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EFFECT OF HERBICIDES ON GROWTH AND YIELD OF WHEAT (*TRITICUM AESTIVUM* L.)

Ajeet Singh[1], Siddharth Mishra[1], Beerbhadra Tripathi[1], Shubham Singh[1]*, Abhishek Singh[1], Jatin Kumar Singh[2] and Sudhanshu Shekhar[1]

[1]Department of Agronomy National Post Graduate College Barhalganj

Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, U.P., India

[2]Department of Entomology, G.B.P.U.A.T., Pantnagar, Uttarakhand-263145, India.

*Corresponding author E-mail: 20shubhamsingh@gmail.com

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ABSTRACT

The present experiment was conducted at the crop research farm, Department of Agronomy, NPGC, Gorakhpur during the *Rabi* season of 2022-2023. Wheat variety, DBW – 187 was sown with row-to-row spacing of 22.5cm. The experimental plan was laid out with the seven treatments which were replicated thrice in a plot size of 5m x 3m. The treatments were T1: Weedy check, T2: Weed-free, T3: Clodinafop propargyl 15wp @ 60g a.i ha^{-1}, T4: Metsulfuron methyl 20% WP @4.0 g a.i ha^{-1}, T5: Carfentrazone ethyl 40 DF @ 20g a.i ha^{-1}, T6: Sulfosulfuron 75 WG @ 25g a.i ha^{-1}, T7: Sulfosulfuron + metasulfuron methyl @32g a.i ha^{-1}. The major weeds of the experimental field were *Phalaris minor, Anagallis arvensis, Avena fatua, Chenopodium album* and other weeds viz., *Cynodan dectylon, convolvulus arvensis, Cichorium intybus, melilotus alba, vicia hirsute Rumex spp.,* and *Cyperus rotundus.* The highest number of tillers was recorded with the weed-free treatment at all stages of crop growth. While a minimum number of tillers was observed under weedy check treatment. Weed-free treatment recorded the highest test weight which was closely equal to over rest of the treatment. Test weight remained un-effected by the use of different herbicides. The highest grain yield was recorded under the weed-free treatment which was at par with Sulfosulfuron + Metsulfuron 30 + 2 g a.i. ha^{-1}. The highest straw yield was recorded under the weed-free treatment which was at par with Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1}. For biological yield, Carfentrazone ethyl 60 + 20 a.i. ha^{-1} and Sulfosulfuron 25 g a.i. ha^{-1} was significantly superior over the rest of the treatments. Harvest index remained un-effected by the use of different herbicides. The highest cost of cultivation was recorded under the weed-free treatment. Highest gross return and net return recorded under the treatment Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1}. The highest benefit-cost ratio was recorded with the treatment Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. $ha^{-1.}$

Keywords: Herbicide, Economics, Yield, Wheat, Triticum

Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop next to rice in India, about a 29-million-hectare area, contributing 37% to the total national food grain production. Wheat the ‘King of all Cereals’, occupies 17% of the world’s cropped area which adds 35% of the staple food and 20% of the calories (Chhokar *et al*.,2014). Wheat ranks first in area and production globally, among major cereals and it contributes more calories and proteins to the world’s human diet. Weed infestation is one of the major biotic factors limiting wheat production and productivity. Weed is a serious problem in crop fields. But this problem always remains underestimated in agriculture although they cause a higher reduction in the economic yield of crops than other pests and diseases. Yaduraju and Rao, 2013 reported that weeds roughly account for 37% of the total annual loss of agricultural produce in India. The losses caused by weeds depend on their types, abundance and environmental factors (Chhokar *et al*., 2012). The estimated yield loss worldwide caused by weeds varied between 7.7 to 23.9% depending on the region (Oerke, 2006; Kosina *et al*., 2021). Again, weeds tend to shift with the change in tillage, management, and cropping system although other factors govern the change in the weed flora. Weeds account for 0-80% yield reduction depending upon the weed species and infestation and cause depletion of soil water up to 6.5cm (Mehra and Gill.1988; Khera *et al*., 1995; Afentouli and Eleftherohorinos, 1996). In India wheat is infested with diverse weed flora, as it is grown under diverse Agro-climatic conditions, under different cropping sequences, tillage and irrigation regimes (Chhokar *et al*., 2012). Crop rotations, tillage and herbicides have pronounced effects on the type of weed flora (Anderson and Beck 2007; Chhokar *et al*., 2007). Other control measures are not found effective against weeds in wheat as due to morphological similarity and various other reasons Thus to control this weed, the application of herbicides is the most appropriate tool along with cost- and time effectiveness. However, the use of the same herbicide repeatedly develops selection pressure resulting resistant weed population. During 1991-92, the first case of herbicide resistance was testified in *P. minor* against isoproturon in India, which was due to the continuous use of isoproturon for more than a decade coupled with mono-cropping of a rice-wheat system (Malik *et al*., 1998; Brar and Walia, 2007; Singh and Singh, 2004). During 1997-98 recommendation of isoproturon was withdrawn due to large-scale crop failure and was replaced by clodinafop, sulfosulfuron, traloxydim and fenoxarop herbicide (Yadav *et al.,* 2006). These herbicides brought down the *P. Minor* infestation and restored the wheat yields (Yadav *et al.,* 2006). However, sole dependence on these herbicides led to the evolution of multiple resistance in *P.minor* in due course of time (Punia and Yadav, 2010). Also, some of the biotypes developed resistance to some new herbicides *viz.,* pinoxaden and mesosulfuron + iodosulfuron. As for now, multiple herbicide-resistant *P. Minor* is endemic causing significant yield reductions in the rice-wheat cropping system of IGPs and farmers having an infestation in wheat fields are facing noteworthy economic losses. At present, it is estimated that *P. minor* invades about 50% (15 mha) of the cultivated wheat areas in India. Of this area, the multiple herbicide-resistant *P. minor* affects about three m/ha of wheat (Chhokar *et al.,* 2019). The practice of herbicide mixtures is now endorsed worldwide as a part of a proactive herbicide-resistant weed management program. Cavan *et al.* (2000) mentioned that alternate herbicides with different mechanisms of action used in rotation resulted in delaying of development of resistance for up to 45 years, as shown in simulation modelling. Therefore, it is necessary to screen the available herbicides with different modes of action for determining the effective combination and implementation of herbicide rotation.

Materials and Methods

The experiment was conducted at the crop research farm, Department of Agronomy, National Post Graduate College, Barhalganj, Gorakhpur during the *Rabi* season of 2022-2023. The soil of the experimental field contains 35 % Sand, 49 % Silt and 16 % Clay. In prior years wheat in *rabi* and paddy in *kharif* season was grown. Wheat variety, DBW – 187 was sown with row-to-row spacing of 22.5cm. The experimental plan was laid out with the seven treatments which were replicated thrice in a plot size of 5m x 3m. The treatments were T1: Weedy check, T2: Weed-free, T3: Clodinafop propargyl 15wp @ 60g a.i ha^{-1}, T4: Metsulfuron methyl 20% WP @4.0 g a.i ha^{-1}, T5: Carfentrazone ethyl 40 DF @ 20g a.i ha^{-1}, T6: Sulfosulfuron 75 WG @ 25g a.i ha^{-1}, T7: Sulfosulfuron + metasulfuron methyl @32g a.i ha^{-1}. The sample for weed flora was collected from the fixed area of $0.25m^2$. The recommended package of agronomical practices was followed during the investigation. For the growth and yield data, five plants were randomly selected from each plot. The data for plant height, number of tillers and dry weight of the weeds were recorded at 30, 60, 90 and 120 DAS. The yield data as of the Number of effective tillers/plants, Number of spikes, Test Weight, Grain Yield (q/ha), and Straw Yield (q/ha) were recorded at harvest from the marked plants. The harvest index (%) was calculated with the following formula. Further economics and statistical analysis were performed.

$$\text{HI} = \frac{\text{Economics Yield}}{\text{Biological Yield}} \times 100$$

Where,

Economic Yield = Grain yield, biological yield

= Grain yield + straw yield

Result and Discussion

Weed flora

Weed flora of the experimental field was collected and identified at different stages of crop growth. The weeds are classified as grassy weeds, sedges and non-grassy weeds. There were several weed species recorded in the field. The major weeds of the experimental field were *Phalaris minor, Anagallis* *arvensis, Avena fatua, Chenopodium album* and other weeds viz., *Cynodan dectylon, convolvulus arvensis, Cichorium intybus, melilotus alba, vicia hirsute Rumex spp.,* and *Cyperus rotundus* (Table 1). The findings related to weed study are given as under: same result was recorded by Singh and Ghosh (1992) and Vaishya and Kumar (1993).

Total weeds (m^{-2})

The observations on total weed count recorded at different stages of crop growth as influenced by different herbicides are summarized in Table 2, indicating that the total weed population increased with increasing crop age up to 90 DAS, at 30 DAS minimum weed density with weed-free which was significantly lower than the rest of the treatments. All herbicides reduced the density of other weeds significantly over a weedy check at all the crop growth stages except 30 DAS where only weed-free treatment reduced weed significantly over the rest of the treatments. At 60 and 90 DAS weed-free gave the most effective control of weeds which reduced the density of total weeds. Among the herbicides combination of Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1} was found most effective for reducing the density of weed being at par with while significantly superior to the rest of the herbicides. whereas, maximum weed density was recorded with a weedy check. The lowest density of total weeds in Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1} treated plot was due to the broad-spectrum activity of herbicides against weeds. The same result was found by Chand and Puniya (2017) and Chaudhari *et al.* (2022).

Weed control efficiency (%)

The weed control efficiency of different herbicides was calculated, have been and presented in Table 2. Among treatments, the highest weed control efficiency was recorded under weed-free conditions (100%), whereas among herbicides combinations of Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1} recorded the highest weed control efficiency (86.25 %) followed by mean basis respectively. The post-emergence application of Sulfosulfuron+ Metsulfuron 25 + 4 g a.i. ha^{-1} exhibited higher weed control efficiency (WCE) after a weed-free treatment (WF). This was mainly due to the lowest density and dry weight of weeds under the respective treated plot. A similar finding was also reported by Choudhary *et al.* (2021).

Weed index (%)

The data presented in Table 2 reveals that the weed index which was denoted the per cent reduction in grain yield. Among the treatments, the average data of weed index indicates that maximum yield loss due to weed was recorded under the weedy check (33.84). Among treatments, the lowest weed index was recorded under weed-free treatment (0.00), whereas among herbicides combination of Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1} lowest weed index (2.28%) was recorded followed by Sulfosulfuron 25 g a.i. ha^{-1} (11.60%), Clodinafop 60 g a.i. ha^{-1} (14.45%), Metsulfuron 4 g a.i. ha^{-1} (19.77%) and Carfentrazone ethyl 20 g a.i. ha^{-1} (21.29%) at 90 DAS on a mean basis respectively. The post-emergence application of Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1} exhibited a lower weed index (WI) after a weed-free treatment (WF). This might be mainly due to lesser crop weed competition in herbicidal treatments and mostly nutrient divert to the crop plants as compared to weedy check results in higher yield and reduced weed index. These results in conformity by Choudhary *et al.* (2021).

Plant attributes

Initial plant population (m^{-2})

Data related to the initial plant population given in Table 2, indicate that the initial plant population was not influenced by weed management practices. However maximum initial plant population was recorded under weed-free treatment.

Plant height (cm)

Data refer to plant height given in Table 3 indicated that the plant height increased with advancement of the age and the rate of increase was more pronounced between at 30 to 90 DAS. Data further revealed that the different herbicides affect plant height significantly at all stages of crop growth except 30 DAS. Maximum plant height was recorded in weed-free treatment which was significantly higher than the rest of the treatments, while among herbicides combination of Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1} recorded the highest plant height, it was at par, Sulfosulfuron ethyl 25 + 20 g a.i. while significantly superior to the rest of the herbicides. whereas, the lowest plant height was recorded with the weedy check. The increase in plant height was due to greater availability of nutrients which result in profuse growth of plants at various growth factors. The results are in close agreement with those reported by Singh *et al.* (2013) and Sheoran *et al.* (2013).

Number of tillers (m^{-2})

Data related to the number of tillers (m^{-2}) given in Table 3 indicate that all treatments affect the number of tillers significantly at all stages of crop growth except 30 DAS. At 30 DAS maximum number of tillers was recorded in the weed-free treatment which was significantly higher than the rest of the treatments. At 60, 90 DAS and at harvest recorded a significantly higher number of tillers in weed-free over Sulfosulfuron 25 g a.i. ha^{-1}, Clodinafop 60 g a.i. ha^{-1}, Metsulfuron 4 g a.i. ha^{-1} and Carfentrazone ethyl 20 g a.i. ha^{-1}. Among herbicides maximum number of tillers recorded with Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1}, being at par with Clodinafop 4 g a.i. ha^{-1}, while significantly higher than the rest of the herbicides. This might be due to there being minimum crop-weed competition and better availability of nutrients under well-managed plot which resulted in a better number of tillers m^{-2} than other treatments. The results are concluded with the findings of Singh *et al.* (2005).

Leaf Area Index

The data related to leaf area index presented in Table 4 indicate that all herbicides affect leaf area index significantly at all stages of crop growth except 30 DAS. The leaf area increased with an increase in the stage of crop up to the 90-day stage and declined thereafter. Mainly due to senescence. Data further revealed that the maximum leaf area index was recorded in weed-free treatment at all stages. At 30 DAS maximum leaf area index (1.64) recorded in weed-free treatment was at par with the rest of the treatment. Whereas at 60 and 90 DAS maximum leaf area index (5.06) and (5.27) respectively were recorded under weed-free treatment which was at par with Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1}, Sulfosulfuron 25 g a.i. ha^{-1} and Clodinafop 60 g a.i. ha^{-1} while significantly higher than the rest of the treatments. Among herbicides, maximum leaf area index was recorded with Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{1} was at par with, Sulfosulfuron 25 g a.i. ha^{-1} and Clodinafop 60 g a.i. ha^{-1} while significantly higher than the rest of the herbicides. The better leaf area index with these treatments might be because sufficient moisture and nutrient availability due to less weed density resulted in better growth i.e.,leaf number and size leading to increased leaf area index. Better leaf area index with best highest weed control reported by Pandey and Kumar (2005).

Yield attributes

Length of spike (cm)

The data relating to the length of the spike of wheat are presented in Table 4 revealing that all treatments had a significant effect on the length of the spike (cm). the highest length of the spike (11.10 cm) was recorded with weed-free treatment which was at par with Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{1}, Clodinafop + Metsulfuron 60 + 4 g a.i. ha^{-1}, Sulfosulfuron + Carfentrazone ethyl 25 +20 g a.i. ha^{-1}, Clodinafop + Carfentrazone ethyl 60 + 20 a.i. ha^{-1} while significantly higher than the rest of the treatments. Among herbicides Sulfosulfuron+ Metsulfuron 25 + 4 g a.i. ha^{1} recorded the highest length of the spike (10.80 cm), it was at par with Clodinafop 20 a.i. ha^{-1} while significantly higher than the rest of the herbicides. The highest length of spike with these treatments might be because sufficient moisture and nutrient availability to crop plants due to less weed density resulted highest length of spike. The result was confirmed by Singh *et al.* (2003).

No. of grain spike^{-1}

The data related to No. of grains $spike^{-1}$ are presented in Table 4 indicating that all treatments had a non-significant effect on No. of grains $spike^{-1}$, however maximum No. of grains, $spike^{-1}$ (42.40) was recorded under weed-free treatment. While among herbicides Sulfosulfuron + Metsulfuron 30 + 2g a.i. ha^{1} recorded maximum No. of grains $spike^{-1}$ (42.20). It might be due to the smothering effect of respective herbicides. Which results in more translocation of food from source to sink their wise maximum number of grains $spike^{-1}$. These results are in close agreement with those reported by Singh *et al.* (2013) and Sheoran *et al.* (2013).

Test weight (g)

The data about the test weight (g) of wheat are presented in Table 4. The effect of different herbicides had a non-significant effect on the test weight (g) of wheat. However maximum test weight (38.85g) was recorded with weed-free treatment. Among herbicides Sulfosulfuron + Metsulfuron 30 + 2 g a.i. ha^{1} was recorded maximum test weight (38.78g). it might be due to less weed competition for different resources resulting in translocation of food from source to sink and it is a cumulative function of various growth parameters and yield attributes viz., number of tillers, grain $spike^{-1}$, length of spike and test weight. These results are in close agreement with those reported by Singh*et al.* (2013) and Sheoran *et al.* (2013).

Yield studies:

Grain yield

The data about the grain yield of wheat is presented in Table 5 indicates that all treatments had a significant effect on grain yield. The highest grain yield (52.60 q. ha^{-1}) was recorded under the weed-free treatment which was at par with Sulfosulfuron + Metsulfuron 30 + 2 g a.i. ha^{1}Metsulfuron60 + 4 g a.i. ha^{-1} and Sulfosulfuron 25 g a.i. ha^{-1} while significantly higher than the rest of the treatments. Among herbicides Sulfosulfuron+ Metsulfuron 30 +2 g a.i. ha^{1}

was recorded highest grain yield (51.40 q. ha^{-1}), which was at par with Clodinafop + Metsulfuron 60 + 4 g a.i. ha^{-1}, Sulfosulfuron 25 g a.i. ha^{-1} while significantly higher than the rest of the herbicides. It might be due to the smothering effect of respective herbicides, which resulted in more translocation of food from source to sink there more yield. similar result was also reported by Balyan *et al.,* (2000) and Singh *et al.* (2003).

Straw yield (q. ha^{-1})

The data interrelated to the straw yield of wheat presented in Table 5 indicate that all treatments had a significant effect on straw yield. The highest straw yield (77.60 q. ha^{-1}) was recorded under weed-free treatment which was at par with Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{1}, Sulfosulfuron ethyl 25 + 20 g a.i. ha^{-1} while significantly higher than the rest of the treatments. Among herbicides Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{1} recorded highest straw yield (75.90 q. ha^{-1}), which was at par with Clodinafop + Metsulfuron 60 + 4 g a.i. ha^{-1}, Carfentrazone ethyl 60 + 20 a.i. ha^{1} and Sulfosulfuron 25 g a.i. ha^{-1} while significantly higher than the rest of the herbicides. The above finding may be due to effective control of weeds which contributes to better growth parameters and yield attributes, better vegetative growth resulted in higher grain and straw yield. The same result was also concluded by Balyan *et al.,* (2000)and Singh *et al.* (2003).

Biological yield (q. ha^{-1})

Data related to biological yield is presented in Table 5 revealing that all treatments had a significant effect on the biological yield of wheat. The highest biological yield (130.20 q. ha^{-1}) was recorded under weed-free treatment which was at par with Sulfosulfuron + Metsulfuron 30 + 2 g a.i. ha^{1} Metsulfuron 60 + 4 g a.i. ha^{-1}, Carfentrazone ethyl 60 + 20 a.i. ha^{1} while significantly higher than the rest of the treatments. Among herbicides Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{1} recorded highest straw yield (75.90 q. ha^{-1}), it was at par with Sulfosulfuron + Carfentrazone ethyl 25 + 20 g a.i. ha^{-1}, and Sulfosulfuron 25 g a.i. ha^{-1} while significantly higher than the rest of the herbicides. This might be due to the effective weed control by such treatment enhanced growth and development resulting in more biological yield. The same result was also concluded by Balyan *et al*., (2000) and Singh *et al.* (2003).

Harvest index (%)

The data related to harvest index is presented in Table 4 disclosed that all treatments had a non-significant effect on the harvest index. However, the highest harvest index (40.40) was recorded under the weed treatment. Among herbicides Sulfosulfuron + Metsulfuron 30 + 2 g a.i. ha^{1} was recorded highest harvest index (40.38). It might be due to proper weed management increased the proportionate distribution of photosynthetic sink i.e., grain which resulted increased harvest index. the result was confirmed by the Singh *et al.* (2017).

Economics

Cost of cultivation (Rs. ha^{-1})

Among all treatments maximum cost of cultivation (Rs. 49454 ha^{-1}) found with weed free treatment whereas minimum under the weedy check treatment. It might be due to high expenditure involved in keeping the weed free plots, whereas in weedy check no need to removed weeds that's why low expenditure involved in that plot.

Gross return (Rs. ha^{-1}):

All treatments resulted higher gross return over weedy check. Data clearly disclosed that weed free treatment gave highest gross return (Rs. 144789 ha^{-1}) and minimum in weedy check (Rs. 97522 ha^{-1}). It might be due to highest yield (Grain yield, Straw yield and biological yield) achieved by weed free plot while lowest yield (Grain yield, Straw yield and biological yield) achieved by weedy check plot.

Net return (Rs. ha^{-1})

All treatments gave higher net return than weedy check. Maximum net return (Rs. 100037 ha^{-1}) recorded under the treatment (T7) Sulfosulfuron+ Metsulfuron 30 + 2 g a.i.ha^{-1} which was closely Sulfosulfuron + 25 g a.i. ha^{-1}. This might be due to less increase cost of cultivation with these treatments compare to weed free treatment. The same result was recorded by Meena *et al.* (2017), Chand and Punia. (2017) and Chauhan *et al.* (2017).

Benefit cost ratio (B:C Ratio)

All treatments had effect on the benefit: cost ratio. Maximum B:C Ratio (2.41) recorded under the treatment (T7) Sulfosulfuron+ Metsulfuron 30 + 2 g a.i which was closely to, Sulfosulfuron 20 g a.i. ha^{-1} Carfentrazone ethyl 60 + 20 a.i. ha^{1}. The weed free was not found to be economical in comparison to other herbicidal treatments because of high expenditure involved in keepings the weed free of plots. In the herbicides the better net return and net return per rupee investment was mainly due to less increase in cost of cultivation with these treatments compare to weed free. The result concluded by Meena *et al.* (2017), Punia *et al.* (2017) and Chauhan *et al.* (2017).

Table 1: Weed flora of experimental crop in weedy check treatment

A.	**Grasses**			
	Weed species	**Common name**	**Family**	**Habitat**
1.	*Phalaris minor* L.	Canary grass	Poaceae	Annual
2.	*Cynodon dactylon*	Bermuda grass	Poaceae	Perennial
B.	**Sedges**			
1.	*Cyperus rotundus*	Nutsedge	Cyperaceae	Perennial
C.	**Broadleaf weeds**			
1.	Chenopodium album L.	Lambs quarter	Chenopodiaceae	Annual
2.	*Anagalis arvensis* L.	Blue pimpernel	Primulaceae	Annual
3.	*Cichorium intybus*	Blue dandelion,chicory	Asteraceae	Perennial

Table 2: Effect of different herbicides on total weed density (m^{-2}) of timely sown wheat at different growth stage.

Treatments	Total weed (no. m^{-2}) Day after sowing			Weed control efficiency	Weed index (%)	Initial plant population
	30 DAS	60 DAS	90 DAS			
T1	11.28 (127.0)	12.98 (168.4)	13.93 (193.4)	100	0	157.9
T2	0.71 (0.00)	0.71 (0)	0.71 (0)	0	33.84	163.1
T3	10.92 (119.0)	8.27 (68)	8.81 (77.3)	61.95	14.49	162.1
T4	11.02 (121.0)	9.10 (82.3)	9.38 (87.6)	54.71	19.77	162.0
T5	11.14 (124.0)	9.32 (86.4)	9.70 (93.8)	51.51	21.29	161.8
T6	10.51 (110.0)	4.78 (22.4)	5.20 (26.6)	86.25	2.28	162.8
T7	10.83 (117.0)	8.17 (66.3)	8.60 (73.6)	68.04	11.60	162.3
Sem±	0.10	0.17	0.08	0.10	0.21	0.23
CD (P ≥ 0.05%)	0.33	0.54	0.26	0.33	0.67	0.72

* The value in parenthesis is original value
**value transformed by $\sqrt{x+0.5}$

Table 3: Effect of different herbicides on initial plant population and plant height of timely sown wheat.

Treatment	Plant height (cm)				Number of tillers (m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T1	22.5	59.1	67.5	69.60	165.8	259.49	260.79	254.40
T2	23.3	89.4	102.	105.2	1.71.33	241.99	343.70	335.29
T3	23.1	76.5	87.3	90.00	170.23	304.53	306.05	300.00
T4	23.1	71.7	81.8	84.40	170.14	287.13	288.57	281.50
T5	23.1	70.3	80.3	82.80	169.96	283.87	284.79	277.81
T6	23.2	87.3	99.7	102.8	171.2	363.31	338.06	329.79
T7	23.1	79.0	90.2	93.00	170.45	312.75	314.31	306.62
SEm±	0.02	0.07	0.23	1.13		0.29	0.34	1.03
CD at 5%	0.06	0.21	0.73	3.54		0.93	1.06	3.21

Table 4: Effect of different herbicides on leaf area index at different growth stage of timely sown wheat.

Treatments	Leaf area index			No. grain of spike(m^{-2})	Length of spike(cm)	Test weight(g)	Harvest index (%)
	30 DAS	60 DAS	90 DAS				
T1	1.55	3.34	3.45	242.29	7.80	37.60	39454
T2	1.64	5.06	5.27	319.32	11.10	38.85	49454
T3	1.61	4.30	4.68	284.34	9.50	38.60	40554
T4	1.61	4.06	4.22	268.10	8.90	38.58	40504
T5	1.60	3.99	4.16	264.58	8.70	38.54	40154
T6	1.63	4.94	5.15	314.08	10.80	38.78	41484
T7	1.62	4.35	4.75	292.02	9.80	38.65	40434
Sem±	0.01	0.07	0.09	0.05	0.03	0.05	0.02
CD(P≥ 0.05%)	0.00	0.21	0.28	0.18	0.11	0.16	0.08

Table 5: Effect of different herbicides on yield and economics of timely sown wheat.

Treatments	Grain yield	Straw yield. ha^{-1}(q)	Biologicalyield (q. ha^{-1})	Total cost (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C Ratio
T1	52.6	77.6	130.2	97522	58068	1.47	40.4
T2	34.80	54.8	89.6	144789	95335	1.92	38.8
T3	44.23	67	112	124175	83621	2.06	40.1
T4	42.20	62.9	105.10	116483	75979	1.87	40.1
T5	41.40	61.85	103.25	114346	74192	1.84	40.1
T6	51.40	75.90	127.3	141521	100037	2.41	40.3
T7	46.50	69.2	115.7	124797.5	84362.5	2.09	40.1
Sem±	0.10	0.03	0.04	-	-	-	-
CD ($P \geq 0.05\%$)	0.32	0.11	0.13	-	-	-	-

Conclusion

Weed-free was found to be most effective in controlling weeds and better for crop growth, yield attributes, and wheat yield. Among herbicides post-emergence application of Sulfosulfuron+ Metsulfuron 30 + 2 g a.i. ha^{-1} which was found most effective in controlling weeds and better for crop growth, yield attributes and yield of wheat. The highest nutrient (N, P and K) uptake by wheat recorded under the weed-free treatment was followed by the Sulfosulfuron + Metsulfuron (30 + 2 g ha^{-1}) and the highest nutrient (N, P and K) removed by weeds under treatment weedy check followed by the Carfentrazone. The highest net return (□100037 ha^{-1}) and B: C (2.41) ratio recorded under the treatment (T7) Sulfosulfuron + Metsulfuron (30 + 2 g ha^{-1}). Thus Sulfosulfuron + Metsulfuron (30 + 2 g ha^{-1}) may be recommended for better weed control and higher wheat yield.

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