand weeding (at 35 DAS) and weedy check. Barley cultivar PL 807 was sown using seed rate of 88 kg/ha in rows 22.5 cm apart on 26 October and 1st November in 2013 and 2014, respectively. The crop was harvested on 2nd April and 8th April during 2014 and 2015, respectively.

The experiment was laid out in randomized block design with three replications in plots of 3.6m x 3.6m. Recommended dose of N (62.5 kg/ha), P (30 kg/ha) and K (30 kg/ha) was applied according to the package of practices of State University. Crop was raised according to package of practices of the State Agricultural University. Three plants per plot were tagged/selected at random to record periodic plant height and dry matter accumulation. Five ears per plot were selected randomly for recording ear length and number of grains per earhead. Dry weight of grassy and broadleaved weeds were recorded in grams per square meter at 60 DAS. Weeds were removed from the ground level from three spots per plot and were first sun dried and then in an oven 60° for 72 hours. Weed Control efficiency (WCE) was calculated by using following formula:

$$WCE = \frac{\text{Dry wt. of weeds (Control Plot) - Dry wt. of weeds (Treated Plot)}}{\text{DM (Control Plot)}} \times 100$$

Protein content was analyzed by using Near Infrared Reflectance Meter (NIR) supplied by FOSS. Malting of barley grains were carried out as per the method suggested by Singh and Sosulski (1985). Properly cleaned, weighed samples of barley grains (100g) were steeped in water at 15oC in an incubator for a period of 60 hours. Water was changed every 8-10 hours and air rest of 1 hr was given after 24 hour during steeping. Then steeped samples taken in a muslin cloth were placed in a wooden box with wire mesh bottom for germination in an incubator at 15oC and relative humidity of more than 90 per cent. They were allowed to germinate for a period of 5 days. Then the green malt was kilned in an oven at 45oC for the first 20 hours and then at 85oC for 4 hours. Roots from the kilned malt were removed. Weight of malt and roots was recorded separately to calculate malt recovery (%).

$$\text{Malt recovery (\%)} = \frac{\text{Malt weight}}{\text{Sample weight}} \times 100$$

Data collected from the experiment were statistically analysed using statistical software CROPSTATE 7.2 (IRRI, 2009)

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3. Results and discussion

3.1 Effect on weeds

Different species belonging to grasses and broadleaf weeds were observed in the experimental field. The dominant weeds were: Phalaris minor, Poa annua, Melilotus indica, Anagalis arvensis, Coronopus didymus, Rumex maritimus and Chenopodium album. The highest dry matter of weeds was recorded under weedy check treatment at 60 DAS, which was significantly higher than of all the herbicidal treatments (Table 1) in 2013-14 and 2014-15. Lowest dry weight of grassy weeds was recorded in pinoxaden (50 g/ha) which was at par with clodinafop (60g/ha) + metsulfuron (4 g/ha). Whereas, dry weight of broad leaved weeds was the minimum in clodinafop (60g/ha) + metsulfuron(4 g/ha) which was at par with isoproturon (936 g/ha) + metsulfuron (4g/ha) during both the years.

Table 1. Effect of different weed control treatments on dry weight of weeds

Treatments	Weed Dry weight at 60 DAS (g/m^2)							
	Grassy		Broadleaf		Total		WCE (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	16.46 (270)	14.84 (220)	11.31 (127.13)	9.53 (90)	19.94 (397)	24.37 (310)	-	-
Hand weeding (35 DAS)	9.53 (90)	8.39 (70)	10.53 (110)	8.19 (66.2)	14.17 (200)	11.75 (136.2)	49.62	56.06
Isoproturon (936 g/ha a.i.)	8.69 (74.6)	7.51 (55.5)	10.78 (115.32)	8.54 (72)	13.81 (189.92)	16.05 (127.5)	52.16	60.61
Isoproturon (936 g/ha) + 2,4-D Na (500 g/ha.)	8.73 (75.3)	7.49 (55.3)	5.59 (31.26)	4.47 (18.0)	10.37 (106.56)	11.85 (73.3)	73.15	76.03
Isoproturon (936 g/ha) + metsulfuron (4 g/ha)	8.76 (75.9)	7.43 (54.36)	5.20 (26.1)	3.95 (15.0)	10.15 (102.11)	11.39 (69.3)	74.27	77.00
Clodinafop (60 g/ha) + metsulfuron (4 g/ha)	2.47 (5.15)	2.04 (3.20)	5.09 (25.0)	3.88 (14.1)	5.58 (30.15)	6.01 (17.3)	92.40	94.29
Fenoxaprop-p-ethyl (100 g/ha)	3.27 (9.73)	2.69 (6.26)	10.87 (117.3)	8.66 (74.2)	11.31 (127.03)	11.35 (80.4)	68.0	74.09
Pinoxaden (50 g/ha)	2.30 (4.3)	1.94 (2.8)	10.83 (116.5)	8.75 (75.6)	11.03 (120.8)	10.69 (78.4)	69.57	74.70
CD (p=0.05)	0.24	0.13	0.27	0.20	0.65	1.31		

Data subjected to √(x+1) transformation, and figures in parentheses are original values.

The lowest weight of grassy weeds in pinoxaden (50g/ha) and clodinafop (60g/ha) + metsulfuron (4 g/ha.) might be due to better control of *Phalaris minor*. Similar findings were reported in wheat by Yadav *et al.* (2010). On the other hand, the lowest weight of broad leaved weeds in both tank mixed combination of clodinafop (60g/ha) + metsulfuron (4 g/ha) and isoproturon(936 g/ha) + metsulfuron (4g/ha) might be due to better control of broad leaves weeds by metsulfuron throughout the study period. Total dry weight of weeds (grassy + broad) was significantly lower in clodinafop (60g/ha) + metsulfuron (4 g/ha) as compared to all other treatments during this study (Table 1). The highest weed control efficiency was observed in clodinafop (60 g/ha) + metsulfuron (4 g/ha) followed by isoproturon (936 g/ha) + metsulfuron(4 g/ha), isoproturon (936 g/ha) + 2,4-D sodium salt (500g/ha), pinoxaden (50 g/ha), fenoxaprop-p-ethyl (100 g/ha), isoproturon (936 g/ha) and hand weeding in both years.

3.2 Effect on crop

The maximum plant height, plant dry matter accumulation were recorded with clodinafop+ metsulfuron at 60+4 g/ha which was significantly higher than isoproturon (936 g/ha) + metsulfuron (4 g/ha), isoproturon (936 g/ha)+ 2,4-D sodium salt (500 g/ha) and alone application of pinoxaden (50 g/ha), fenoxaprop-p-ethyl (100 g/ha), isoproturon (936g/ha) and hand weeding in both the years (Table 2 and 3). Maximum number of effective tillers/m^2, number of grains per spike and test weight wererecorded in clodinafop + metsulfuron at 60+4 g/ha which was significantly higher than all other treatments in 2013-14 and 2014-15. All the herbicides treatments registered significantly higher crop yield over control. Maximum grain yield of 55.2 and 57.6 q/ha were recorded in clodinafop + metsulfuron at 60+4 g/ha which was significantly higher than all other treatments in both years. However, isoproturon (936 g/ha) + metsulfuron (4g/ha) and isoproturon (936 g/ha) + 2, 4-D sodium salt (500 g/ha) were statistically at par with each other. Better yield in treatment clodinafop (60 g/ha) + metsulfuron (4 g/ha) might be due to better weed control by combined application of clodinafop + metsulfuron as compared to other herbicidal combinations. Bharat et al. (2012) also found treatment clodinafop + metsulfuron better than isoproturon + 2, 4-D, isoproturon and fenoxaprop with respect to yield of wheat. Likewise, Ram and Singh (2009) reported poor weed control efficiency in case of isoproturon alone.

Table 2. Effect of different weed control treatmentson growth and yield of barley (2013-14)

Treatment	Plant height (cm)	Effective tillers (m^{-2})	No. of grains per ear	Test weight (g)	Grain yield (q/ha)
Control	79.3	196	44.9	34.3	27.19
Hand weeding (35 DAS)	88.1	211	47.6	35.8	34.25
Isoproturon (936 g/ha)	89.8	217	48.4	36.0	35.57
Isoproturon (936 g/ha a.i.) +2,4-D Na(500 g/ha)	97.7	248	53.8	38.1	48.26
Isoproturon (936 g/ha a.i.)+ Metsulfuron (4 g/ha)	98.5	250	54.2	38.4	50.17
Clodinafop (60 g/ha a.i.)+ Metsulfuron (4 g/ha)	102.6	264	57.0	39.6	55.20
Fenoxaprop-p-ethyl (100 g/ha)	94.2	237	51.1	37.1	43.13
Pinoxaden (50 g/ha)	96.2	243	52.3	37.7	45.62
CD (p=0.05)	3.92	9.17	2.21	0.76	4.69

Table 3. Effect of different weed control treatmentson growth and yield of barley (2014-15)

Treatment	Plant height (cm)	Effective tillers (m^{-2})	No. of grains per ear	Test weight (g)	Grain yield (q/ha)
Control	80.1	200	46.4	36.0	30.17
Hand weeding (35 DAS)	88.7	216	50.3	37.0	37.20
Isoproturon (936 g/ha a.i.)	89.5	220	50.5	37.3	38.85
Isoproturon (936 g/ha a.i.) +2,4-D Na500 g/ha)	99.2	260	55.8	38.8	50.55
Isoproturon (936 g/ha a.i.)+ Metsulfuron (4 g/ha)	100.3	262	56.1	39.3	51.53
Clodinofop (60 g/ha) + Metsulfuron (4 g/ha)	104.7	274	59.0	40.2	57.56
Fenoxaprop-p-ethyl (100 g/ha)	94.4	248	53.1	37.8	44.61
Pinoxaden (50 g/ha)	97.1	249.4	54.7	38.5	46.42
CD (p=0.05)	4.15	11.53	2.32	0.89	5.20

3.3 Effect on quality

Nitrogen content was significantly higher in clodinafop (60 g/ha) + metsulfuron (4 g/ha.) than all other treatments (Table 4). Higher nitrogen content of grains in clodinafop + metsulfuron may be due to the less competition for nutrients and water through limiting weeds infestation with herbicidal treatments. Metwally *et al.* (2010) reported the similar response. Protein content was significantly higher in clodinafop(60g /ha) + metsulfuron (4g /ha) than all other treatments in both years study. However, isoproturon (936 g/ha) + metsulfuron (4 g/ha), isoproturon (936g/ha) + 2, 4-D sodium salt (500 g/ha) and alone application of pinoxaden (50 g/ha), pinoxaden (50 g/ha) with fenoxaprop-p-ethyl (100 g/ha a.i.) and isoproturon (936g/ha) with hand weeding were statistically at par with each other.

Table 4. Effect of different weed control treatments on quality parameter of barley

Treatments	Nitrogen content (%)		Protein content (%)		Malt recovery (%)		Malt yield (q/ha)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	1.68	1.73	10.68	10.81	87.75	87.62	23.85	26.43
Hand weeding (35 DAS)	1.75	1.80	11.06	11.25	87.38	87.21	29.92	32.44
Isoproturon (936 g/ha)	1.77	1.82	11.19	11.37	87.30	87.17	31.05	33.86
Isoproturon (936 g/ha) + 2,4-D Na (500 g/ha)	1.90	1.92	12.03	12.0	86.67	86.39	41.82	43.67
Isoproturon (936 g/ha) + metsulfuron (4 g/ha)	1.91	1.94	12.10	12.12	86.62	86.28	43.45	44.46
Clodinofop (60 g/ha) + metsulfuron (4 g/ha)	1.99	2.01	12.47	12.56	85.92	84.76	47.42	48.78
Fenoxaprop-p-ethyl (100 g/ha)	1.84	1.87	11.55	11.68	86.95	86.79	37.50	38.71
Pinoxaden (50 g/ha)	1.88	1.90	11.80	11.87	86.83	86.58	39.61	40.19
CD (p = 0.05)	0.05	0.04	0.31	0.27	0.28	0.34		

These results might be due to the less competition for nutrients, water and light through limiting weeds infestation with herbicidal and hand hoeing treatments which leads to more uptake of nitrogen. Metwally *et al.* (2010) reported the similar findings. The highest malt recovery was found in control which was differed significantly from all other treatments. Malt recovery found to be the minimum in clodinafop (60 g/ha) + metsulfuron (4 g/ha) Table 4. Higher malt recovery in control may be due to lower protein content formation under intense crop-weed competition for nutrient uptake. Kumar *et al.* (2013) reported inverse relationship between malt recovery and protein content. On the other hand malt yield was higher in clodinafop (60 g/ha) + metsulfuron (4 g/ha) followed by isoproturon (936 g/ha) + metsulfuron (4g/ha), isoproturon (936g/ha) + 2,4-D sodium salt (500 g/ha) and alone application of pinoxaden (50 g/ha a.i.), fenoxaprop-p-ethyl (100 g/ha) and isoproturon (936 g/ha) along with hand weeding. Despite low recovery, clodinafop (60 g/ha) + metsulfuron (4g/ha) showed higher malt yield due to higher seed yield in both years.

Conclusion

On the basis of two year study, it can be concluded that application of Clodinafop (60 g/ha) + metsulfuron (4 g/ha) in barley increased the grain and malt yield but with reduced malt recovery as a result of the better WCE .

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