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Influence of weed control measures on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract
One year field experiment was conducted during rabi season of 2021-2022 at the agricultural research farm (Pili Kothi) Tilak Dhari Post Graduate College Jaunpur U.P. The experiment comprised of nine treatments *viz.* weedy check, weed free (Two hand weeding), Clodinofop @0.005 kg ha^{-1}, Metsulfuron @0.006 kg ha^{-1}, Metsulfuron @0.004 kg ha^{-1}, Pendimethalin @1.25 kg ha^{-1},Metribuzin @0.2 kg ha^{-1}, 2,4-D 0.5 kg ha^{-1} and Carfentrazone @0.02 kg ha^{-1} replicated four times in Randomized Block Design. Wheat variety HD-2967 was used at attest crop. Application of Metsulfuron @0.006 kg ha^{-1} significantly increased the plant height and dry matter accumulation at different growth stages over weedy check resulted into higher yield attributes viz. effective plant population in m2 at 120 days, grain ear^{-1} and 1000 grain weight (38.77 g) consequently, highest grain (45.03 q/ha) Straw (57.19 q/ha) and biological yield (102.22 q/ha) were through controlling weeds by Metsulfuron @0.006 kg ha^{-1} after two hand weeding which was at per Metsulfuron @0.004 kg ha^{-1} (43.70, 57.69,101.39 q/ha) followed by 2,4-D 0.5 kg ha^{-1} and proved significantly superior over rest of other treatments.

Keywords: Wheat, weed control, growth, yield

Introduction
Wheat *Triticum aestivum (L.*) is the most important grain crop both in regard to its antiquality and its use as a source of human food. Wheat serves as a stable food for about one billion people in as many as 43 countries of the world. It provides about 20 percent of total food calories for the human race. Wheat is growing in approximately 220 million ha. Worldwide, about half of which is in developing countries. The main wheat growing countries include China, India,
U.S.A, Russia, France, Canada, Germany, turkey, Australia, and Ukraine. In 2020, the total global production of wheat was 760 million tons. China, India, and Russia are the three largest individual wheat producers in the world, accounting for about 41% of the world's total wheat production. The United States is the fourth-largest individual wheat producer in the world. However, the European Union, if it were counted as a single country, its wheat production would exceed that of any country except China. Wheat contributes more calories (20%) and more protein to the world's diet than any other food crop (Source – FAO 2020-21).
Weeds can negatively influence wheat yield as weed emerge simultaneously and grow vigorously with wheat. Weed–crop interactions are based on competition for water, nutrients, space and solar radiation which causes 33% reduction in wheat yield (Karim, 1987) [3]. A critical weed free period up to 40 days after sowing is needed for proper growth and higher yield (Tariful *et al*. 1998) [6]. Therefore, to avoid yield loss, weed management should be done in such a time so that minimum weed infestation occurs in wheat. The conventional method of weed control is much effective but knowledge about appropriate stage of weeding along with lack of labor availability at those stages makes hand weeding non-effective. Therefore, use of herbicide could be more feasible and efficient to check early weed competition (Hossain *et al*. 2020) [2]. Again, wheat cultivars vary in their competitiveness against weeds (Lemerle *et al*., 2006) [5] and those with a high degree of competitive ability, especially against aggressive weeds, are was conducted at Agronomy Research Farm, Acharya Narendra highly beneficial because they protect against the build-up of weed infestation and proliferation of the weed seed

Bank (Feledyn- Szewczyk *et al*. 2013) [1]. So, the best wheat variety and weed management techniques need to be adopted by the farmers to reduce weed infestation and maximizing wheat yield.

2. Materials and Methods

The experiment was carried out during rabi season of 2021-22 at the instructional farm, Department of Agronomy Tilak Dhari Post Graduate College Jaunpur U.P. The site lies in the eastern Gangetic plains characterized by a subtropical climate with a cool winters and hot summers. The weekly mean maximum and minimum temperature varied from 19.80 to 39.50oC and 3.90oC to 20.5oC during the crop growth stages. Relative humidity ranged from 65-90%, and occasionally winters showers provided supplemental moisture.t

Weekly meteorological data were collected from the nearest observatory.These data confirmed that the season was favorable for wheat cultivation with adequate soil moisture during crop establishment and moderate temperatures during reproductive stages.

2.1 Soil Characteristics

Pre-sowing soil analysis revealed that the experimental field had a sandy loam texture with a slightly alkaline reaction (pH 7.6). The soil contained low organic carbon (0.43%), medium levels of available nitrogen (220 kg ha^{-1}), phosphorus (21.5 kg ha^{-1}), and potassium (210 kg ha^{-1}). The site was well-drained and favorable for wheat cultivation; however, its moderate fertility emphasized the need for balanced nutrient application.

2. Experimental Design and Treatments

The experiment was laid out in a Randomized Block Design (RBD) with three replications and nine Treatments.

Treatments included:

- **T_1:** Weedy check (no herbicide, no weeding)
- **T_2:** Weed-free (manual weeding at regular intervals)
- **T_3:** Clodinofop@0.005 kg ha^{-1}
- **T_4:** Metsulfuron @ 0.006 kg ha^{-1}
- **T_5:** Metsulfuron @0.004 kg ha^{-1}
- **T_6:** Pendimethalin @1.25 kg ha^{-1}
- **T_7:** Metribuzin @0.2 kg ha^{-1}
- **T_8:** 2,4-D 0.5 kg ha^{-1}
- **T_9:** Carfentrazone @0.02 kg ha^{-1}

2.3 Crop details

The experimental crop was wheat (*Triticum aestivum* L.), variety HD 2967, a high-yielding cultivar adapted to the eastern plains. Sowing was performed in 22.5 cm row spacing with a seed rate of 100 kg ha^{-1}. Fertilization followed the recommended dose of 120:60:40 kg N:P:K ha^{-1}, applied through urea, single superphosphate, and muriate of potash. At sowing, half of the nitrogen along with the full phosphorus and potassium was incorporated, and the remaining nitrogen was top-dressed at the first irrigation. Uniform crop management practices, including irrigation, plant protection, and other agronomic operations, were maintained across all treatments.

3. Experimental Finding

Table 1: Effect of different weed control measures on No. of shoots per meter square and Plant height (cm)

Treatment	No. of shoots per meter square				Plant height (cm)			
	30 DAS	60 DAS	90 DAS	120 DAS	30DAS	60DAS	90 DAS	120 DAS
T_1 Weedy check	218	255	228	212	23.93	68.72	97.26	97.21
T_2 Weed free	230	329	326	293	24.80	71.76	97.53	97.43
T_3 Clodinofop@ 0.005 kg ha^{-1}	331	261	235	218	23.30	65.82	93.38	93.29
T_4 Metsulfuron @0.006 kg ha $^{-1}$	236	318	309	283	23.32	68.86	95.63	95.51
T_5 Metsulfuron @0.004kg ha^{-1}	233	313	297	279	24.18	67.72	95.43	95.42
T_6 Pendimethaline @ 1.25 kg ha^{-1}	234	289	275	257	25.13	67.52	94.23	94.18
T_7 Metribuzin @ 0.2 kg ha^{-1}	228	268	260	248	23.23	66.83	93.67	93.54
T_8 2,4-D @ 0.5 kg ha^{-1}	230	301	283	264	23.13	67.52	96.26	96.18
T_9 Carfentrazone@0.02kg ha^{-1}	225	266	262	236	22.90	66.33	95.98	95.79
SEm +_	7.494	10.909	10.243	9.900	0.770	2.358	3.734	3.587
C.D. at 5% -	N.S.	32.032	30.076	29.068	N.S.	N.S.	N.S.	N.S.

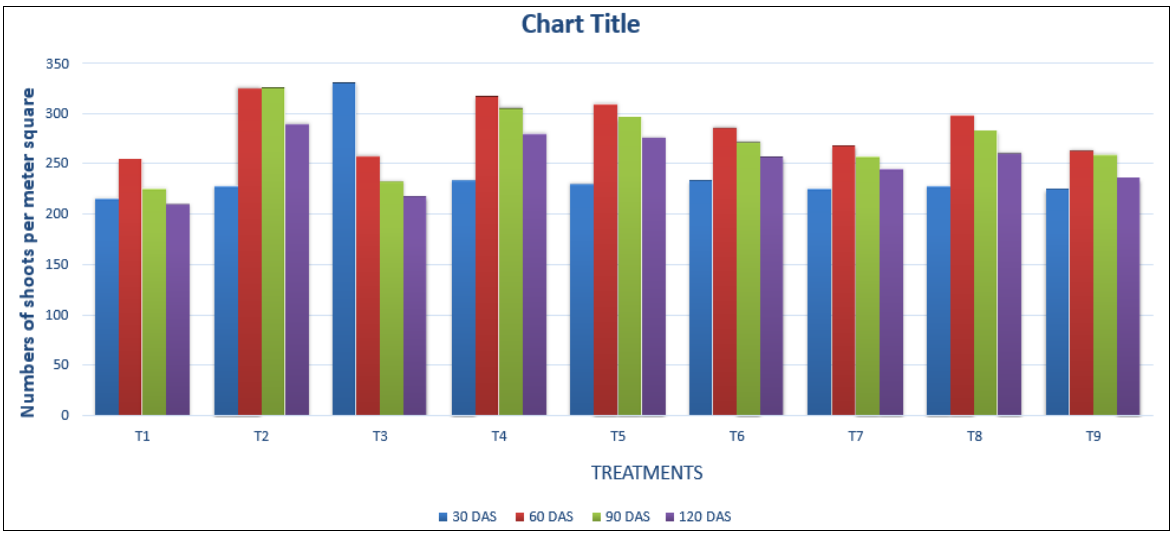

Fig 1: Effect of different weed control measures on No. of shoots per metre square

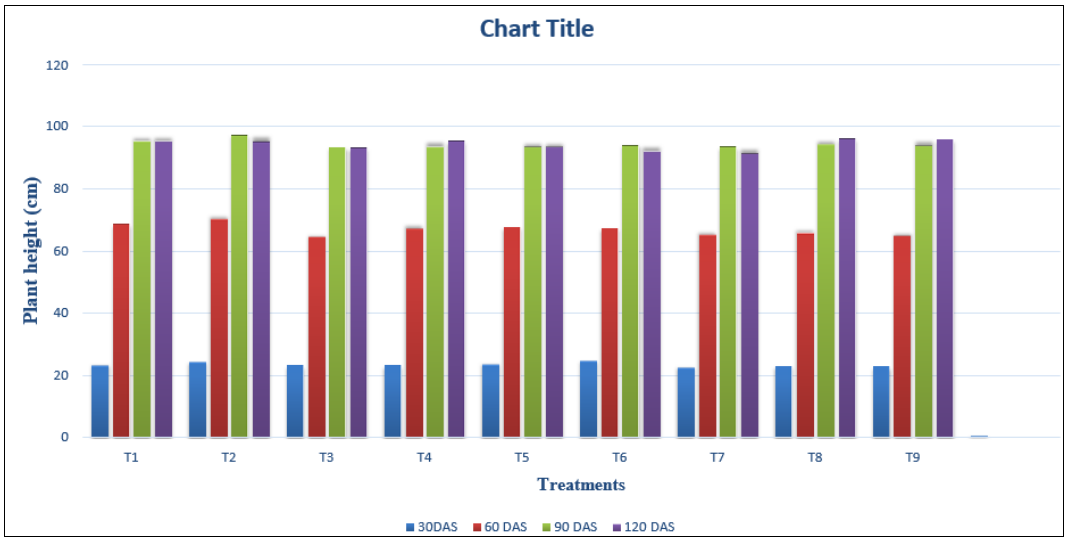

Fig 2: Effect of different weed control measures on Plant height

Table 2: Effect of different weed control measures on crop dry weight (g)

Treatment	Days after Sowing			
	30	60	90	120
T_1 Weedy check	27.78	204.00	593.82	802.28
T_2 Weed free	37.82	272.36	960.20	1199.89
T_3 Clodinofop@ 0.005 kg ha^{-1}	30.02	211.41	646.25	845.92
T_4 Metsulfuron @0.006 kg ha^{-1}	41.25	262.35	886.90	1178.75
T_5 Metsulfuron @0.004kg ha^{-1}	41.17	256.68	831.68	1171.15
T_6 Pendimethaline @ 1.25 kg ha^{-1}	38.24	241.30	792.67	1021.36
T_7 Metribuzin @ 0.2 kg ha^{-1}	34.95	221.86	765.88	1004.92
T_8 2,4-D @ 0.5 kg ha^{-1}	36.69	243.82	809.35	1097.30
T_9 Carfentrazone@0.02kg ha^{-1}	28.89	215.46	729.49	863.52
SEm +_	1.338	8.321	27.807	34.155
C.D at 5%	3.928	24.433	81.646	100.286

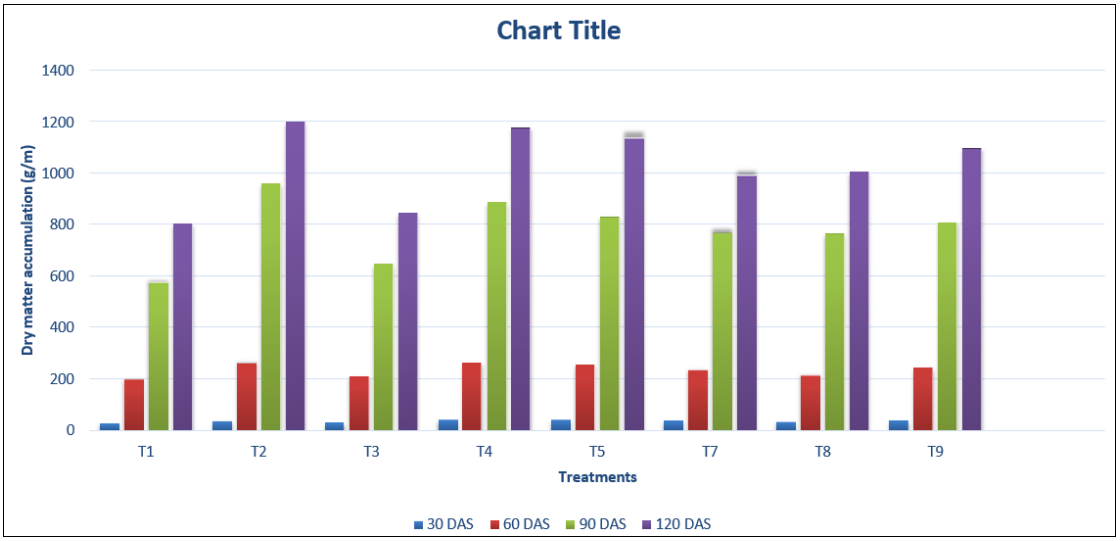

Fig 3: Effect of different weed control measures on crop dry weight (g)

Table 3: Effect of different weed control measures on No. of ear head /m2, No. of grain/ear head, Test weight (g), Length of ear head (cm).

Treatment	No. of ear head /m2	No. of grain/ear head	Test weight (g)	Length of ear head (cm)
T_1 Weedy check	198	43	36.02	10.27
T_2 Weed free	290	50	39.46	11.04
T_3 Clodinofop@ 0.005 kg ha^{-1}	200	44	36.53	10.31
T_4 Metsulfuron @0.006 kg ha^{-1}	275	49	38.77	10.75
T_5 Metsulfuron @0.004kg ha^{-1}	270	48	38.72	10.72
T_6 Pendimethaline @ 1.25 kg ha^{-1}	239	46	37.05	10.57
T_7 Metribuzin @ 0.2 kg ha- 1	233	46	36.98	10.48
T_8 2,4-D @ 0.5 kg ha^{-1}	245	47	38.59	10.63
T_9 Carfentrazone@0.02kg ha^{-1}	217	45	36.95	10.42
SEm +_	9.18	1.69	1.395	0.394
C.D at 5%	26.953	N.S.	N.S.	N.S.

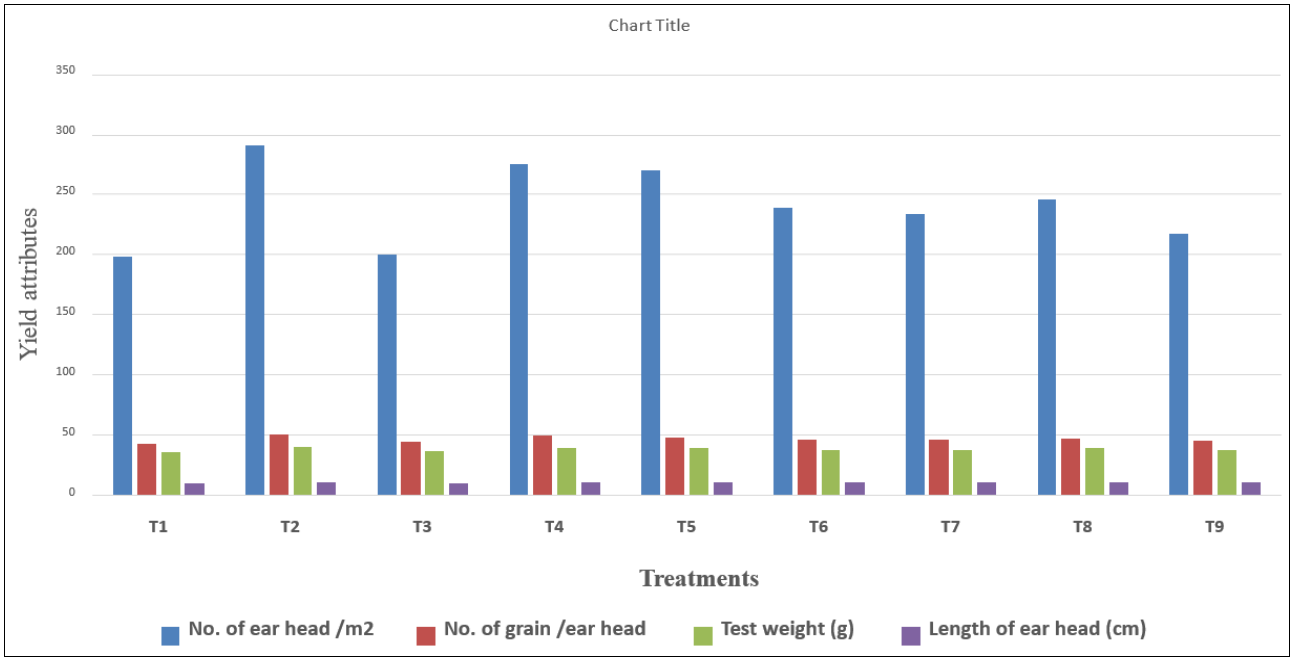

Fig 4: Effect of different weed control measures on No. of ear head /m2, No. of grain/ear head, Test weight (g), Length of ear head (cm)

Table 4: Effect of different weed control measures on Grain yield (q/ha), Straw yield (q/ha) Biological yield (q/ha) and Harvest index.

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index
T_1 Weedy check	24.53	43.17	67.70	0.36
T_2 Weed free	49.75	55.72	105.47	0.47
T_3 Clodinofop@ 0.005 kg ha^{-1}	25.92	43.03	68.95	0.37
T_4 Metsulfuron @0.006 kg ha^{-1}	45.03	57.19	102.22	0.44
T_5 Metsulfuron @0.004kg ha^{-1}	43.70	57.69	101.39	0.43
T_6 Pendimethaline @ 1.25 kg ha^{-1}	34.22	53.05	87.27	0.39
T_7 Metribuzin @ 0.2 kg ha^{-1}	33.02	51.85	84.87	0.38
T_8 2,4-D @ 0.5 kg ha^{-1}	37.65	54.98	92.63	0.40
T_9 Carfentrazone@0.02kg ha^{-1}	29.81	48.00	77.81	0.38
SEm +	1.373	2.032	2.706	0.016
C.D at 5%	4.030	5.967	7.946	0.046

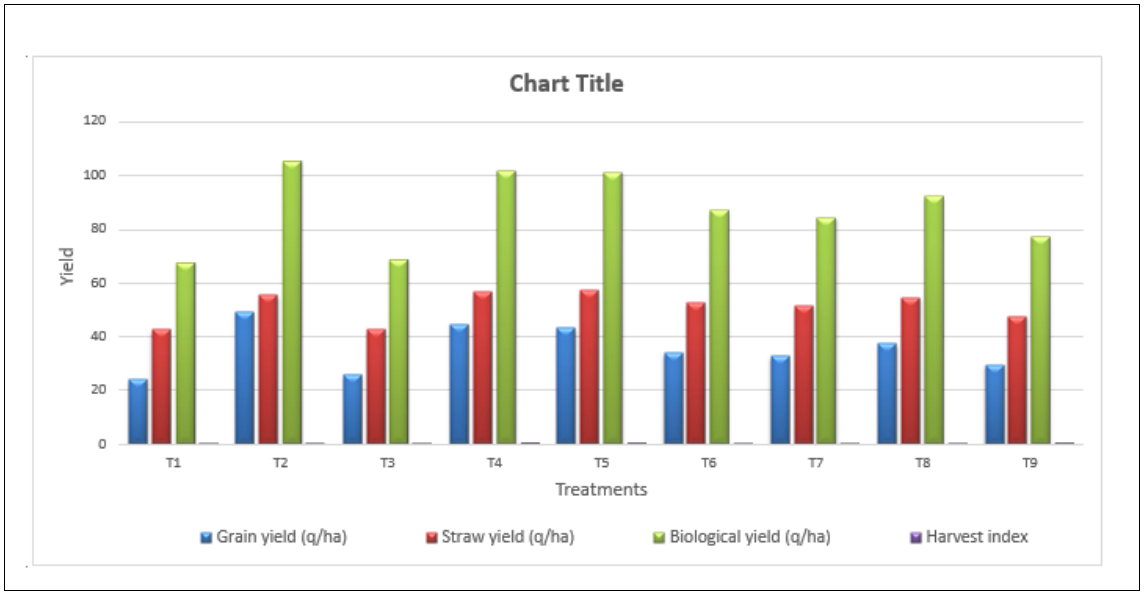

Fig 5: Effect of different weed control measures on Grain yield (q/ha), Straw yield (q/ha), Biological yield (q/ha) and Harvest index

4. Results and Discussion

4.1 Effect of Weed Control Measures on Growth Characters of Wheat

4.1.1 Number of Shoots m^{-2}

Shoot density increased until 60 DAS and declined thereafter across all treatments (Table 1). Significant differences were observed at 60, 90, and 120 DAS. At 30 DAS, the maximum shoots were recorded with metsulfuron (0.006 kg ha^{-1}), though the differences were non-significant. At 60 DAS, weed-free plots registered the highest shoot density, followed by

metsulfuron (0.006 and 0.004 kg ha⁻¹), whereas clodinafop (0.005 kg ha⁻¹) produced the lowest. Metsulfuron (0.006 kg ha⁻¹) was significantly superior to metribuzin, carfentrazone, and clodinafop, and statistically at par with pendimethalin, 2, 4-D, and metsulfuron (0.004 kg ha⁻¹). A similar trend was observed at 90 and 120 DAS, with metsulfuron (0.006 kg ha⁻¹) maintaining the highest shoot density and clodinafop (0.005 kg ha⁻¹) being least effective but superior to the weedy check.

4.1.2 Plant Height
Weed control measures did not significantly affect plant height at any stage (Table 1). At 30 DAS, pendimethalin (1.25 kg ha⁻¹) produced the tallest plants, whereas carfentrazone (0.02 kg ha⁻¹) resulted in the shortest. At 60 DAS, maximum height was noted in weed-free plots and the minimum in clodinafop (0.005 kg ha⁻¹). At 90 DAS, 2, 4-D (0.5 kg ha⁻¹) produced the tallest plants, while clodinafop again recorded the minimum. By 120 DAS, weed-free plots maintained the highest plant height, followed by the weedy check, with clodinafop (0.005 kg ha⁻¹) consistently producing the shortest plants.

4.1.3 Dry Matter Accumulation
Dry matter accumulation increased progressively with crop age and was significantly influenced by weed management (Table 2). Weed-free plots consistently recorded the highest values, while the weedy check produced the lowest. At 30 and 60 DAS, metsulfuron (0.006 kg ha⁻¹) produced the maximum biomass, significantly outperforming most herbicides, whereas clodinafop (0.005 kg ha⁻¹) recorded the minimum. Metsulfuron (0.004 kg ha⁻¹) ranked second and was statistically comparable with pendimethalin (1.25 kg ha⁻¹) and 2,4-D (0.5 kg ha⁻¹). At 90 and 120 DAS, weed- free plots remained superior, followed by metsulfuron (0.006 kg ha⁻¹), which was significantly higher than several herbicides but comparable with 2,4-D and metsulfuron (0.004 kg ha⁻¹).

4.2 Effect of Weed Control Measures on Yield Attributes
4.2.1: Number of Ear Heads m⁻²
Ear head density was significantly influenced by weed management (Table 3). Weed-free plots recorded the highest number, while the weedy check produced the minimum. Metsulfuron (0.006 kg ha⁻¹) resulted in the maximum ear heads, closely followed by metsulfuron (0.004 kg ha⁻¹). Both treatments were statistically at par but significantly superior to other herbicides.

4.2.2 Number of Grains per Ear Head
Number of Grains per Ear Head The number of grains per ear head was not significantly affected by weed control treatments. Weed-free plots produced the maximum (50 grains), while the weedy check had the minimum. Among herbicides, metsulfuron (0.006 kg ha⁻¹) recorded the highest grain number, followed by metsulfuron (0.004 kg ha⁻¹). Clodinafop (0.005 kg ha⁻¹) was least effective, with only 44 grains per ear, though it still surpassed the weedy check.

4.2.3 Test Weight
All weed management practices improved test weight compared to the weedy check, though differences were statistically non-significant (Table 3). Weed-free plots recorded the highest test weight, followed by metsulfuron (0.006 kg ha⁻¹). The lowest was obtained with clodinafop (0.005 kg ha⁻¹).

4.2.4 Ear Head Length
Ear head length did not differ significantly among treatments. Weed-free plots produced the longest ear heads, while the weedy check had the shortest. Among herbicides, metsulfuron (0.006 kg ha⁻¹) produced the maximum length, followed by metsulfuron (0.004 kg ha⁻¹). Clodinafop
(0.005 kg ha⁻¹) was the least effective but performed better than the untreated control.

4.3 Effect of Weed Control Measures on Yield and Harvest Index
4.3.1 Grain Yield
The wheat crop produced the highest grain yield under weed-free conditions. Grain yield increased by 50.69% in weed-free plots compared to the weedy check, where intense competition from weeds—reflected in higher weed density and dry matter—caused an average reduction of 2.305 t/ha in grain yield. Similar findings were reported by Kaur *et al*. (2015) [4]. The weed-free treatment yielded 49.75 q/ha, which was significantly higher than all herbicide treatments and the weedy check, although no herbicidal treatment matched the yield of the weed-free plot statistically. The improved grain yield in both weed-free plots and those treated with Metsulfuron at 0.006 kg a.i./ha is primarily due to enhanced yield-contributing traits and a higher harvest index (Table -4).

4.3.1 Straw Yield
The maximum straw yield was recorded with metsulfuron (0.004 kg ha⁻¹), followed by metsulfuron (0.006 kg ha⁻¹). The minimum yield was obtained under clodinafop (0.005 kg ha⁻¹). Metsulfuron (0.004 kg ha⁻¹) was statistically at par with metribuzin, pendimethalin, 2,4-D, and metsulfuron (0.006 kg ha⁻¹), but significantly superior to carfentrazone and clodinafop.

4.3.2 Biological Yield
Biological yield was maximized under weed-free conditions and minimized in the weedy check. Among herbicides, metsulfuron (0.006 kg ha⁻¹) produced the highest biological yield (102.22 q ha⁻¹), followed by metsulfuron (0.004 kg ha⁻¹). The lowest yield (68.95 q ha⁻¹) was observed with clodinafop (0.005 kg ha⁻¹), though it remained superior to the weedy check.

4.3.4 Harvest Index
Harvest index was significantly affected by weed management. Weed-free plots recorded the maximum value, followed closely by metsulfuron (0.006 and 0.004 kg ha⁻¹), which were statistically comparable with the weed-free treatment. Other herbicides did not show superiority over the weedy check.

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