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# Weed management effect on weed dynamics, nutrient depletion and productivity of barley under north-western plain zone

**Raghuvir Singh Meena*, R.P.S. Chouhan[1], H.K. Sumeriya[2], Rupesh Kumar[3], B.L. Meena[4] and Narendra Kumawat[5]**

[1]*Agricultural Research Station (SKRAU, Bikaner), Sriganganagar, Rajasthan 335001, India*
[2]*Rajasthan College of Agriculture (MPUAT), Udaipur, Rajasthan 313004, India*
[3]*Krishi Vigyan Kendra, Padampur, Sriganganagar, Rajasthan 335001, India*
[4]*College of Agriculture (SKNAU, Jobner), Lalsot, Dausa, Rajasthan 303511, India*
[5]*College of Agriculture (RVSKKV), Indore, Madhya Pradesh 452001, India*
**Email: rajagronomymeena.18@gmail.com*

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**ABSTRACT**

A field experiment was conducted on loamy sand soil at Agricultural Research Station, Sriganganagar, Rajasthan, India during two consecutive *Rabi* (winter) seasons of 2012-13 and 2013-14 to identify effective weed management treatments for attaining higher productivity of barley (*Hordeum vulgare* L.), while understanding the associated weeds dynamics. *Chenopodium album* and *Chenopodium murale* were the major dicot weeds that occurred along with the emergence of crop. *Cyperus rotundus*, *Phalaris minor* and *Asphodelus tenuifolius* were the dominant monocot weed species. The hand weeding twice at 25 and 45 days after seeding (DAS) and isoproturon at 500 g/ha + 2,4-D at 250 g/ha 30 DAS resulted in significant reduction in weed density and weed biomass. Maximum weed control efficiency (WCE) with minimum N, P and K depletion by weeds at harvest was observed with hand weeding twice (95.06%) followed by isoproturon 500 g/ha + 2,4-D at 250 g/ha 30 DAS (80.24%). Significantly higher seed, straw, biological yields of barley were observed with hand weeding twice. Next best treatments were isoproturon 500 g + 2,4-D at 250 g/ha 30 DAS and isoproturon at 500 g + metsulfuron methyl 4 g/ha 30 DAS.

## INTRODUCTION

Barley (*Hordeum vulgare* L.) is a major source of food for large number of people living in the cooler semi-arid areas of the world. Barley is an important cereal in India. The chief barley growing regions in the country are higher Himalayas (Himachal Pradesh, Jammu Kashmir and West Bengal), central parts of eastern Uttar Pradesh, eastern parts of Rajasthan and north-western parts of North Bihar. The barley is mostly used in India as grain feed to livestock and poultry, as malt for manufacture of beer and other liquors like whisky, brandy *etc* (Kumar *et al*. 2019). In Rajasthan, during 2017-18 the barley was cultivated on 3.01 mha with 10.78 mt of production and 3.58 t/ha productivity. The average productivity of barley in the state is far lower (Government of Rajasthan, 2020) than the attainable yield of 4.0-5.0 t/ ha (Choudhary *et al*. 2014).

The losses caused by weeds were estimated to be much higher than those caused by insects, pests and diseases together (Gharde *et al.* 2018). Weed competition throughout the crop season reduces yield by 10-38% depending upon time and intensity of weed infestation (Balyan and Malik 1994, Kumar *et al.* 2010). Conventional cultural practices of weed management are time consuming and labour intensive, even though, the additional benefits of providing greater aeration, improving root growth enabling greater absorption of moisture and nutrients from deeper soil layers and moisture conservation cannot be ignored. The farmers sometimes fail to carry out the timely agricultural operations including manual weeding because of the increasing demand of labour due to rapid urbanization / industrialization and adoption of intensive and multiple cropping systems. In barley, very limited herbicides have been tested and recommended. Thus, exploring the possibility of a suitable broad spectrum and cost-effective herbicide deserves the attention. Among the herbicides, 2,4-D is widely used in barley to control broad-leaf weeds.

The tank mix application of isoproturon and 2,4-D was recommended to control mixed weed flora in barley (Ram *et al.* 2003). The major concern with the over-dependence on single herbicide is build-up of herbicide resistant weeds and shift in weed flora. Therefore, new herbicides having a different mode of actions in various combinations are mainly needed to use as one of the management strategies for integrated weed management in barely (Yadav *et al.* 2018 and Ram *et al.* 2020). The herbicides such as metsulfuron-methyl, sulfosulfuron, carfentrazone and isoproturon have shown excellent efficiency in the control of broad and narrow leaf weeds in wheat and barley crop. The study was conducted to identify efficient weed management options to minimize the weed infestation with minimal nutrient removal by weeds and attain higher barley productivity in Sriganganagar region of Rajasthan.

## MATERIALS AND METHODS

Studies were conducted at Research Farm, Agricultural Research Station, Sriganganagar, Rajasthan (India) in two *Rabi* (winter) seasons of 2012-13 and 2013-14. This station is located between 28.4$^0$ to 30.3$^0$ North latitude and 72.3$^0$ to 75.3$^0$ East longitudes and the study area receives average annual rainfall of 322 mm, with temperature ranged fluctuates as low as – 10 $^0$C to as high as 48.9 $^0$C from December to June. The soil of experimental field was loamy sand with low organic carbon (0.33%), low in available nitrogen (138.60 kg/ha) medium in available phosphorus (21.60 kg/ha) and potassium (231.8 kg/ha), and slightly alkaline (pH 8.2) in reaction. The experiment was laid out in randomized block design with three replications and eight treatments, *viz.* 2,4-D at 250 g/ha, isoproturon at 500 g/ha, isoproturon at 500 g + metsulfuron-methyl at 4 g/ha, isoproturon at 500 g/ha + carfentrazone at 15 g/ha, isoproturon at 500 g/ha + 2-4-D at 250 g/ha (tank-mixtures), fenoxaprop -ethyl at 75 g/ha, hand weeding twice at 25 and 45 DAS, weedy check. Barley variety '*RD 2035*' was used as test crop. All post-emergence herbicides, *viz.* 2,4-D, metsulfuron-methyl, sulfosulfuron, carfentrazone and isoproturon herbicides were applied at 30 days after seeding (DAS), excepting fenoxaprop -ethyl was only applied at 25 DAS. Herbicides were applied using knapsack hydraulic sprayer using spray volume of water 500 lit/ha. The urea and DAP were uniformly applied at the time of last ploughing. Bullock drawn desi plough was used for sowing in row spaced at 22.5 cm with average depth of 5.0 cm with seed rate of 100 kg/ha. The crop was sown at 7$^{th}$ and 9$^{th}$ November, 2012-13 and 2013-14 and harvested on 8$^{th}$ and 12$^{th}$ April, respectively during 2013 and 2014. All the plant protection measures were adopted to ensure good and healthy crop. For weed density estimation, an area of 0.25 m$^2$ was selected randomly by a metallic quadrat of size 0.25 × 0.25 m at two places before treatment application, and after treatment application and expressed as density (number/m$^2$). Total number of weeds were counted species wise taken from each plot and analyzed. Weed samples for dry matter production (biomass) were taken to assess the effect of various treatments on weed growth. The collected weed samples were first sun-dried and then in oven at 70$^0$C till constant weight to estimate weed biomass. Crop biomass yield of a net plot was weighted after harvesting at physiological maturity and expressed in tons/ha. Grain yield was calculated by threshing of total plot biomass and presented in tons/ha. Economics of different treatments was worked out by taking the prevailing market prices of inputs and produce under consideration. The nutrient content (NPK) estimation in weeds at 90 DAS, calculation of weed control efficiency (WCE) and weed index (WI) were done as per standard methods. The original data on weed density at all stages were subjected to square root transformation before statistical analysis to analyze the significant effect of different weed management treatments on weed growth.

## RESULTS AND DISCUSSION

### Effect on weed flora

Both monocot and dicot weeds were observed but dominance of dicot weeds was more in entire field as observed earlier by Poornima *et al.* (2018). Major weed flora observed in the experimental field of barley during *Rabi* (winter) seasons of 2012-13 and 2013-14 were: *Chenopodium murale* L., *Asphodelus tenuifolius* cav., *Rumex dentatus* L., *Melilotus alba* Medik., *Spergula arvensis* L., *Cynodon dactylon* (L.) Pers., *Anagallis arvensis* L., *Convolvulus arvensis* L., *Heliotropium ellipticum* Ledeb., *Launaea aspleniifolia* (Willd.) Hook.f., *Cyperus rotundus* L., *Phalaris minor* Retz. and *Verbesina encelioides* (Cav.) A.Gray.

### Effect on weed density before and after herbicides spray

The differences in weed species wise and total weeds density were non-significant before application of treatments (**Table 1, 2** and **3**). However, after application of treatments, significantly lowest density of monocots (*Avena fatua, Phalaris* *minor*, *Cyprus rotundus* and others) and dicots (*Chenopodium album*, *C. murale*, *C. arvensis*, *Anagallis arvensis*, *Coronopus didymus*, *Rumex* and others) were recorded with hand weeding twice. Among the herbicide treatments, significantly lowest density of monocot and dicot as well as total weeds was observed with the application of isoproturon at 500 g/ha + 2, 4-D at 250 g/ha and isoproturon at 500 g + metsulfuron-methyl at 4 g/ha. The maximum weed density was recorded in weedy check during both the seasons. These results were in concurrence with the findings of Puniya *et al.* (2016).

**Weed biomass**

All the weed control treatments led to significant reduction in weed biomass of monocots and dicots than weedy check (**Table 4**). The lowest biomass of monocots (*Avena fatua*, *Phalaris minor*, *Cyprus rotundus*, others), dicots (*Chenopodium album*, *C. murale*, *C. arvensis*, *Anagallis arvensis*, *Coronopus didymus*, *Rumex* and others), total monocot, total dicot (4.35 g/m$^2$) and total weeds was observed in hand weeding twice. Among the herbicidal treatments, lowest weed biomass of monocot, dicot, total monocot and dicot as well as total weeds was recorded with isoproturon 500 g/ha + 2,4-D 250 g/ha followed by isoproturon 500 g + metsulfuron-methyl

**Table 1. Effect of weed control treatments on weed density (no./m$^2$) before spray in barley (pooled data of two years)**

| Treatment | Monocot weed | | | | Dicot weed | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Avena fatua* | *Phalaris minor* | *C. rotundus* | Others | *C. album* | *C. murale* | *C. arvensis* | *Anagallis arvensis* | *Coronopus didymus* | *Rumex* | Others |
| 2,4-D 250 g/ha at 30 DAS | 2.83 (7.54) | 2.61 (6.33) | 2.70 (6.78) | 2.52 (5.87) | 2.94 (8.16) | 2.81 (7.40) | 2.67 (6.65) | 2.62 (6.39) | 2.23 (4.47) | 1.86 (2.96) | 1.35 (1.31) |
| Isoproturon 500 g/ha at 30 DAS | 2.87 (7.74) | 2.64 (6.49) | 2.73 (6.96) | 2.55 (6.03) | 2.98 (8.38) | 2.85 (7.60) | 2.71 (6.83) | 2.66 (6.56) | 2.25 (4.58) | 1.88 (3.03) | 1.36 (1.35) |
| Isoproturon 500 g + metsulfuron-methyl 4 g/ha at 30 DAS | 2.84 (7.58) | 2.62 (6.36) | 2.71 (6.82) | 2.53 (5.90) | 2.95 (8.21) | 2.82 (7.44) | 2.68 (6.69) | 2.63 (6.42) | 2.23 (4.49) | 1.86 (2.97) | 1.35 (1.32) |
| Isoproturon 500 g/ha + carfentrazone 15 g/ha at 30 DAS | 2.86 (7.70) | 2.64 (6.46) | 2.73 (6.93) | 2.55 (6.00) | 2.97 (8.34) | 2.84 (7.56) | 2.70 (6.79) | 2.65 (6.52) | 2.25 (4.56) | 1.88 (3.02) | 1.36 (1.34) |
| Isoproturon 500 g/ha + 2-4-D 250 g/ha at 30 DAS | 2.85 (7.62) | 2.63 (6.39) | 2.71 (6.85) | 2.54 (5.93) | 2.96 (8.25) | 2.82 (7.48) | 2.69 (6.72) | 2.64 (6.46) | 2.24 (4.51) | 1.87 (2.99) | 1.35 (1.32) |
| Fenoxeprop-ethyl 75 g/ha at 25 DAS | 2.89 (7.86) | 2.66 (6.59) | 2.75 (7.07) | 2.57 (6.12) | 3.00 (8.51) | 2.87 (7.72) | 2.73 (6.93) | 2.68 (6.66) | 2.27 (4.66) | 1.89 (3.08) | 1.37 (1.37) |
| Hand weeding twice at 25 and 45 DAS | 2.89 (7.86) | 2.66 (6.59) | 2.75 (7.07) | 2.57 (6.12) | 3.00 (8.51) | 2.87 (7.72) | 2.73 (6.93) | 2.68 (6.66) | 2.27 (4.66) | 1.89 (3.08) | 1.37 (1.37) |
| Weedy check | 2.86 (7.66) | 2.63 (6.43) | 2.72 (6.89) | 2.54 (5.97) | 2.97 (8.29) | 2.83 (7.52) | 2.69 (6.76) | 2.64 (6.49) | 2.24 (4.54) | 1.87 (3.00) | 1.35 (1.33) |
| LSD (p=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses

**Table 2. Effect of weed control treatments on weed density after spray (50 DAS) in barley (pooled data of two years)**

| Treatment | Monocot weed (no./m$^2$) | | | | Dicot weed (no./m$^2$) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Avena fatua* | *Phalaris minor* | *C. rotundus* | Others | *C. album* | *C. murale* | *C. arvensis* | *Anagallis arvensis* | *Coronopus didymus* | *Rumex* | Others |
| 2,4-D 250 g/ha at 30 DAS | 1.81 (2.76) | 1.68 (2.32) | 1.73 (2.49) | 1.63 (2.15) | 1.85 (2.93) | 1.78 (2.65) | 1.70 (2.39) | 1.67 (2.29) | 1.45 (1.60) | 1.25 (1.06) | 0.98 (0.47) |
| Isoproturon 500 g/ha at 30 DAS | 1.92 (3.17) | 1.78 (2.66) | 1.83 (2.85) | 1.72 (2.47) | 1.96 (3.36) | 1.88 (3.04) | 1.80 (2.74) | 1.77 (2.63) | 1.53 (1.84) | 1.31 (1.22) | 1.02 (0.54) |
| Isoproturon 500 g + metsulfuron-methyl 4 g/ha at 30 DAS | 1.69 (2.36) | 1.57 (1.98) | 1.62 (2.12) | 1.53 (1.84) | 1.73 (2.50) | 1.66 (2.26) | 1.59 (2.03) | 1.57 (1.95) | 1.37 (1.37) | 1.18 (0.90) | 0.95 (0.40) |
| Isoproturon 500 g/ha + carfentrazone 15 g/ha at 30 DAS | 1.77 (2.64) | 1.65 (2.22) | 1.70 (2.38) | 1.60 (2.06) | 1.82 (2.80) | 1.74 (2.54) | 1.67 (2.28) | 1.64 (2.19) | 1.42 (1.53) | 1.23 (1.01) | 0.97 (0.45) |
| Isoproturon 500 g/ha + 2,4-D 250 g/ha at 30 DAS | 1.63 (2.15) | 1.52 (1.81) | 1.56 (1.94) | 1.48 (1.68) | 1.67 (2.28) | 1.60 (2.07) | 1.54 (1.86) | 1.51 (1.79) | 1.32 (1.25) | 1.15 (0.83) | 0.93 (0.37) |
| Fenoxeprop-ethyl 75 g/ha at 25-DAS | 1.86 (2.97) | 1.73 (2.49) | 1.78 (2.67) | 1.68 (2.31) | 1.91 (3.14) | 1.83 (2.85) | 1.75 (2.56) | 1.72 (2.46) | 1.49 (1.72) | 1.28 (1.14) | 1.00 (0.50) |
| Hand weeding twice at 25 and 45 DAS | 1.18 (0.89) | 1.12 (0.75) | 1.14 (0.80) | 1.09 (0.70) | 1.20 (0.95) | 1.17 (0.86) | 1.13 (0.77) | 1.11 (0.74) | 1.01 (0.52) | 0.92 (0.34) | 0.81 (0.15) |
| Weedy check | 2.78 (7.23) | 2.56 (6.07) | 2.65 (6.51) | 2.48 (5.63) | 2.86 (7.66) | 2.73 (6.95) | 2.60 (6.24) | 2.55 (6.00) | 2.17 (4.19) | 1.81 (2.77) | 1.32 (1.23) |
| LSD (p=0.05) | 0.13 | 0.12 | 0.14 | 0.09 | 0.15 | 0.11 | 0.11 | 0.12 | 0.09 | 0.06 | 0.03 |

Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses at 4 g/ha. This might be due to their effectiveness in reducing weed density and biomass due to better weed control. Bhullar *et al.* (2013) reported that the application of carfentrazone-ethyl or metsulfuron-methyl was effective in reducing density and biomass of broad-leaf weeds.

### Weed control efficiency

All the weed control treatments had significant effect on monocot and dicot weeds control efficiency (**Table 5**). Among the herbicide treatments, the maximum WCE of monocot, *viz*. *Avena fatua* (80.24%), *Phalaris minor* (80.22%), *C. rotundus* (80.23%), other monocot (80.22%) and dicot, *viz. C. album* (80.22%), *C. murale* (80.22%), *Anagallis arvensis* (80.23%), *Coronopus didymus* (80.22%), *Rumex* (80.24%) and other dicot (80.20%) was recorded with isoproturon at 500 g/ha + 2,4-D at 250 g/ha followed by isoproturon at 500 g + metsulfuron-methyl at 4 g/ha. Similarly, highest WCE of total monocot (80.24%), total dicot (80.23%) and total weeds (80.24%) was found with isoproturon at 500 g/ha + 2,4-D at 250 g/ha followed by isoproturon at 500 g + metsulfuron-methyl at 4 g/ha. This may be attributed to better weed management achieved with these treatments resulting in reduced weed density and biomass and improved WCE, which provided more space and resources to the crop as reported by Bhullar *et al.* (2013) and Ram *et al.* (2020).

**Table 3. Effect of weed management treatments on total monocot and dicot weeds density (no. m[2]) before and after spray of herbicides (pooled data of two years)**

| Treatment | Before spray | | | After spray (50 DAS) | | |
|---|---|---|---|---|---|---|
| | Total monocot weed | Total dicot weed | Total weeds (monocot+dicot) | Total monocot weed | Total dicot weeds | Total weeds (monocot+dicot) |
| 2,4-D 250 g/ha at 30 DAS | 5.20(26.52) | 6.15(37.14) | 8.02(63.86) | 3.20 (9.72) | 3.73 (13.39) | 4.86 (23.11) |
| Isoproturon 500 g/ha at 30 DAS | 5.26(27.22) | 6.23(38.33) | 8.13(65.55) | 3.41 (11.15) | 3.98 (15.36) | 5.20 (26.51) |
| Isoproturon 500 g + metsulfuron-methyl 4 g/ha at 30 DAS | 5.21(26.66) | 6.17(37.53) | 8.04(64.19) | 2.96 (8.29) | 3.45 (11.42) | 4.50 (19.71) |
| Isoproturon 500 g/ha + carfentrazone 15 g/ha at 30 DAS | 5.28(27.08) | 6.21(38.13) | 8.11(65.21) | 3.13 (9.29) | 3.65 (12.80) | 4.75 (22.09) |
| Isoproturon 500 g/ha + 2-4-D 250 g/ha at 30 DAS | 5.22(26.80) | 6.18(37.73) | 8.06(64.53) | 2.84 (7.58) | 3.31 (10.44) | 4.30 (18.02) |
| Fenoxeprop-ethyl 75 g/ha at 25 DAS | 5.30(27.64) | 6.28(38.92) | 8.19(66.57) | 3.31 (10.44) | 3.86 (14.37) | 5.03 (24.81) |
| Hand weeding twice at 25 and 45 DAS | 5.30(27.64) | 6.28(38.92) | 8.19(66.57) | 1.91 (3.14) | 2.20 (4.23) | 2.82 (7.47) |
| Weedy check | 5.24(26.94) | 6.20(37.93) | 8.08(64.88) | 5.09 (25.45) | 5.96 (35.04) | 7.81 (7.49) |
| LSD (p=0.05) | NS | NS | NS | 0.27 | 0.23 | 0.22 |

Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses

**Table 4. Effect of weed control treatments on weed biomass (g/m[2]) after spray (60 DAS) (pooled data of two years)**

| Treatment | *Avena fatua* | *P. minor* | *C. rotundus* | Other monocot | *C. album* | *C. murale* | *C. arvensis* | *Anagallis arvensis* | *Coronopus didymus* | *Rumex* | Other dicot | Total monocot | Total dicot | Total weed (monocot +dicot) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,4-D 250 g/ha at 30 DAS | 1.87 (7.23) | 1.74 (6.06) | 1.79 (6.50) | 1.69 (5.63) | 1.94 (7.83) | 1.86 (7.09) | 1.78 (6.38) | 1.75 (6.12) | 1.51 (4.28) | 1.30 (2.83) | 1.01 (1.26) | 3.33 (25.42) | 3.93 (35.79) | 5.10 (61.21) |
| Isoproturon 500 g/ha at 30 DAS | 1.90 (7.36) | 1.76 (6.17) | 1.82 (6.62) | 1.71 (5.73) | 1.97 (7.97) | 1.89 (7.21) | 1.80 (6.49) | 1.77 (6.24) | 1.53 (4.36) | 1.31 (2.88) | 1.02 (1.28) | 3.38 (25.88) | 3.99 (36.44) | 5.18 (62.33) |
| Isoproturon 500 g + metsulfuron-methyl 4 g/ha at 30 DAS | 1.86 (4.12) | 1.73 (3.46) | 1.78 (3.71) | 1.68 (3.21) | 1.93 (4.46) | 1.85 (4.05) | 1.76 (3.64) | 1.74 (3.49) | 1.50 (2.44) | 1.29 (1.62) | 1.01 (0.72) | 3.31 (14.50) | 3.90 (20.41) | 5.06 (34.91) |
| Isoproturon 500 g/ha + carfentrazone 15 g/ha at 30 DAS | 1.87 (5.40) | 1.73 (4.53) | 1.78 (4.86) | 1.68 (4.21) | 1.93 (5.85) | 1.85 (5.30) | 1.77 (4.77) | 1.74 (4.58) | 1.50 (3.20) | 1.29 (2.12) | 1.01 (0.94) | 3.31 (19.00) | 3.91 (26.75) | 5.07 (45.75) |
| Isoproturon 500 g/ha + 2-4-D 250 g/ha at 30 DAS | 1.79 (3.51) | 1.66 (2.95) | 1.71 (3.16) | 1.61 (2.74) | 1.85 (3.80) | 1.77 (3.45) | 1.70 (3.10) | 1.67 (2.98) | 1.45 (2.08) | 1.25 (1.38) | 0.98 (0.61) | 3.16 (12.32) | 3.72 (17.40) | 4.83 (29.75) |
| Fenoxeprop-ethyl 75 g/ha at 25 DAS | 1.90 (7.59) | 1.76 (6.37) | 1.81 (6.83) | 1.71 (5.91) | 1.97 (8.22) | 1.88 (7.46) | 1.80 (6.70) | 1.77 (6.44) | 1.53 (4.50) | 1.31 (2.98) | 1.02 (1.32) | 3.38 (26.71) | 3.99 (37.61) | 5.18 (64.32) |
| Hand weeding twice at 25 and 45 DAS | 1.75 (0.88) | 1.63 (0.74) | 1.68 (0.79) | 1.58 (0.68) | 1.81 (0.95) | 1.74 (0.86) | 1.66 (0.77) | 1.64 (0.74) | 1.42 (0.52) | 1.23 (0.34) | 0.97 (0.15) | 3.09 (3.09) | 3.63 (4.35) | 4.71 (7.44) |
| Weedy check | 1.97 (17.8) | 1.83 (14.9) | 1.88 (16.0) | 1.77 (13.8) | 2.04 (19.2) | 1.96 (17.4) | 1.87 (15.7) | 1.84 (15.1) | 1.58 (10.5) | 1.35 (6.97) | 1.04 (3.09) | 3.52 (62.5) | 4.16 (88.0) | 5.40 (150.6) |
| LSD (p=0.05) | 0.27 | 0.26 | 0.30 | 0.28 | 0.32 | 0.39 | 0.34 | 0.26 | 0.21 | 0.10 | 0.09 | 0.47 | 0.72 | 0.75 |

Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses

**Table 5. Effect of weed control measures on weed control efficiency (WCE %) after spray (60 DAS) (pooled data of two years)**

| Treatment | *Avena fatua* | *Phalaris minor* | *C. rotundus* | Other monocot | *C. album* | *C. murale* | *C. arvensis* | *Anagallis arvensis* | *Coronopus didymus* | *Rumex* | Other Dicot | Total monocot | Total dicot | Total weeds (Monocot +Dicot) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,4-D 250 g/ha at 30 DAS | 59.32 | 59.32 | 59.32 | 59.29 | 59.32 | 59.30 | 59.28 | 59.30 | 59.30 | 59.32 | 59.30 | 59.35 | 59.34 | 59.35 |
| Isoproturon 500 g/ha at 30 DAS | 58.58 | 58.59 | 58.58 | 58.54 | 58.60 | 58.54 | 58.53 | 58.57 | 58.57 | 58.58 | 58.55 | 58.60 | 58.60 | 58.60 |
| Isoproturon 500 g + metsulfuron-methyl 4 g/ha at 30 DAS | 76.81 | 76.78 | 76.80 | 76.78 | 76.81 | 76.79 | 76.77 | 76.79 | 76.80 | 76.81 | 76.78 | 76.81 | 76.81 | 76.81 |
| Isoproturon 500 g/ha + carfentrazone 15 g/ha at 30 DAS | 69.62 | 69.58 | 69.58 | 69.56 | 69.59 | 69.59 | 69.57 | 69.59 | 69.60 | 69.62 | 69.55 | 69.61 | 69.61 | 69.61 |
| Isoproturon 500 g/ha + 2-4-D 250 g/ha at 30 DAS | 80.24 | 80.22 | 80.23 | 80.20 | 80.22 | 80.22 | 80.22 | 80.23 | 80.22 | 80.24 | 80.20 | 80.24 | 80.23 | 80.24 |
| Fenoxeprop-ethyl 75 g/ha at 25 DAS | 57.28 | 57.26 | 57.27 | 57.22 | 57.29 | 57.22 | 57.27 | 57.28 | 57.22 | 57.28 | 57.23 | 57.27 | 57.27 | 57.28 |
| Hand weeding twice at 25 and 45 DAS | 95.06 | 95.06 | 95.06 | 95.06 | 95.06 | 95.05 | 95.06 | 95.06 | 95.06 | 95.06 | 95.06 | 95.06 | 95.06 | 95.06 |
| Weedy check | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| LSD (p=0.05) | 1.33 | 1.34 | 1.28 | 1.35 | 1.20 | 1.50 | 1.56 | 1.34 | 1.51 | 1.33 | 2.56 | 0.54 | 0.49 | 0.32 |

**Table 6. Effect of weed control treatments on nutrient content of weeds (pooled data of two years)**

| Treatment | N (%) | | P (%) | | K (%) | | N removal (kg/ha) | | Total N removal (kg/ha) | P removal (kg/ha) | | Total P removal (kg/ha) | K removal (kg/ha) | | Total K removal (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mono cot | Dicot | Monocot | Dicot | Monocot | Dicot | Monocot | Dicot | | Monocot | Dicot | | Mono cot | Dicot | |
| 2,4-D 250 g/ha at 30 DAS | 1.027 | 1.042 | 0.208 | 0.223 | 1.235 | 1.250 | 26.10 | 37.29 | 63.39 | 5.30 | 8.00 | 13.30 | 31.41 | 44.75 | 76.16 |
| Isoproturon 500 g/ha at 30 DAS | 1.031 | 1.046 | 0.209 | 0.224 | 1.240 | 1.255 | 26.67 | 38.10 | 64.77 | 5.41 | 8.17 | 13.58 | 32.08 | 45.74 | 77.82 |
| Isoproturon 500 g + metsulfuron-methyl 4 g/ha at 30 DAS | 1.040 | 1.055 | 0.211 | 0.226 | 1.251 | 1.266 | 15.07 | 21.52 | 36.59 | 3.06 | 4.61 | 7.67 | 18.13 | 25.83 | 43.96 |
| Isoproturon 500 g/ha + carfentrazone 15 g/ha at 30 DAS | 1.049 | 1.064 | 0.213 | 0.228 | 1.261 | 1.276 | 19.92 | 28.44 | 48.36 | 4.04 | 6.09 | 10.13 | 23.97 | 34.15 | 58.12 |
| Isoproturon 500 g/ha + 2-4-D 250 g/ha at 30 DAS | 1.067 | 1.082 | 0.216 | 0.231 | 1.283 | 1.299 | 13.18 | 18.82 | 31.99 | 2.67 | 4.03 | 6.70 | 15.85 | 22.59 | 38.45 |
| Fenoxeprop-ethyl 75 g/ha at 25 DAS | 1.089 | 1.104 | 0.221 | 0.236 | 1.310 | 1.325 | 29.09 | 41.53 | 70.61 | 5.91 | 8.88 | 14.78 | 35.00 | 49.83 | 84.83 |
| Hand weeding twice at 25 and 45 DAS | 1.088 | 1.104 | 0.222 | 0.235 | 1.310 | 1.324 | 3.36 | 4.80 | 8.16 | 0.68 | 1.02 | 1.71 | 4.05 | 5.76 | 9.81 |
| Weedy check | 0.985 | 1.001 | 0.200 | 0.215 | 1.185 | 1.200 | 61.58 | 88.10 | 149.67 | 12.50 | 18.95 | 31.45 | 74.07 | 105.66 | 179.73 |
| LSD(p=0.05) | 0.036 | 0.038 | 0.009 | 0.008 | 0.048 | 0.047 | 0.89 | 1.56 | 2.10 | 0.25 | 0.33 | 0.32 | 1.25 | 2.40 | 2.42 |

## Nutrient depletion by weeds

The nutrient contents (NPK) and their removal by monocot and dicot weeds was significantly influenced by different management practices (**Table 6**). The lowest removal of N, P and K and total nutrients by weeds was observed with hand weeding twice and it was on par with isoproturon at 500 g/ha + 2,4-D at 250 g/ha. The highest nutrients removal by monocots, dicots and total weeds was recorded in weedy check. The reduction in NPK depletion by weeds under the effective treatments might be due to the corresponding reduction in dry matter accumulation of weeds due to their effective weed control and smothering effect of crop exerted on weed growth. Greater biomass of weeds accumulated under weedy check might be due to higher nutrients depletion by fast growing weeds (Puniya *et al.* 2016).

## Yields and weed index

The hand weeding twice at 25 and 50 DAS resulted in highest grain (6.73 and 7.05 t/ha), straw (7.54 and 7.91 t/ha) and biological yield (14.27 and 14.96 t/ha) in both the years (**Table 7**). Weedy check registered the lowest mean grain, straw and biological yield. Among the herbicide treatments, isoproturon at 500 g/ha + 2,4-D at 250 g/ha has recorded maximum grain yield (6.28 and 6.58 t/ha), straw yield (7.03 and 7.38 t/ha) and biological yield (13.31 and 13.96 t/ha) with significantly minimum weed index (6.82) amongst the treatments tested. The higher yield in these treatments might be due to more availability of

**Table 7. Effect of weed control treatments on grain and straw yield of barley and weed index**

| Treatment | Grain yield (t/ha) | | Straw yield (t/ha) | | Biological yield (t/ha) | | Weed index (%) |
|---|---|---|---|---|---|---|---|
| | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | |
| 2,4-D 250 g/ha at 30 DAS | 5.64 | 5.91 | 6.30 | 6.62 | 11.95 | 12.53 | 16.14 |
| Isoproturon 500 g/ha at 30 DAS | 5.36 | 5.61 | 5.98 | 6.28 | 11.33 | 11.89 | 20.47 |
| Isoproturon 500 g + metsulfuron-methyl 4 g/ha at 30 DAS | 6.10 | 6.39 | 6.83 | 7.17 | 12.93 | 13.56 | 9.56 |
| Isoproturon 500 g/ha + carfentrazone 15 g/ha at 30 DAS | 5.93 | 6.21 | 6.61 | 6.94 | 12.55 | 13.16 | 12.00 |
| Isoproturon 500 g/ha + 2-4-D 250 g/ha at 30 DAS | 6.28 | 6.58 | 7.03 | 7.38 | 13.31 | 13.96 | 6.82 |
| Fenoxeprop-ethyl 75 g/ha at 25 DAS | 5.39 | 5.65 | 6.20 | 6.51 | 11.59 | 12.16 | 19.80 |
| Hand weeding twice at 25 and 45 DAS | 6.73 | 7.05 | 7.54 | 7.91 | 14.27 | 14.96 | 0.00 |
| Weedy check | 4.39 | 4.68 | 5.77 | 6.13 | 10.16 | 10.81 | 34.17 |
| LSD (p=0.05) | 0.48 | 0.40 | 0.45 | 0.50 | 0.62 | 0.47 | 5.83 |

nutrients and moisture as there was less competition between weeds and crop. Bhullar *et al.* (2013) reported that the application of carfentrazone-ethyl or metsulfuron-methyl effectively controlled the broad-leaf weeds and enhanced the grain yield of barley. Ram *et al.* (2020) reported highest grain yield in weed-free treatment which was at par with isoproturon 750 g/ha + 2,4-D 500 g/ha and pinoxaden 40 g/ha + carfentrazone 20 g/ha. Uncontrolled weeds competition in weedy check, caused an average 8-54% barley yield reduction compared to weed-free treatment. These findings were in concurrence with those of Ram and Singh (2009), Puniya *et al.* (2016) and Kumar *et al.* (2019).

It may be concluded that the combination of isoproturon 500 g/ha + 2,4-D 250 g/ha at 30 DAS and alternately, isoproturon at 500 g/ha. + metsulfuron-methyl 4 g/ha at 30 DAS can be used for effective weed control and higher productivity of barley.

## REFERENCES


Balyan RS and Malik RK. 1994. Chemical weed control studied in barley (*Hordeum vulgare* L.). *Indian Journal of Weed Science* **26**: 1–5.

Bhullar MS, Kaur S, Kaur T, Singh T, Singh M and Jhala, AJ. 2013. Control of broad-leaf weeds with post-emergence herbicides in four barley (*Hordeum* spp.) cultivars. *Crop Protection* **43**: 216–222.

Choudhary S, Yadav LR, Shivran AC and Puniya MM. 2014. Effect of fertilizers and manures with foliar application of iron on barley (*Hordeum vulgare* L.). *Green Farming* **5**(1): 41–45.

Gharde Y, Singh PK, Dubey RP and Gupta PK. 2018. Assessment of yield and economic losses in agriculture due to weeds in India. *Crop Protection* **107**: 12–18

Government of Rajasthan. 2020. *Fourth Advance Estimate Rabi and Kharif* 2019-20, Agriculture Statistics (Agriculture Department), Commissionerate of Agriculture, Rajasthan-Jaipur

Kumar S, Vivek, Rana NS, Kumar R, Naresh RK and Dhyani BP. 2019. Effect of weed and nutrient management on the growth and yield of barley (*Hordeum vulgare* L.) and associated weeds. *International Journal of Current Microbiology and Applied Sciences* **8**(2): 993–1001.

Kumar S, Bhattoo M, Punia SS and Singh S. 2010. Evaluation of pinoxaden in combination with 2, 4-D against complex weed flora in Barley. *Indian Journal Weed Science* **42**: 120–122.

Poornima S, Siva Lakshmi Y, Ram Prakash T and Srinivas A. 2018. Weed management through early post-emergence herbicides to improve productivity and nutrient uptake in barley. *Indian Journal of Weed Science* **50**: 82–84

Puniya MM, Yadav SS, Bajya DR and Kumar A. 2016. Influence of weed management and nitrogen fertilization on weed dynamics, nutrient depletion by weeds, productivity and profitability of barley (*Hordeum vulgare* L.) in hot semi-arid region of western India. *Indian Journal of Agricultural Sciences* **86**(9): 1151–1157.

Ram H, Walia US. and Brar HS. 2003. Investigation on the chemical control of weeds in irrigated barley (*Hordeum vulgare* L.). *Indian Journal Weed Science* **34**: 24–27.

Ram H and Singh A. 2009. Studies on efficacy of tank mix herbicides for the control of weeds in irrigated barley (*Hordeum vulgare* L.). *Indian Journal Weed Science* **41**: 167–171.

Ram H, Singh G, Gupta N and Dhaliwal SS. 2020. Control of mixed weed flora with different herbicides in barley. *Indian Journal of Weed Science* **52**(2): 138–142.

Yadav RK, Kumawat N, Singh A, Tomar IS, Singh M and Morya J. 2018. Bio-efficacy of new herbicides in mixture and alone on weed dynamic, yields and nutrient uptake of maize (*Zea mays* L.) under rainfed conditions. *Indian Journal of Agricultural Sciences* **88** (7): 1123–1128.