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Evaluation of integrated weed management on growth and yield of barley crop (*Hordeum vulgare* L.) in Eastern U.P

Shubham Singh, Beerbhadra Tripathi, Geetanjali Kumari, Jatin Kumar Singh and Sheetal Singh

Abstract

The experiment was carried out at the Agricultural Research Farm of National Post Graduate College Barhalganj, Gorakhpur, U.P. During *rabi* 2022-23. This experiment consisted of one barley variety BH-393 and 7 weed control treatments was laid-out in Randomized Block Design with 3 replications. There were eight main weed species (grassy-2, non-grassy-5 and sedges^{-1}) in the experimental field. Non-grassy weeds (*Anagallis arvensis, Chenopodium album, Melilotus indica, Lathyrus aphaca and Fumaria parviflora*) dominated over grassy weeds and sedges. At 30 days after sowing, the weed density and dry weight of weed almost similar under all weed control treatments whereas in later stages weed control treatments reduced the weed density and dry weight of weeds as compared to weedy check. The most effective weed control treatment was T_7.Each weed control treatment proved better than weedy check in enhancing growth, growth attributing characters, and yield attributing characters. The highest net returns were recorded under T_6 (sulfosulfuron 30 DAS + 2,4-D 40 DAS) and T_4 (sulfosulfuron 30 DAS), respectively.

Keywords: Crop protection, weed management, IWM, Eastern Uttar Pradesh, Gorakhpur

Introduction

Barley (*Hordeum vulgare* L.) is an ancient cereal crop belongs to the Poaceae (Gramineae) family. The most important use of barley as grain animal fodder source of fermentable material for beer and certain distilled beverages, and as a component of various health food. Barley chapattis is highly palatable and digestible as compared to the wheat. It does not contain gluten. Barley is very nutritious and rich source of vitamin B-complex and protein of superior quality as compared to corn and beans. Barley grain contains 12.5 percent moisture, 11.5 percent, 1.3 percent fat, 3.9 percent minerals and 69.6 percent carbohydrates. Globally barley was cultivated in nearly 49.00-million- hectare area with a production of 145.9 million metric tons ((Anonymous, 2022) [3]. In India, during 2021-22 barley occupied nearly 0.677 m ha-1 area producing nearly 1.67 million tons grains, with the productivity of 3046 kg ha^{-1} (Anonymous, 2022) [3]. However, during early nineties, due to economic liberalization, the industrial demand for barley increases and presently 25-30% of total barley produced is used in the manufacturing of malt extract, which is further utilized for brewing, distillation, baby foods, coco –malt drinks and medicinal syrups. Weeds are the most severe and widespread biological constraint to crop production and cause invisible damage till the crop is harvested. They compete with crops for soil moisture, nutrients, solar radiation and space, thus reduce the crop yield and degrade the quality of produce, besides raising cost of cultivation. Effective weed management practices are very important in crop production to maintain weed density below economic threshold level and to increase cropping intensity (Shrivastava, 2015) [29]. The weed flora associated with barley has been found with variation in different agro-ecological zones of the country. *Chenopodium album*, *Lepidium sativa*, *Anagallis arvensis* and other broad-leaved weeds, which also compete with crop causing yield reduction up to 25 percent. In India, these broad-leaved weeds are dominant in the wheat and barley. The minor weeds including *Lathyrus aphaca*, *Vicia sativa*, *Avena ludoviciana* and *Phalaris minor* (Singh *et al.*, 2003) [31]. Lack of effective weed control measures and basic knowledge of weed management in barley have emerged as one of the limiting factors in barley production. Hand-weeding was formerly a most widely used and effective method of weed control, but this practice was abandoned because its practical and economic feasibility is often limited by unfavorable climatic and soil conditions, unavailability of labor during critical period of weeding and also high wages of labor (Pandey *et al*., 2007) [24]. Historically hand weeding is proved to be the most effective method of controlling weeds as compared to chemical and mechanical methods (Ghosh *et al*., 1977) [14]. Though, hand weeding is very effective but it is tedious, time consuming and expensive. Due to continuous rains in rainy season weed control by hand weeding become more difficult. In such situations use of herbicides can take care of weeds right from the beginning of crop growth and increase wheat yields. Before the introduction of high yielding dwarf varieties, the barley crop was mostly infested with non-grassy weeds, which could easily be controlled by a spray of 2,4-D (Mukhopadhyay, 1980) [23]. Over a decade, isoproturon has been used to control grassy weeds continuously and optimum use of isoproturon led to herbicidal resistance particularly in Phalaris minor (Malik *et al*., 1995) [20, 22]. In India, during 1992- 93, *Phalaris minor* (canary grass) developed resistance against isoproturon due to continuous use of only this herbicide in the rice-wheat cropping system (Malik and Singh, 1995) [20, 22]. Continuous use of 2, 4-D for 13 years in rice-wheat cropping system buildup weed seed bank of *Rumex dentatus* and *Chenopodium album* L. in the soil. Therefore, herbicides with alternate mode of action are required to control broadleaved weeds in small grains including barley. Keeping the points in view the present investigation was laid out to evaluate the efficacy of different weed management practices in controlling weed, crop growth and their economics.

Materials and Methods

The present investigation was carried out at the Research Field of Department of Agronomy, National Post Graduate College, Barhalganj, Gorakhpur, Uttar Pradesh, during the year 2022-23. The experimental farm is situated at 26° 16' 45.3180'' N latitude and 83° 30' 47.7360'' E longitude and 71 meter (232.94 feet) elevation. The experiment was laid out in Randomized Block Design with three replications with seven treatments including weedy check. The treatments were T_1: Weedy check, T_2: Metribuzin (30 DAS), 0.5 kg ha^{-1}, T_3:2,4-D (40 DAS), 0.5 kg ha^{-1}, T_4: Sulfosulfuron(30 DAS), 0.33 kg ha^{-1},T_5: Isoproturon (30 DAS), 1.0 kg ha^{-1}, T_6: Sulfosulfuron +2,4-D (30+40 DAS),0.33 kg ha^{-1}+0.5 kg ha^{-1}, T_7: Weed free. The barley variety BH- 393 was sown in plot size of 5 m x 3 m, 20 cm spacing between the rows with 1 m distance between replication and 0.3 m between the plots on 12th November, 2022, seed rate of 100 kg ha^{-1}. The recommended fertilizer dose of urea, di-ammonium phosphate (DAP) and Murate of potash was applied at 105, 65.2 and 34 kg ha^{-1}. Half of the nitrogen and full dose of P and K was applied as basal dose at the time of sowing, while the remaining half dose of nitrogen was top dressed at the time of first irrigation. The data of crop stand was collected from each plot total number of barley plants metre^{-1} row length were counted and recorded at 15 DAS in the experimental field. Weed study was performed from Each plot in the experimental field was surveyed before herbicide application at randomly selected places by using 0.5 m^2 quadrate for studying weed flora composition in the field. List of weed species found during the period of investigation. The weed density was recorded at 30, 60, 90 DAS and at harvest. This was done by using 0.5 m^2 quadrate at randomly selected spots in each plot, averaged and finally weed count was expressed as number 0.5 m^2. Separate counts were recorded for major broad-leaved weeds present in experimental area. Weed dry matter was calculated by collecting weed samples for measuring weed dry matter accumulation studies and weed control efficiency at 30, 60 days after herbicides spray and at harvest. These samples were first sun-dried and then oven dried at 70 °C until constant weight. The final dry mass of broad-leaved weeds was recorded in g 0.5 m^2. Weed control efficiency and weed index were calculated by formulas at last of the materials and methods. Plant height was collected by collecting five randomly selected plants in each plot was measured at 30, 60, 90 DAS and at harvest from the soil surface to fully opened top leaf of the plant before ear emergence and up to the top of upper spikelet (excluding awns) at harvest and mean height was worked out in cm. Plant dry weight was calculated as similar to weed dry matter. Total number of tillers were counted from 0.5 metre row length in each plot before crop maturity. Related growth rate and crop growth rate formula at last of materials and methods. Yield and yield attributes were calculated at harvest on five randomly selected plants after threshing. The effective tillers, number of grains ear $^{-1}$, Grain weight ear $^{-1}$, ear length, test weight, grain yield, straw yield, biological yield, harvesting index was calculated. The data were subjected to square root transformation $\sqrt{x+0.5}$ to normalize their distribution. Economic analysis was performed for various treatments.

$$\text{WCE} \ \frac{\text{WCE-WDT}}{\text{WDE}} \times 100$$

Where, WDC = Weed biomass (g m^2) in control plot, WDT = Weed biomass (g m^2) in treated plot

Weed index (WI) was calculated using the formula:

$$\text{WI} \ \frac{X-Y}{X} \times 100$$

Where, X = Yield (kg ha^{-1}) from treated plot, Y = Yield (kg ha^{-1}) from control plot

Related growth rate (RGR) was estimated by using the formula:

$$\text{RER} \ \frac{\text{In W2-in W1}}{\text{T2-T1}}$$

Where,
RGR is expressed as g^{-1} day^{-1}
In = Natural logarithm
W_1 = dry weight of plant at time one (g)
W_2 = Dry
Weight of plant at time two (g)
T_1 = time one (in days), T_2 = time two (in days)

$$\text{HI (\%)} = \frac{\text{Grain yield (kg ha)}}{\text{Biological yield kg ha)}} \times 100$$

Results and Discussion

Weed Flora

Weed flora (species wise) of the experimental field were collected, identified and classified into different groups. There were eight main weed species (grassy-2, non- grassy-5 and sedges-1) and other weeds (not identified) in the experimental field (Table 1.). Non grassy weeds (Krishnaneel, Senji, Bathua & Gajri etc.) dominated over grassy weeds and sedges during the years. It was also deserved during the course of investigation, that the *Anagallis arvensis* was the most dominant weed and which constituted major part of weed flora throughout the crop growth period during the years: The next dominant weeds were *Melilotus spp*. and *Chenopolium album*. Further scanning of the clearly indicates that the weed flora composition changed at the later stage of the crop growth during the investigation. *Cyperus rotundus* constituted major part of the weed flora at the later stage that is at maturity during the years. Similar weed species have also been reported in northern plains of India by numerous workers (Bhardwaj and Verma, 1961; Kumar and Singh, 1996; Kumar *et al.*, 1997; Singh *et al*., 2002 and Chopra *et al*., 2008) [9, 17, 18, 33, 12].

Growth and weed studies

Data pertaining to weed density (m^{-2}) recorded in 2022-23 at different growth stages are presented in Table 1. A perusal of data revealed that weed control treatments caused significant differences in total weed density at all stages during the years. There were minimum differences in total weed density due to various weed control treatments at 30 days after sowing during the years. At 60 and 90 days after sowing, the highest total weed density (m^{-2}) was recorded under T_1 (weedy check) followed by T_3 (2, 4-D 40 DAS) at all stages of growth in the years. The lowest total weed density (m^{-2}) was observed under T_7 (Weed free) followed by T_4 (sulfosulfuron 30 DAS) as compared to other treatments during the years. In this investigation, it was also observed that the higher total weed density (m^{-2}) was recorded in year (2022-23) at all stages of growth of barley crop under all the weed control treatments. It may be due to the fact that herbicides were applied at 30 DAS. Therefore, there were nominal differences at 30 DAS. At 60 and 90 DAS the total weed density was reduced remarkable by the active action of these herbicides in suppressing weed growth. Similar results have also been reported by Kushwaha and Singh (2000) [19], Sharma (2003) [28] and Chhipa *et al.* (2005) [10]. The data pertaining to dry weight of total weeds as influenced by various weed control treatments at different stages in the years are presented in Table 1. Scanning of the table it is evident that significant differences in dry weight of total weeds were observed due to different weed control treatments at all the stages of growth of barley crop in the years. The dry weight of total weeds increased with increase in days after sowing up to 90 days after sowing and thereafter it decreased markedly during the years. The maximum dry weight of total weed was recorded in general at 90 days after sowing. Maximum dry weight of weeds at all stages were recorded in T_1 (weedy check) plots during the years. The dry weight of weeds was influenced significantly due to application of weed control measures at all stages of crop growth in comparison to weedy check. Scanning of the table the lowest total dry weight was observed under T_7 (Weed free) at 30, 60 and 90 days after sowing during the years. These results are in Agreement with the findings of Pandey (2002) [25, 26], Tiwari and Vaishya (2004) [34], Wani *et al.* (2005) [36], Malik *et al.* (2005) [21], Kumar *et al.* (2006) [16] and Singh *et al.* (2005) [32]. The data pertaining to weed control efficiency at various stage of crop growth are presented in Table 1. Weed control efficiency was significantly influenced by different weed control treatments at all the stages of crop growth during both the years. Highest weed control efficiency was recorded under T_7 (weed free) at all the stages of crop growth in the years. Out off our herbicides, application of sulfosulforon and metribuzin were observed to be highly effective in controlling weeds in wheat crop in both the years. It might be due to the rapid action of these herbicides reducing the weed density and dry weight of weeds and thereby weed control efficiency increased and weed index decreased. These results are in close conformity with the findings of Chhipa *et al*. (2005) [10] and Kumar *et al.* (2006) [16]. The data regarding weed index are presented in Table 1. A perusal of data reveals that weed control treatments caused significant differences in weed index in the years. The lowest weed index was noticed in T_7 (weed free) followed by T_4 (sulfosulfuron 30 DAS) during the years. The highest weed index was noticed under the effect of T_1 (weedy check) and T_3 (2, 4-D 40 DAS) during the years. It means that maximum reduction in grain yield was noticed under weedy check (T_1). The data pertaining to plant height of barley crop at different growth stages in the years are presented in Table 3. The scanning of the table clearly indicates that various weed controls treatments caused significant differences in plant height were clearly observed at 60 DAS in the years and at maturity in the year (2022-23) while, non-significant differences in plant height were noticed at 30 and 90 DAS in the years and at maturity. The highest plant height of barley crop was recorded under the influence of T_7 (weed free) at all the stages of growth in the years. The next better treatments were T_4 (sulfosulfuron 30 DAS) and T_5 (isoproturon 30 DAS) regarding plant height. The lowest plant height was observed under the influence of T_1 (weedy check) followed by T_5 (isoproturon 30 DAS) and T_3 (2, 4-D 40 DAS) at all the stages of growth in the years. The increase in plant height under these weed control treatments was due to less competition between crop and weeds. Similar results have also been reported by Satao and Padola (1994) [27]. It is evident from the Table 2 that significant differences in number of tillers per plant were observed at 60 and 90 DAS due to various weed control treatments during the years. However, the higher number of tillers per plant were observed at all stages of growth under the influence of T_7 (weed free), T_6 (sulfosulforon 30 DAS + 2,4-D 40 DAS) and T_2 (metribuzin 30 DAS) as compared to other weed control treatments during the years. The lowest number of tillers per plant were observed in T_1 (weedy check) followed by T_3 (2, 4-D 40 DAS) at all stages of growth in the years. In general, all the weed control treatments increased the number of tillers per plant at all stages of growth as compared to T_1 (weedy check). More number of tillers per plant were observed in the year (2022-23) at all stages of growth under all weed control treatments. It may be attributed to the fact that there was better availability of nutrients under these treatments which resulted in better tillering than weedy plots. These results are in accordance with the findings of Angiras and Sharma (1981) [2], Satao and Padola (1994) [27] and Pandey and Verma (2002) [25, 26]. The number of green leaves per plant recorded at different stages of crop growth are presented in Table 2. Weed control treatments exerted significant difference in number of green leaves per plant at all stages of growth during the years. The highest number of green leaves per plant were recorded under T_7 (weed free) followed by T_6

(sulfoslulfuron 30 DAS + 2, 4-D 40 DAS) and T_4 (sulfosulfuron 30 DAS) at all stages of crop growth during the year. The lowest number of green leaves per plant were noticed under T_1 (weedy check) as compared to other treatments at all stages of growth in the year. In this experiment it was observed that number of green leaves per plant increased up to 60 days after sowing and decreased with the age of plant i.e., 90 DAS in the years. It might be due to the fact that sufficient moisture and nutrient availability due to lesser weed density resulted in better growth under these weed control treatments. These findings are in conformity with the findings of Satao and Padola (1994) [27]; Banga and Yadav (2004) [6]. Dry matter accumulation in the plant is the resultant of all growth and yield attributes. Therefore, dry weight per plant increased significantly under T_7 (Weed free), T_6 (sulfosulfuron + 2, 4-D 40 DAS), T_4 (sulfosulfuron 30 DAS) and T_2 (metribuzine 30 DAS) at all stages, (weedy check) plot produced lowest dry weight per plant. This might be due to the more synthesis of food material in plants under low weed density conditions. Wani *et al.* (2005) [36] and Kumar *et al.* (2006) [16] also reported increase in dry matter production with the use of herbicides.

Yield parameters

The data pertaining to ears per m row are presented in Table 3. A perusal of the data clearly indicates that weed control treatments exerted significant differences in number of ears per m row in the years. The highest ears per m row were noticed under T_7 (weed free) followed by T_6 (sulfosulfouron 30 DAS + 2, 4-D 40 DAS) and T_4 (sulfosulfuron 30 DAS) in the years. The lowest ears per m row were recorded under T_7 (weedy check) followed by T_3 (2,4-D 40 DAS) and T_2 (metribuzin 30 DAS) in the years. It was also observed that each weed control treatment proved better than T_1 (weedy check) in enhancing ears per m row. The data presented in Table 3. Clearly indicate that weed control treatments caused non-significant differences in ear length during both the years. However, greater ear length was observed under T_7 (weed free) and T_6 (sulfosulfuron 30 DAS + 2, 4-D 40 DAS) than other weed control treatments in the years. The next better treatments were T_4 (sulfosulfuron 30 DAS) and T_2 (metribuzin 30 DAS). The shorter ears were noticed under T_1 (weedy check) in both the years. The data pertaining to grains per ear summarized in Table 3. From the table, it is evident that weed control treatments brought about significant differences in grains per ear in the years. Under T_7 (weed free) and T_6 (sulfosulfuron 30 DAS + 2,4-D 40 DAS), more number of grains per ear were produced than all the treatments. Lower number of grains per ear were observed in T_1 (weedy check). In this investigation, it was also observed that each weed control treatment proved better than T_1 (weedy check) in the year. The data presented in Table 3 clearly reveal that significant differences in grain yield per plant (g) due to different weed control treatments were observed during the years. The highest grain yield per plant was recorded under T_7 (weed free) followed by T_6 (sulfosulfuron 30 DAS + 2, 4-D 40 DAS) and T_4 (sulfosulsuron 30 DAS) in the years. The lowest grain yield per plant was noticed under T_1 (weedy check) during the years. Overall, all the weed control treatments proved better than T_1 (weedy check) in increasing grain yield per plant. The data pertaining to 1000 grain wt. are presented in Table 3. A perusal of the table reveals that non-significant differences in 1000-grain weight, due to various weed control treatments were observed during the years. However, the higher 1000 - grain weight was recorded under T_7 (weed free) and T_6 (sulfosulfuron 30 DAS + 2, 4-D 40 DAS) than the other weed control treatments in the years. The lowest 1000-grain Weight, was noticed under T_1 (weedy check).

The higher values of all the yield attributes under these weed control treatments might be due to the high weed control efficiency and low dry weight of weeds. As a result, moisture, space, light and nutrients were maximum available to the crop plants and hence, more values of all the yield attributes were noticed. Angiras and Sharma (1981) [2], Pandey (2002) [25, 26], Singh (2006) [30] and Bhardwaj *et al* (2004) [8] have also reported that use of herbicides enhanced the values of yield attributes as compared to weedy check. The data on biological yield are presented in Table 3. A perusal of data reveals that weed control treatments differed significantly regarding biological yield. The highest biological yield 139.65 was noticed under T_7 (weed free) followed by T_4 (sulfosulfuron 30 DAS) as compared to other treatments. The next better treatments were T_2 (metribuzin 30 DAS) and T_1 (isoproturon 30 DAS) regarding biological yield. The lowest biological yield 113.16 q/ha were observed under T_1 (weedy check). In this study, it was also observed that all the weed control treatments proved better than weedy check (T_1). The data pertaining to grain yield are presented in Table 3. It is evident from the table that weed control treatments had profound effect on weeds. The highest grain yield 53.71 qha^{-1} was observed under T_7 (weed free) followed by T_4 (sulfosulfuron 30 DAS) and T_2 (metribuzin 30 DAS). These treatments were significantly superior to weedy check (T_1). The lowest grain yield 40.42 qha^{-1} was recorded under T_1 (weedy check). In this investigations, it was clearly observed that application of sulfosulfuron and metribuzin was highly effective in controlling weeds as compared to 2, 4-D and isoproturon. In General, higher grain yield was observed in (weed free) under all weed control treatments. The straw yield (q ha^{-1}) data presented in Table 3. Clearly indicate that significant differences in straw yield were observed due to various weed control treatments. It is obvious that the highest straw yield 85.94 qha^{-1} was obtained from weed free plot (T_7). The next better weed control treatments were T_4 (sulfosulfuron 30 DAS), T_2 (metribuzin 30 DAS) and T_5 (isoproturon 30 DAS). The lowest straw yield 72.74 qha^{-1} was recorded under T_1 (weedy check). All the weed control treatments increased the straw yield to a greater extent as compared to weedy check (T_1). The data on harvest index are presented in Table 3. Significant differences in harvest index were observed due to weed control treatments. In this experiment, it was clearly observed that almost all the weed control treatments were significantly superior to weedy check (T_1) regarding harvest index. The lowest harvest index was recorded under T_1 (weedy check) as compared to other weed control treatments.

The higher biological yield, grain yield and straw yield under these weed control treatments are mainly due to the low weed density, low dry weight of weeds, high weed control efficiency and higher values of all the yield attributing characters as the yield is the resultant of co-ordinated inter play of growth characters and yield attributing characters. It means that integrated weed management in barley crop is more important in comparison to alone application of herbicides. These results are in close confirmity with the findings of Dixit and Bhan (1997) [13], Balyan *et al.* (2000) [5], Azad *et al*. (2003) [4], Walia *et al.* (2000) [35], Singh *et al.* (2003) [31], Chhokar *et al.* (2001) [11], Wani *et al*. (2005) [36] and Kaur *et al.* (2007) [15].

Economics

Economics of crop production is the most important aspect regarding the practical feasibility of treatments. The data pertaining to economics of different treatments presented in Table 4 clearly indicate that all the weed control treatments gave more net return over weedy check. In calculating the economics, the existing price of herbicides, labors, fertilizers, seeds and finally the produce was taken into consideration. It is evident from the data that the highest net return of Rs. 22,774.80 ha^{-1} under T_6 (sulfosulfuron 30 DAS +2, 4-D 40 DAS) was observed followed by Rs. 20,845.10 ha^{-1} under T_4 (sulfosulfuron 30 DAS). The lowest net return of Rs. 18,798.60 ha^{-1} was noticed under T_1 (weedy check). It was noted that manual weeding (weed free) was least effective as B:C ratio was minimum.

The better net return was mainly due to higher grain and straw yields to a greater extent. The weed free plot was not found to be economical as compared to these weed control treatments as the B:C ratio is minimum because of high expenditure involved in keeping the plots free from weeds. These results are in accordance with the findings of Ali and Bhanumurthy (1985) [1], Kushwaha and Singh (2000) [19] and Bharat and Kachroo (2007) [7].

Table 1: Effect of various treatments on total weed density (m^2), dry weight of total weeds (g/m^2), weed control efficiency (%) at different growth stage and weed index (%) of barley crop.

Treatment	Total weed density (m^2)			Dry weight of total weeds (g/m^2)			Weed control efficiency (%)		Weed index
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	(%)
T_1	17.69	16.48	14.53	3.50	7.51	6.30	1.73	1.73	5.16
T_2	17.57	11.48	10.44	3.47	6.33	5.26	5.82	5.70	3.71
T_3	17.70	11.60	10.55	3.48	6.61	5.41	5.45	5.01	4.07
T_4	17.55	11.36	10.36	3.47	6.36	5.21	5.94	5.59	3.45
T_5	17.60	11.56	10.46	3.48	6.56	5.33	5.53	5.08	3.76
T_6	17.77	10.97	10.02	3.44	6.16	5.11	6.18	5.96	2.80
T_7	1.73	1.73	1.73	1.73	1.73	1.73	9.96	9.98	1.73
S. Em. ±	0.26	0.12	0.11	0.11	0.20	0.21	0.10	0.10	0.04
CD (5%)	0.81	0.39	0.44	0.37	0.63	0.66	0.32	0.31	0.13
F-value	*	*	*	3.57	9.35	5.12	*	*	*

Table 2: Effect of various treatments on plant height (cm), number of tillers per plant, number of green leaves of barley crop at different growth stages.

Treatment	Total weed density (m^2)				Number of tillers $plant^{-1}$			Number of green leaves $plant^{-1}$		
	30 DAS	60 DAS	90 DAS	At maturity	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	32.35	68.65	104.55	111.60	3.20	5.00	6.50	10.15	21.45	17.95
T_2	33.55	74.30	107.30	115.55	3.75	5.95	8.30	11.70	25.15	22.30
T_3	33.10	71.75	106.50	114.60	3.48	5.50	7.40	11.35	23.75	20.65
T_4	33.10	75.75	107.45	115.55	3.60	6.30	8.30	12.05	25.20	22.80
T_5	33.50	73.45	106.55	114.40	3.35	5.85	7.80	11.70	24.25	21.50
T_6	32.40	78.45	110.30	119.60	4.00	6.85	9.30	12.40	27.40	24.45
T_7	36.50	83.50	119.50	125.65	4.35	8.40	10.40	13.50	32.80	29.55
S. Em. ±	0.22	0.20	0.20	0.23	0.01	0.03	0.01	0.10	0.05	0.03
CD (5%)	0.70	0.63	0.64	0.74	0.03	0.10	0.03	0.31	0.04	0.09
F-value	*	*	*	*	*	*	*	*	*	*

Table 3: Effect of various treatments on number of ears per m^{-1} row, ear length (cm), number of grains per ear, test weight (g) of grain (1000-grain weight) and biological yield (qha^{-1}), Grain yield (qha^{-1}), straw yield (qha^{-1}) and harvest index (qha^{-1}) of barley crop.

Treatment	Number of ears per m row	Ear length (cm)	Number of grains per ear	Test weight (g) of grains (1000-grains wt)	Biological yield (qha^{-1})	Grain yield (qha-1)	Straw yield (qha^{-1})	Harvest index (qha^{-1})
T_1	95.00	9.25	46.80	32.95	113.16	40.42	72.74	35.71
T_2	108.75	10.10	52.65	34.95	123.20	47.39	75.82	38.46
T_3	105.00	9.70	49.65	34.45	119.22	45.85	73.36	38.45
T_4	110.00	10.20	54.70	35.10	125.76	48.37	77.39	38.45
T_5	106.50	9.85	50.35	34.53	122.46	47.10	75.36	38.45
T_6	115.25	10.65	56.70	36.85	131.47	50.57	80.90	38.46
T_7	130.00	12.03	59.80	37.98	139.65	53.71	85.94	38.45
S. Em. ±	0.21	0.03	0.06	0.13	0.09	0.05	0.09	0.15
CD (5%)	0.68	0.11	0.18	0.40	0.06	0.17	0.28	0.48
F-value	*	*	*	*	*	*	*	*

Table 4: Economics of different treatments

Treatment	Grain yield (qha^{-1})	Straw yield (qha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio
T_1	40.42	72.74	31,624.50	95,182.70	63,558.20	2.00
T_2	47.39	75.82	32,324.50	1,07,810.65	75,486.15	2.33
T_3	45.85	73.36	31,984.50	1,04,308.75	72,324.25	2.26
T_4	48.37	77.39	31,744.50	1,10,040.95	78,296.45	2.46
T_5	47.10	75.36	32,424.50	1,07,152.50	75,728.00	2.33
T_6	50.57	80.90	32,104.50	1,15,041.95	82,937.45	2.58
T_7	53.71	85.94	38,624.50	1,22,191.85	83,567.35	2.16

Conclusion

On the basis of the results obtained in this study, the following conclusions are being drawn could be useful for both scientists and farmers. It has been observed that alone application of herbicides was not effective regarding growth and yields of crop but may be harmful to soil, plant and environment. Therefore, integrated weed management may be used in practice which is not only effective but economical too. For obtaining higher growth and yields of barley crop, use of sulfosulfuron @ 0.33 kg/ha^{-1} + 2,4-D 0.5 kg/ha^{-1} at 40 days after sowing and sulfosulfuron @ 0.33 kg/ha^{-1} at 30 days after sowing may be recommended under eastern U.P. conditions.

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