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Pinoxaden in Combination with other Herbicides against Complex Weed Flora in Barley

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Abstract: *Field experiments were conducted during 2014-15 and 2015-16 at New Research Farm of ICAR-Indian Institute of Wheat and Barley Research, Karnal. The treatment comprising individual application of pinoxaden and isoproturan in combination with metsulfuron /carfentrazone / 2,4- D or alone. In addition weedy check and weed free plots were also maintained. The major weeds present in experimental site were Phalaris minor (Mandusi/Kanki), Anagallisarvensis (Krishna neel), Chenopodium album (bathua), Melilotusindica (senji), Rumexdentatus, Polypogonmonspeliensis and Coronopusdidymus (pith papda). Among herbicide treatments the grain yield was at par when pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1} and tank mixing of pinoxaden withcarfentrazone or metsulfuron. The grain yield reduction due to weeds was 37.7 percent as compared to weed free conditions.Combined application of pinoxaden with metsulfuron-methyl/carfentrazone (as tank mixed or as followed by) resulted in significantly lower total weed density and weed biomass. Among herbicides, weed control efficiency (89.7 %), weed control index (88.4 %) and herbicide efficiency index (4.11%) were highest when pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1} were applied to control weeds whereas; weed index (37.74 %) was highest in weedy check. Hectolitre weight and bold grain per cent were at par with weed free conditions when pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1} and the tank mixed pinoxaden with broad-leaved herbicides was applied.*

Key words: *Barley, Pinoxaden, Isoproturon, Metsulfuron, Carfentrazone,Tank mix, Weed indices, Yield*

INTROUCTION

Barley is the world's fourth most important cereal crop after wheat, rice and maize. It is a major source of food for large number of people living in the cooler semi-arid areas of the world. In India, it is staple food of the hill people and also used for food and feed in the plains ofRajasthan, Punjab, Haryana, Uttar Pradesh and Madhya Pradeshin the country. Barley is also used for malt production, which is principally used in brewing industry and provides a good source forbetter rural livelihood. The 3rd advance estimates for *Rabi* 2015-16 have indicated nearly 1620 thousand tons of barley production in 697 thousand ha area with a productivity of 2447 kg ha^{-1}. Between humans and continuing food supply, there stand four natural hazards, e.g. weather, weeds, insect pests and plant diseases. Weather conditions, weeds, insect pests and plant diseases are the four important yield determinants that control the supply of food.Sometimes these factors work independently and many times they work hand in hand. Weeds are the most underestimated crop pests in tropical agriculture and cause maximum reduction/loss in the yields of crops than other pests and diseases. Of the total annual loss of agricultural produce from various pests in India, weeds roughly account for 37%, insects for 29%, diseases for 22% and other pests for 12% (Yaduraju, 2006). They affect adversely the quantity and quality of produce/food, fibre, oil, forage/fodder, animal products (meat and milk) and cause health hazards for humans and animals. Thus weed control is crucial in every crop production system. Barley crop has early vigorous

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growth and by active tillering stage, it completely covers the soil resulting in smothering of weeds, but weeds can lower the yield significantly. Irrigated barley with high fertilization usually suffers from severe weed competition. The major weedsof barley crop are *Phalaris minor (Mandusi/Kanki), Anagallisarvensis* (*Krishna neel*), *Avenafatua* (wild oat), *Chenopodium album* (*bathua*), *Chenopodiummurale, Cirsiumarvense* (*kateli*), *Melilotus alba* and *Melilotusindica* (*senji*), *Euphorbia heliscopia, Spergulaarvensis, Convolvulus arvensis, Rumexdentatus, Asphodelustenuifolius, Lathyrusaphaca, Viciasativa, Polypogonmonspeliensis and Avenaludoviciana.* Weeds usually pose greater problem in irrigated areas. Under normal conditions, both broadleaf and grassy weeds infest the crop. Isoproturon and 2,4-D were the only herbicides recommended for weed control in barley; however, due to resistance to isoproturon in *P. minor*, this herbicide has limitations of use (Singh, 2007, Ram and Singh, 2009). Not all wheat herbicides are selective for barley (Singh and Punia, 2007). Metribuzin has been found to control weeds in barley, but can cause crop damage by reducing plant stand by a quarter (Kleemann and Gill, 2008). There have been complaints of crop damage at farmers' fields in Haryana where the new herbicides recommended for wheat (sulfosulfuron, clodinafop-propargyl and fenoxaprop-P-ethyl) were sprayed in barley. As barley has become remunerative and competes well with weeds compared to wheat; farmers can grow it effectively even rotating with wheat for resistance issues and for efficient resource management (under limited irrigation and fertilizers conditions), provided weeds are successfully managed (Singh, 2007). The present field studies were conducted to manage weeds in barley through suitable herbicides and their combination without crop injury.

MATERIALS AND METHODS

Field experiments were conducted during 2014-15 and 2015-16 at New Research Farm of ICAR-Indian Institute of Wheat and Barley Research, Karnal. The soil of the experimental field was clay loam in texture, low in OC and available N, medium in P_2O_5 and high in K_2O with a pH of 8.3. Barley cv. DWRB 101 and DWRUB 52 were planted at a row spacing of 20 cm during 2014-15 and 2015-16 respectively. The experiment was laid out in randomized block design with eleven treatments and three replications. The treatment comprising individual application of pinoxaden and isoproturan in combination with metsulfuron / carfentrazone / 2,4- D or alone. In addition weedy check and weed free plots were also maintained. Full doses of P and K and half of nitrogen were applied as basal. The rest of nitrogen was applied at 1st irrigation. Sowing was done using 100 kg seed ha^{-1}. Other cultural practices were as per recommendations for crop. The individual herbicides were first dissolved individually in the container, and then these were mixed in the sprayer tank for tank mix application of two herbicides. All herbicide treatments were applied at 2-3 leaf stage of weeds. A knapsack sprayer fitted with flat fan nozzle using 375-400 litres of water per hectare was used for spraying the herbicide. Weed population was taken by quadrate method and dry weight was recorded after sun drying of the weeds. Observations on weed dry weight and their density were recorded 90 DAS by placing a quadrat of 50 x 50 cm at two places in each replication. Data on total weed count and weed dry weight was subjected to "x+1 square root transformation to normalize the distribution. The grain yield of barley was recorded at harvest from the net plot area. The various impact assessment indices namely weed control efficiency (WCE), weed index (WI), herbicide efficiency index (HEI) and weed control index (WCI) were calculated as per formulae suggested by Mani *etal.,*(1973), Gill and Vijay Kumar (1966), Walia (2003) and Mishra and Tosh (1979) respectively.

RESULTS AND DISCUSSION

Barley crop was infested with both grassy and broad-leaved weeds. The major weeds present in experimental site were *Phalaris minor (Mandusi/ Kanki), Anagallisarvensis (Krishna neel), Chenopodium album (bathua), Melilotusindica (senji), Rumexdentatus, Polypogonmonspeliensis and Coronopusdidymus (pith papda).*

Effect on Yield and Yield Attributing Characters

The pooled data of both the years (Table 1) revealed that all weed control treatments were significantly superior over weedy check in enhancing grain yield of barley. Among herbicide treatments the highest grain yield (3793 kg ha^{-1}) was recorded when pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1} was applied. pinoxaden @ 40g ha^{-1} + carfentrazone @ 20g ha^{-1} and pinoxaden @ 40g ha^{-1} + metsulfuron @ 4g ha^{-1}were statistically at par with pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1} treatment, but the highest grain yield was recorded in weed free treatment (4130 kg ha^{-1}) . The grain yield reduction due to weeds was 37.7 percent as compared to weed free conditions. The increase in grain yield of barley due to application of pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1} ranged from 4.0 to 25.3% over rest of the herbicidal treatments and 47.5 % over weedy check. The increase in yield was due to control of different weeds. Yield attributing characters *viz.*earhead m^{-2}, grains/earhead and 1000 grains weight were also maximum in weed free treatment and were significantly affected due to various herbicide treatments. Similar results were also reported by Shoeran *et al.,* during 2013 in case of wheat. Tank mixing of carfentrazone with pinoxaden although caused injury in terms of yellowing of tips and spots on leaves but injury symptoms disappeared within 15 days after spray and did not result in any detrimental effect on grain yield of barley.

Effect on Weeds

All the herbicides treatments resulted in significant lower weed count and dry matter of weeds as compared to untreated check at 90 days after treatment (Table 2). Among herbicide treatments the lowest weed count and dry weight of weeds was recorded when pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1} was applied. The tank mix application of pinoxaden with broad-leaved herbicides proved significantly effective in reducing density and dry weight of weeds. This was because of control of mixed weed flora. Similar results were also reported by Shoeran *et al.,*2013 and Katara *etal.,* 2012 in case of wheat. Metsulfuron and carfentrazone can effectively be used for the control of broad leaf weeds in barley as tank mix with Pinoxaden for broad spectrum weed control. Bhullar*etal.,* 2013 reported that carfentrazone-ethyl and metsulfuron-methyl are additional tools for control of broadleaved weeds in barley. Pinoxaden @ 40g ha^{-1} controlled *Phalarisminor (Mandusi/Kanki) and Polypogonmonspeliensis* effectively whereas, isoproturon controlled only *Polypogonmonspeliensis.* Chhokar*et al*., 2008 reported that pinoxaden @ 30 g ha^{-1} effectively controlled isoproturon resistant *P. minor* in barley.

Impact Assessment of Different Herbicide Treatments

Among herbicides, weed control efficiency (89.7 %), weed control index (88.4 %) and herbicide efficiency index (4.11%) were highest when pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1} were applied to control weeds whereas; weed index (8.16 %) was lowest in this treatment (Table 3). Weed control efficiency, weed control index and herbicide efficiency index were more when pinoxaden was tank mixed with metsulfuron or carfentrazone compared to tank mixing of isoproturon with metsulfuron or 2, 4-D.

Effect on Grain Quality of Barley

Hectolitre weight and bold grain per cent were at par with weed free conditions when pinoxaden @ 40g ha^{-1} followed by metsulfuron @ 4g ha^{-1}and the tank mix application of pinoxaden with broad-leaved herbicides was applied. The lowest hectolitre weight (66.93 kg hectolitre^{-1}) was recorded in weedy check conditions (Table 4). The reduction in hectolitre weight and bold per cent was due to competition by weeds. Higher hectolitre weight and bold per cent in barley is must for industrial purpose.

CONCLUSIONS

Based on this study, it can be concluded that pinoxaden@ 40 -50 g ha^{-1}is highly effective against grassy weeds (*Phalaris minor*and *Polypogonmonspeliensis*). Metsulfuron and carfentrazone can effectively be used for the control of broad leaved weeds in barley as tank mix with pinoxaden for broad spectrum weed control.

Table 1
Effect of different treatments on yield and yield attributing characters (Two years' pooled data)

Treatments	*Dose (g ha^{-1})*	*Earhead m^{-2}*	*Grains / earhead*	*1000 grain weight (g)*	*Yield (kg ha^{-1})*
Pinoxaden	30	500	32.0	44.7	3268
Pinoxaden	40	516	33.0	45.6	3538
Pinoxaden	50	499	32.2	45.2	3476
Pinoxaden +Metsulfuron-methyl	40+4	527	33.0	45.9	3617
Pinoxaden followed by Metsulfuron-methyl	40 and 4	543	33.5	46.3	3793
Pinoxaden + Carfentrazone-ethyl	40+20	539	32.7	46.4	3648
Isoproturon	1000	458	32.2	44.1	3026
Isoproturon + 2,4-D	750 & 500	481	31.8	44.9	3407
Isoproturon +Metsulfuron-methyl	750+4	487	32.5	45.2	3364
Weedy check		453	30.8	43.0	2571
Weed free		569	33.0	46.8	4130
CD at 5%		40	1.5	1.6	157

Table 2
Effect of different treatments on weed count and dry weight of weeds (Two years' pooled data)

Treatments	*Dose (g ha^{-1})*	*Weed density (m^{-2})*	*Weed dry weight (g m^{-2})*
Pinoxaden	30	13.1(171)	7.67(58.08)
Pinoxaden	40	12.0(145)	7.05(48.98)
Pinoxaden	50	11.7(137)	6.88(46.77)
Pinoxaden +Metsulfuron-methyl	40+4	9.8(96)	5.80(32.97)
Pinoxaden followed by Metsulfuron-methyl	40 and 4	5.6(31)	3.62(12.27)
Pinoxaden + Carfentrazone-ethyl	40+20	7.6(57)	4.60(20.23)
Isoproturon	1000	15.3(237)	9.00(80.72)
Isoproturon + 2,4-D	750 & 500	11.7(137)	6.90(47.22)
Isoproturon +Metsulfuron-methyl	750+4	11.6(134)	6.79(45.65)
Weedy check		17.2(299)	10.28(106.15)
Weed free		1.0(0.0)	1.00(0.00)
CD at 5%		0.55	0.31

Table 3
Effect of different treatments on herbicide and weed indices (Two years' pooled data)

Treatments	*Dose (g ha^{-1})*	*Weed Index (%)*	*Weed control efficiency (%)*	*Weed control index (%)*	*Herbicide efficiency index (%)*
Pinoxaden	30	20.88	42.9	45.3	0.49
Pinoxaden	40	14.35	51.6	53.9	0.81
Pinoxaden	50	15.83	54.2	55.9	0.80
Pinoxaden +Metsulfuron-methyl	40+4	12.44	68.0	68.9	1.31
Pinoxaden followed by Metsulfuron-methyl	40 and 4	8.16	89.7	88.4	4.11
Pinoxaden + Carfentrazone-ethyl	40+20	11.69	80.9	80.9	2.19
Isoproturon	1000	26.74	20.9	24.0	0.23
Isoproturon + 2,4-D	750 & 500	17.51	54.2	55.5	0.73
Isoproturon +Metsulfuron-methyl	750+4	18.55	55.1	57.0	0.72
Weedy check		37.74	0.0	0.0	-
Weed free		-	100.0	100.0	-

Table 4
Effect of different treatments on grain quality of barley (Two years' pooled data)

Treatments	*Dose (g ha^{-1})*	*Hectolitre weight (kg hectolitre^{-1})*	*Bold grain (%)*	*Thin grain (%)*
Pinoxaden	30	67.23	80.91	3.58
Pinoxaden	40	68.57	85.99	2.84
Pinoxaden	50	68.56	85.65	3.02
Pinoxaden +Metsulfuron-methyl	40+4	68.41	86.42	2.00
Pinoxaden followed by Metsulfuron-methyl	40 and 4	68.02	90.49	1.98
Pinoxaden + Carfentrazone-ethyl	40+20	68.19	89.55	1.87
Isoproturon	1000	67.26	80.63	3.51
Isoproturon + 2,4-D	750 & 500	67.52	83.89	3.02
Isoproturon +Metsulfuron-methyl	750+4	67.51	84.59	3.02
Weedy check		66.93	81.80	4.15
Weed free		68.13	89.67	2.04
CD at 5%		1.17	4.20	0.37

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