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Effect of different herbicidal weed management practices in wheat (*Triticum aestivum* L.)

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Abstract
A trail consisted 8 treatments *viz.*, VESTA 500 g ha^{-1} (Clodinafop 15%+ Metsulfuron methyl 1%,75+5 g), Atlantis 400 g ha^{-1} (Mesosulfuron 3%+ Iodosulfuron 0.6%, 12 + 2.4 g), Total 40 g ha^{-1} (Sulfosulfuron 75%+ Metsulfuron methyl 5%, 32 g), Accord plus 1250 g ha^{-1} (Fenoxaprop 7.77% + Metribuzin 13.6%,100+175 g), Clodinofop (60 g ha^{-1}), Sulfosulfuron (25 g ha^{-1}), Weed free and Weedy check was arranged out in randomized block design with 3 replications at agriculture research farm of the University during *Rabi* 2018-19. All of the herbicides were showered as a post-emergence treatment after 32 days of broadcasting with flat fan nozzled Knapsack sprayer using 500 litres water per hectare. The most common documented weed species were *Phalaris minor*, *Chenopodium album*, *Melilotus alba, Anagallis arvensis, Rumex spp, Coronopus spp, Convolvulus arvensis Cynodon dactylon Vicia hirsuta Lathyrus aphaca and Cyperus rotundus.* The post-emergence utilization of VESTA (500 g ha$^{-1)}$ followed by Accord plus (1250 g ha^{-1}) was perceived to be most cost effective ready mixed weedicides for the weed management in wheat cultivation during *Rabi* season.

Keywords: Post-emergence, ready mixed herbicides, wheat

Introduction
Wheat (*Triticum aestivum* L.), being dubbed as the "King of Cereals", is a staple food globally. The situation is devoted over 220 million hectares acreage, making its yearly production about to 764.4 million tonnes with averaging 3.53 tonnes ha^{-1} in productivity from 2019 to 2020 (USDA, 2020) [8]. India ranks as the second-largest producer of wheat in the world because of its diversified agro-ecological conditions. With a productivity of 3.44 tonnes per hectare, it is farmed over a surface area of 31.62 million hectares and produces 108.75 million tonnes. According to FAO (2013), the global demand of wheat will increase to about 900 million tonnes by the year 2050. In contrast to its current estimated production of 109.24 million tonnes, it has been estimated that India will require at least 140 million tonnes of wheat by 2050. (Business Standard, PTI, New Delhi, Feb., 24, 2021). Using the cereal-cereal (rice-wheat) farming system, seeding the crop late, managing weeds ineffectively, unbalanced fertilisation, and other factors could be to blame for the low productivity of wheat. Weeds are a big reason for low productivity, which can lead to yield losses of between 3 and 50% (Chhokar *et al*., 2012) [1] and 15 to 50% (respectively) depending on the kind and strength of the weed flora (Jat *et al*., 2003) [3]. The *Avena fatua, Phalaris minor, Anagallis arvensis, Chenopodium album, Convolvulus arvensis, Cyperus rotundus, Lathyrus aphaca, Cynodon dactylon Avena sterilis, Phalaris brachystachys, Alopecurus myosuroides Huds., Lolium multiflorum, Poa annua, Sinapis arvensis, Galium tricornutum, Ranunculus arvensis, Geranium dissectum, Cirsium arvense*, etc. species of weeds are common in wheat fields (Singh *et al*., 2004; Yadav *et al*., 2009; Dheer *et al*., 2021) [7, 10, 2], which reduce wheat production by 33% on their own. One of the most damaging problems with wheat in this system is *Phalaris minor*, which results in a crop loss of almost 100%. Some weeds with broad leaves are also a threat, but they're easier and more effective to control than *Phalaris minor*. Haryana and western Uttar Pradesh identified Isoproturon-resistant *Phalaris minor* in the 1990s. Later, Sulfosulfuron, Clodinafop, and Fenoxaprop were advised to control *Phalaris minor* in wheat. These chemicals no longer kill this weed plant as of 2010. Broad-leaved weeds are proliferating in wheat fields as a result of the persistent application of grassy weed killer chemicals. Finding chemicals that can control both grassy and wide foliage weeds is crucial in this scenario.

In order to eliminate grassy and broad-leaved weeds, ready-mixed herbicides with excellent efficacy at lower dosages have been created. When killing weeds, these substances could be more efficient and less harmful (Kushwaha *et al*., 2023) [4]. In light of these facts, the current study was conducted to standardise affordable Ready-Mixed herbicide (s) that would help manage overall weeds and result in a greater wheat yield.

Material and Methods

Experimental site

The trial site is located at an elevation of 126 metres above mean sea level, with a latitude of approximately 26.57º North and a longitude of approximately 80.21 º East. The test soil was a sandy loam with a pH of 7.4, 0.46 dSm^{-1} EC, 0.53% organic carbon, 138.2 kg ha^{-1} of readily available nitrogen, 14.7 kg ha^{-1} of readily available phosphorous, and 225.7 kg ha^{-1} of readily available potassium.

Preparatory tillage

In the experimental field, a pre-sowing irrigation technique known as Palewa was implemented with the intention of achieving the ideal level of moisture required for the seeds to germinate effectively. After the field had been turned over once with a tractor-drawn soil turning plough, it was then cross-harrowed with the assistance of a cultivator to achieve the desired tilth. After that, the field was planked to level it and provide fine tilth, which are both necessary for successful germination. On November 17, 2021, following the completion of the land preparation, the experiment's layout was carried out.

Treatments and their application

The trial consisted 8 treatments *viz*., T_1 = VESTA 500 g ha^{-1} (Clodinafop 15%+ Metsulfuron methyl 1%,75+5g), T_2 = Atlantis 400g ha^{-1} (Mesosulfuron 3%+ Iodosulfuron 0.6%, 12 + 2.4g), T_3 = Total 40 g ha^{-1} (Sulfosulfuron 75%+ Metsulfuron methyl 5%, 32g), T_4 = Accord plus 1250 g ha^{-1} (Fenoxaprop 7.77% + Metribuzin 13.6%,100+175g), T_5 = Clodinofop (60g ha^{-1}), T_6 = Sulfosulfuron (25g ha^{-1}), T_7 = Weed free and T_8 = Weedy check was laid out in randomized block design with 3 replications at agriculture research farm of the University during *Rabi* 2018-19. With the use of a manually operated, flat fan-equipped knapsack sprayer, all of the herbicides were applied as a post-emergence treatment after 32 Days of seed germination. Per hectare, 500 litres of water were used.

Variety and sowing

The C.S.A.U.A.&T., Kanpur-developed wheat variety K 1006 was utilised. For the cultivar to mature, it takes about 120–130 days. A 100 kg ha-1 seed rate was planted in each treatment at the same intervals. On November 18th, 2018, uniform and healthy wheat seed of variety K 1006 was sown in a plot of 5 m × 4 m at a distance of 20 cm.

Fertilizers and irrigation

Fertilizers @ 120 kg N, 60 kg $P_2O_5$and 40kg K_2O ha^{-1} were broadcasted. Before sowing, the soil received half a nitrogen dose, full phosphate, and potash. At tillering and boot phases, 50% nitrogen was aired. Four irrigations were added.

Observations recorded

In order to measure the impact of numerous weed management trials, observations happening the crop besides the weeds were made at various phases of the crop's growth. As a result of the fact that it was not possible to analyse all of the plants in the experimental population, samples from each plot were picked at random and tagged so that they might be used in further research.

Weed flora of the experimental plot

Weed species were collected from three locations chosen at random on the 30th, 60th, 90th and 120th days after seeding from the weedy check plot were collected and documented.

Weed density

Weed species as well as total numbers were recorded from three random locations within each plot at the 30th, 60th, 90th, and 120th days after sowing While recording the weed density, a quadrate with dimensions of 50 cm × 50 cm was employed. Weeds contained within the quadrate were counted, and the result was reported as a number of weeds per square metre.

Weed dry weight

The dry matter of the weed was measured at the 30th, 60th, 90th, and 120th DAS in each plot at three different locations that were chosen at random. After being dried in the sun, the weeds were placed in an oven with heated air at a temperature of 70 ± 1 degrees Celsius until a constant weight was achieved.

Nitrogen uptake by weeds and crop

Nitrogen content was analysed using the micro Kjeldahl method (Jackson, 1973) after the weed samples had been oven-dried, thoroughly crushed, and extensively digested. In order to calculate the amount of nitrogen that was removed by weeds, the percentage of nitrogen content was multiplied by the respective total dry weight of the weeds.

$$\text{N uptake (kg ha}^{-1}) = \frac{\%\text{ N content} \times \text{Yield (kg ha}^{-1})}{100}$$

Nitrogen uptake by crop was also estimated through taking the nitrogen content in grain and straw, then multiplying that value by the grain yield and the straw yield, respectively.

Weed control efficiency

Based on the dry weight of the weeds, the following formula was used to regulate the efficacy of various weed management methods:

$$\text{W.C.E.}(\%) = \frac{W_0 - W_1}{W_0} \text{ x } 100$$

Where,

W_0 – Weed dry weight in weedy check plot

W_1 – Weed dry weight in treated plot

Weed index

The weed index for each of the several weed control strategies was calculated using the method shown below:

$$W.I. = \frac{Y_{wf} - Y_t}{Y_{wf}} \times 100$$

Where,
Y_{wf} – Grain yield of weed free plot
Y_t = Grain yield of treated plot

Plant height (cm)
The height of the main plant is tagged at 30th, 60th, 90th, and harvest stages. The plant's height was measured twice with a metre scale: once from the ground to the tip of the highest leaf before the ear appeared and again from the ground to the base of the ear after the ear developed. The plant height averaged cm.

Leaf area index
The plants were gathered with a row length of 20 cm to determine the leaf area index, and their green leaves were dissected to measure their surface area using an automated leaf area metre. Small, medium, and big leaves were sorted. Five random leaves from each group had their surface areas measured. The total leaf area was calculated by multiplying the average leaf area of five leaves by the number of leaves in each group. The LAI equation was:

$$LAI = \frac{L}{A}$$

LAI	-	Leaf area index
L	-	Leaf area (cm^2)
A	-	Land area (cm^2)

Dry matter accumulation
The buildup of dry matter was measured at the 30th, 60th, and 90th stages, as well as at harvest time. In order to accomplish this, the plant shoots that made up one metre of row length were trimmed down to a level that was somewhat close to the ground and then placed in paper bags. The samples were completed in an oven with hot air at a temperature of 70+ 1 degrees Celsius after being sun-dried in order to produce a constant weight. The figures of the plant's dry weight were computed in terms of grams per square metre.

Number of effective tillers
At harvest, the number of effective shoots that borne the spike were counted from the one metre row length that was marked (marked with sticks) in each plot for the various growth trials, and then the average of those counts was calculated.

Spike Length
Following the collection of ten ear heads from the plants that had been tagged in each plot, the length of each ear head was measured in centimetres. A calculation was made to determine the typical length of the ear head.

Number of spikelets spike^{-1}
Number of spikelets from the ten spikes for each plot were selected to compute the spikelet per spike and average was computed.

Number of grains spike^{-1}
The grains were separated, cleaned, and counted from the 10 wheat spikes that were chosen, and the average number of grains per spike was calculated.

Test weight (1000-grain weight)
Following the threshing and weighing of the grain, a representative sample of the grain yield from each plot was chosen at random. A random count of one thousand grains was performed on this sample, and the total weight of those grains, in grams, was noted.

Biological yield
Product was sun dried for a week after the crop was harvested, after which the weight of all the product collected from the net plot area of each plot was recorded and converted to q ha^{-1}.

Grain yield
After determining biomass weight, each net plot's crop was threshed, sorted, and sun-dried to 12%. The data were subsequently converted to kilogrammes ha^{-1} after tracking the grain yield in kg $plot^{-1}$.

Harvest index
The harvest index is the economic yield divided by the biological yield.

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} x100$$

Cost of cultivation (Rs. ha^{-1})
We added all of the costs spent during the cultivation of the experimental crop to the common costs that arose from the multiple activities and inputs that were used for estimating the cost of growing different treatments. As a consequence, the price of cultivation for each treatment was calculated.

Gross return (Rs. ha^{-1})
The grain yield and straw yield for each of the various treatment combinations were multiplied by the cost of the corresponding good on the market to get the gross return. The monetary worth of the grain and the value of the straw were combined to determine the gross return.

Net return (Rs. ha^{-1})
The gross return of each distinct treatment combination was subtracted from the cultivation cost, and the net return was calculated.

Net return = Gross return – Cost of cultivation.

Benefit-cost ratio
We divided the net return by the total cost of cultivation to arrive at the benefit-cost ratio for each specific treatment.

$$B:C = \frac{\text{Net return (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

Data transformation
Data transformation is used to build a new data set that is anticipated to meet the requirements of homogeneity of variance since it is the most suitable corrective technique for variance heterogeneity. This is due to the functional relationship between the variance and mean values in the new

scale, which creates a new collection of data. The data on the population of the various weed species and their dry matter were assessed after the square root transformation was used ($x = \sqrt{x + 0.5}$). Comparisons between the treatments were made at a 5% level of significance.

Statistical analysis

The following method for randomised block design (RBD) was used to statistically assess the data pertaining to the numerous observations. The standard error of the means was determined for each aspect of the research, and the least square differences (LSD) at a 5% level of significance was found out in order to comparison between the treatment means in cases in which the 'F' test yielded a positive result.

Results and Discussion

Weed flora

At various phases of crop development, the weed flora of the trial field was recognized and enumerated (Table-4.1) in the weedy check plot. In the experimental area, the most occurring weed species were *Phalaris minor* among the grasses and *Melilotus alba*, *Chenopodium album*, *Anagallis arvensis*, *Coronopus spp*, *Rumex spp* and *Convolvulus arvensis* among the broad-leaved weeds. *Convolvulus arvensis* was the most common of the broad-leaved weeds. A number of scientists working in various agro-climatic zones of the country have identified similar weed flora in wheat crops cultivated under normal sowing condition (Jat *et al*., 2003; Singh *et al*., 2004; Dheer *et al*., 2021) [3, 7, 2].

Table 1: Weed flora of experimental field

S. No.	Weed species	Common name	Family	Habitat
A.	**Grasses**			
1.	*Phalaris minor*	Canary grass	Poaceae	Annual
B.	**Broad leafy weeds**			
1.	*Chenopodium album* L.	Lamb's quarter	Chenopodiaceae	Annual
2.	*Anagallis arvensis* L.	Blue pimpernel	Primulaceae	Annual
3.	*Convolvulus arvensis* L.	Field bind weed	Convolvulaceae	Annual
4.	*Melilotus alba*	Sweet clover	Leguminaceae	Annual
5.	*Rumex spp.*	Dock	Polygonaceae	Perennial
6.	*Coronopus spp.*	Lesser swine-cress	Brassicaceae	Annual
C.	**Other weeds**			
1.	*Cynodon dactylon*	Bermuda grass	Poaceae	Perennial
2.	*Vicia hirsuta*	Common vetch	Leguminaceae	Annual
3.	*Lathyrus aphaca*	Wild pea	Leguminaceae	Annual
4.	*Cyperus rotundus*	Nut sedge	Cyperaceae	Perennial

Weed density

The weed density of several weed species and weeds as a whole was significantly impacted by various herbicidal treatments (Table 2). The application of VESTA (500 g ha^{-1}) recorded significantly lower density of *Phalaris minor, M. alba, C. album, C. arvensis* and other weeds over rest of the treatments. Accord Plus (1250 g ha^{-1}) had the second-lowest weed density, with Total (40 g ha^{-1}) and Atlantis (400 g ha^{-1}) following closely after. When it came to *Coronopus* spp. density, VESTA (500 g ha^{-1}) reported a much lower density than the other treatments while being at par. The experimental field's *Coronopus* spp. densities were highest and lowest in weedy and weed-free treatments, respectively. Regarding the overall weed density, VESTA (500 g ha^{-1}) alone recorded a significant decrease compared to the other treatments, followed by Accord plus (1250 g ha^{-1}) and Total (40 g ha^{-1}), while Clodinofop (60 g ha^{-1}) observed a relatively high weed density within herbicidal treatments. While weed free and weedy check treatments, respectively, had the considerably lowest and highest overall weed density.

Weed control efficiency

The Table3 showed that numerous weed control treatments influenced their weed control efficiency substantially. The most effective method for controlling weeds was VESTA (500 g ha^{-1}), which was quite equivalent to the weed-free treatment (100%). However, Accord plus (1250 g ha^{-1}), (Total 40 g ha^{-1}) and Atlantis (400g ha^{-1}) also recorded the weed control efficiency quite fare. The effectiveness of weed management using Clodinofop (60g ha^{-1}) and Sulfosulfuron (25 g ha^{-1}) formulations of herbicides was, however, much less.

Weed index

Weed index indicates the quantum of reduction in grain yield because of weeds. The information given in the Table 3 indicate that in case of weed index reverse trend was found as of weed control efficiency. The treatment, in which the highest value of weed control efficiency was recorded, showed the lowest value of weed index. Thus, the minimum weed index (8.70) was observed under the treatment of VESTA (500 g ha^{-1}) and the maximum weed index (30.83) was with the weedy check. Similar results have also been reported by Dheer *et al*., (2021) [2].

Table 2: Effect of different herbicidal treatments on weed density in wheat cv K 1006

Treatment	*P. minor*	*M. alba*	*C. album*	*Rumex spp*	*Coronopus spp*	*A. arvensis*	*C. arvensis*	*Others*	Total
VESTA (500 g ha^{-1})	1.2 (1.0)	1.3 (1.3)	1.6 (2.0)	1.6 (2.2)	0.7 (0.0)	1.7 (2.3)	1.6 (1.6)	1.8 (2.7)	3.7 (13.1)
Atlantis (400 g $ha^{-1)}$	1.5 (1.8)	1.6 (2.2)	1.9 (3.0)	1.8 (2.9)	1.7 (2.4)	2.0 (3.6)	1.8 (2.7)	2.1 (4.0)	4.81 (22.6)
Total (40 g $ha^{-1)}$	1.4 (1.5)	1.6 (2.0)	1.8 (2.8)	1.9 (3.0)	1.6 (2.0)	1.7 (2.4)	1.7 (2.4)	2.1 (3.8)	4.53 (20.0)
Accord plus (1250 g ha^{-1})	1.2 (1.0)	1.5 (1.6)	1.7 (2.3)	1.8 (2.6)	1.3 (1.3)	1.7 (2.4)	1.6 (1.9)	1.9 (3.0)	4.07 (16.1)
Clodinofop (60 g ha^{-1})	1.6 (2.0)	1.9 (3.0)	2.2 (4.2)	2.0 (3.4)	1.8 (2.9)	2.3 (4.8)	1.9 (3.2)	2.4 (5.2)	5.40 (28.7)
Sulfosulfuron (25 g ha^{-1})	1.6 (2.0)	1.8 (2.6)	2.2 (4.5)	1.9 (3.2)	1.8 (2.6)	2.2 (4.4)	1.8 (2.9)	2.3 (5.0)	5.26 (27.2)
Weed free	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)
Weedy check	4.6 (20.3)	4.3 (18.3)	4.9 (24.0)	3.0 (8.5)	3.9 (14.8)	3.2 (10.0)	4.2 (17.5)	3.2 (10.0)	11.13 (123.4)
S.Em±	0.06	0.06	0.08	0.12	0.06	0.12	0.07	0.07	0.47
CD (P=0.05)	0.18	0.18	0.23	0.35	0.17	0.38	0.20	0.20	0.98

Figures in parenthesis are original values

Table 3: Weed control efficiency and weed index of some weed control treatments in wheat cv K 1006

Treatments	Weed control efficiency (%)	Weed index (%)
VESTA (500 g ha^{-1})	76.79	8.70
Atlantis (400 g $ha^{-1)}$	60.41	14.25
Total (40 g $ha^{-1)}$	64.46	13.06
Accord plus (1250 g ha^{-1})	71.42	10.26
Clodinofop (60g ha^{-1})	55.14	16.18
Sulfosulfuron (25g ha^{-1})	59.21	15.76
Weed free	100.0	0.00
Weedy check	0.00	30.83

Growth attributes

The plant height, leaf area index and dry matter accumulation were taken in to account to growth attributes in the present study. These growth attributes were not affected significantly initially (30 DAS) as all the treatments were executed after 30^{th} day stage (Table 4). However, all the herbicidal treatments increased these growth attributes significantly as compared to weedy check at all rest stages of growth and development of the crop. The maximum growth attributes were observed under the weed free treatment. That is the logic that there was no any sort of competition between the weeds and crop plants. Among the herbicidal treatments, the application of VESTA (500 g ha^{-1}) was observed most effective to increase the maximum plant height, leaf area index and dry matter accumulation throughout the crop development followed by the application of Accord plus (1250 g ha^{-1}). The crop dry matter is the net outcome of photosynthesis after respiration, At the same time, whereas density and the dry weight of weeds have a significantly inverse relationship, growth characteristics such as plant height, LAI, and number of tillers (m^{-2}) directly influence the accumulation of dry matter. This is incredibly true in this situation as well; the treatments reduced the density and dry weight more efficiently, offered a more favourable microenvironment to promote crop growth, and eventually had more crop dry weight in the corresponding treatments. Crop dry matter accumulation was increased appreciably due to the weed control treatments as compared to weedy check at all the growth stages of crop, except at 30 DAS. This may also be attributable to the successful management of BLWs and narrow leaf weeds. Clodinafop, metsulfuron methyl, and sulfosulfuron, however, control the narrow leaved as well as the narrow as well. Crop growth and yield were mostly impacted by BLWs, particularly C. album, and were not overly severely affected by P. minor or other narrow leaf weed infestations. Similar impact of herbicidal treatments have also been reported by Yadav *et al*. (2009) [10] and Dheer *et al*. (2021) [2].

Table 4: Effect of various weed control treatments on growth attributes at different growth stages in wheat

Treatment	Plant height (cm)				Leaf area index			Dry matter (g m^{-2})			
	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	120 DAS
VESTA (500 g ha^{-1})	19.5	59.2	96.2	94.80	1.41	3.40	3.98	46.4	365.6	788.0	1063.0
Atlantis (400 g $ha^{-1)}$	20.5	52.1	85.7	84.10	1.40	3.10	3.70	46.5	346.0	692.0	1045.12
Total (40 g $ha^{-1)}$	21.0	58.4	86.8	84.30	1.42	3.30	3.96	46.4	360.0	780.0	1058.23
Accord plus (1250 g ha^{-1})	20.0	50.6	92.0	90.40	1.43	3.30	3.94	47.3	358.4	740.8	1051.68
Clodinofop (60 g ha^{-1})	21.3	56.7	88.3	86.70	1.38	3.20	3.60	46.6	338.2	670.0	1032.87
Sulfosulfuron (25 g ha^{-1})	20.6	57.9	90.3	89.70	1.40	3.30	3.80	46.8	349.2	716.6	1025.37
Weed free	21.9	61.0	100.0	97.60	1.45	3.70	4.20	45.0	400.0	810.0	1130.34
Weedy check	20.8	42.8	74.3	72.60	1.44	2.40	2.90	46.0	269.4	550.5	817.91
S.Em±	0.5	1.45	2.38	2.340	0.03	0.08	0.09	1.26	9.25	19.05	27.62
CD (P= 0.05)	NS	4.42	7.27	7.18	NS	0.26	0.29	NS	28.34	58.35	84.59

Yield attributes

The vegetative and reproductive development of the plants determine the qualities ad quantities of yield. With weed management techniques over weed control, every yield attribute namely, number of effective tillers m^{-2}, spike length (cm), number of spikelets $spike^{-1}$, and number of grain $spike^{-1}$increased significantly. The significantly highest values of all the yield contributing traits were recorded with weed free, which were at par with post emergence application of VESTA (500 g ha^{-1}) followed by the Total (40 g $ha^{-1)}$ while being substantially more expensive than the other weed management techniques. This may be the result of better nutrients, moisture, space, and light availability, which led to better growth and development of plants (Dheer *et al*., 2021) [2]. The highest test weight was found under weed free and VESTA (500 g ha^{-1}). It may be because there was less competition for resources, which led to more food being translated from the source to sink relationship.

Table 5: Effect of weed control treatments on yield attributes in wheat cv. K1006

Treatment	Effective tillers (m^{-2})	Spike Length (cm)	No. of spikelets $Spike^{-1}$	No. of grains spike-1	Test weight (g)
VESTA (500 g ha^{-1})	325.2	9.0	16.10	42.2	39.0
Atlantis (400 g $ha^{-1)}$	304.0	7.9	14.20	38.2	37.3
Total (40 g $ha^{-1)}$	324.2	8.5	14.35	40.2	38.2
Accord plus (1250 g ha^{-1})	307.5	8.2	14.27	37.3	37.6
Clodinofop (60 g ha^{-1})	321.4	7.0	13.51	40.2	38.3
Sulfosulfuron (25 g ha^{-1})	320.8	7.9	13.75	40.0	38.2
Weed free	348.8	9.3	16.15	43.5	39.0
Weedy check	232.0	6.2	12.15	33.0	37.3
S.Em±	8.26	0.21	0.38	1.04	1.02
CD (P=0.0 5)	25.30	0.65	1.17	3.20	NS

Grain yield

The percentage of the entire biomass (total dry matter accumulation) that becomes economically usable (grain yield) as a result of bio-physiological processes is known as the grain yield. The source-sink connection exhibits this. The many yield features, such as the number of spikes, length of the spike, number of grains $spike^{-1}$, and 1000-grain weight, etc., all contribute to the grain yield. The treatments that produced the best results for these characteristics would ultimately produce greater yields of both grain and straw. Because the various weed management methods had a considerable impact on the growth characteristics and yield characteristics, grain and straw yields were also strongly impacted. The maximum grain yield (46.42 q ha-1) wasobtained with weed free practice followed by at par with herbicidal treatment VESTA (500 g ha^{-1}) and Accord plus (1250 g ha^{-1}). The yield levels were relatively less in cases of Clodinofop (60 g ha-1) and Sulfosulfuron (25 g ha-1) treatments. It might be due to the smothering effect of the respective weed management practices. Which resulted in more translocation of synthetizes from source to sink. Almost similar findings have also been reported by Yadav *et al.* (2009) [10], Malik *et al.* (2013) [6] and Dheer *et al.* (2021) [2].

Biological yield

Biological yield is the sum of grain and straw yield. The maximum biological yield (10745.30 kg ha^{-1}) was recorded under weed free although, was at par (10491.53 kg ha^{-1}) with post emergence application of VESTA (500 g ha^{-1}) followed (10023.46 kg ha^{-1}) by Accord plus (1250 g ha^{-1}). This can be because higher growth and development brought to more biological yield. Yadav *et al*. (2009) [10], Malik *et al.* (2013) [6] and Dheer *et al*. (2021) [2] have also reported a comparable result.

Harvest index

Harvest index (HI) indicates the effectiveness of translocation of photosynthetes from source (leaf) to sink (spikelets). It is also called as coefficient of effectiveness. The highest value (43.25%) of harvest index was recorded with VESTA (500 g ha^{-1}) followed at par by weed free (43.20 %), Accord plus 1250 g ha-1(42.55%) and Total 40 g ha-1(42.19%). Overall, weed control treatments influenced the harvest index to greater extent. As compared to weedy check. Similar results have also been repoted by Malik *et al.* (2013) [6] and Dheer *et al*. (2021) [2].

Nitrogen uptake by crop

The nitrogen content of grain and straw, as well as the multiplication of the corresponding yield values, are the causes of nitrogen uptake. The variation that was reported was mostly due to differences in grain and straw yields as influenced by various treatments because nitrogen content in grain and straw was not significantly impacted by various weed control methods. The maximum value of nitrogen uptake was recorded with VESTA (500 g ha^{-1}) followed by Accord plus (1250 g ha^{-1}) and Total (40 g ha^{-1}) to the tune of 101.50, 100.80 and 96.38 kg ha^{-1}, respectively. It could be because these treatments increased the dry matter of the crops, and dry matter and nitrogen uptake have a positive correlation. However, weed-free treatment had the highest level of nitrogen uptake (102.81 kg ha^{-1}), and that why, this treatment also had the highest levels of biological and grain yield. Malekian *et al.* (2014) [5] and Dheer *et al.* (2021) [2] have also observed almost similar results.

Net return

Any research plan that shows the financial viability of a certain treatment has one of its most crucial elements. In this experiment, a typical cost of cultivation for growing wheat crop was determined, and it proved to be worth Rs. 41092.00 Rs. ha^{-1}. The cost of the various treatments was then computed, added to the basic cost, and the sum total of cultivation expenses was determined. By calculating the market unit price (Rs. Kg^{-1}) with the appropriate yield of grain and straw and adding both, the gross income of the various weed control treatments was determined. Accordingly, the benefit-cost ratio and net profit were computed. With regard to the various treatments, VESTA (500 g ha^{-1}) showed the greatest net profit (Rs. 71927.21 ha^{-1}) and benefit-cost ratio (Rs. 1.71 re^{-1} invested), followed by Accord plus (1250 g ha^{-1}) (Rs. 68753.27 ha^{-1} and 1.61). Weed-free treatment was shown to be less profitable than VESTA (500 g ha^{-1}). It may be as a result of the fact that the operation required a larger salary investment from labourers in order to achieve a weed-free plot. Walia *et al.* (2011) [9], Dheer *et al.* (2021) [2] and Kushwaha *et al.*, (2023) [4] also narrated similar economic feasibility of ready mixed herbicides over weedy free treatment.

Table 6: Effect of weed control treatments on yields and nitrogen up take in wheat cv. K 1006

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)	Nitrogen uptake by crops (kg ha^{-1})	Net Return (Rs ha^{-1})	B:C Ratio
VESTA (500 g ha^{-1})	4237.86	5953.67	10491.53	43.25	101.50	71927.21	1.71
Atlantis (400 g ha$^{-1)}$	3980.40	5532.76	9513.16	41.84	88.81	64950.54	1.56
Total (40 g ha$^{-1)}$	4035.50	5665.64	9801.14	42.19	96.38	65623.94	1.53
Accord plus (1250 g ha^{-1})	4165.30	5758.16	10023.46	42.55	100.80	68753.27	1.61
Clodinofop (60 g ha^{-1})	3890.70	5485.89	9376.59	41.49	92.86	62831.94	1.50
Sulfosulfuron (25 g ha^{-1})	3910.30	5474.42	9384.72	41.67	89.71	63059.56	1.50
Weed free	4641.60	6103.70	10745.30	43.20	102.81	75956.8	1.46
Weedy check	3210.20	5457.34	8667.54	37.04	74.42	48948.50	1.19
S.Em±	108.06	152.53		-	2.49		
CD (P=0.0 5)	330.93	454.90		-	7.61		

Conclusion
In light of the aforementioned data, it is determined that the post-emergence application of VESTA (500 g ha^{-1}) and Accord plus (1250 g ha^{-1}) would be the most affordable ready-mixed weedicides for the weed control in wheat production during the *Rabi* season.

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