The Pharma Innovation Journal 2023; 12(10): 394-397

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 394-397

www.thepharmajournal.com
Received: 27-07-2023
Accepted: 09-09-2023

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Effect of weed management practices on weed dry matter, growth and yield of wheat (*Triticum aestivum* L.)

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Abstract
An investigation was carried out at Agronomy farm, Sai Institute of Paramedical and Allied Science, Dehradun during *rabi* 2021-22 to find out the "Effect of weed management practices on weeds and productivity of wheat (*Triticum aestivum* L.)". Twelve practices of weed management were used for research with three replications in randomized block design. PBW-154 variety of wheat was used as test crop. Among herbicides, post-emergences application of Clodinafop + Metsulfuron (60+4) @ 64 g *a.i.* ha^{-1} reduced better dry matter of weed, which was statistically at par with over rest of the treatments, except weed free, two hand weeding at 20 and 40 DAS and Sulfosulfuron + Metsulfuron @ 30+2 g ha^{-1} and also increasing growth parameters *i.e.*, plant height, fry matter accumulation, number of tillers m^{-2} and leaf area index, grain (51.20 q ha^{-1}) and straw (64.10 q ha^{-1}) yield of wheat. Herbicides applied as post-emergence and hand weeding at 20 and 40 DAS can all help the crop's weed-suppressing abilities.

Keywords: Wheat, yield, weed dry matter, growth parameters

Introduction
The Poaceae family includes the grain known as wheat (*Triticum aestivum* L.), which is a staple diet in every country. Indian subcontinent's north-western regions are their origin. *Triticum aestivum*, *Triticum durum* and *Triticum dicoccom*, sometimes known as common bread wheat, Marconi wheat, and Emmer wheat, respectively, are the three main types of wheat that are grown today. In the form of chapaties prepared from wheat flour, about 80 to 85% of wheat grains are ingested. Consumption has been continuously increasing over the past 15 years due to population growth, and in 2020 it is anticipated to reach a record high of 780 million tonnes. In contrast to its present production of 11.5 million tonnes, estimations state that India will need at least 125 million tonnes of wheat by 2023 (Anonymous, 2022) [1].
According to Chhokar *et al*. (2008) [3], *Phalaris minor, Chenopodium album, Anagallis arvensis, Avenafatua, Convolvulus arvensis, Lathyrusaphaca, Cyperus rotundus* and *Cynodon dactylon* are some of the more noticeable weeds found in wheat fields and they alone reduce wheat output by 33%. One of the most significant farming systems in the country's north is rice-wheat. In this cropping system, the *Phalaris minor* is one of the most serious problems with wheat and sometimes crop losses of about 65% have been documented. The yield of wheat is reduced by weeds by around 33% to 50%. One of the main reasons for low wheat output is weed infestation, which decreases wheat yield by 37–50% (Waheed *et al*., 2009) [13]. Herbicides can effectively manage weeds in the current environment. Herbicides have made it possible to successfully control a variety of weeds in wheat. Clodinafop + Metsulfuron @ 60 + 4 g ha^{-1} and Sulfosulfuron + metsulfuron @ 32 g ha^{-1} applied at 30 DAS was found to effectively lower weed biomass and density.

Materials and Methods
A field investigation was carried out at Agronomy farm, Sai Institute of Paramedical and Allied Science, Dehradun during *rabi* 2021-22. The research used a randomised block design with three replications and twelve weed management practises. With an elevation of 650 metres above mean sea level, this area has a subtropical climate and is located at 30°2 North latitude and 77°93 East longitude. During the experiment, 61.5 mm of rain fall on this area. The maximum and minimum temperatures, respectively, are averaged at 37.8 °C and 3.5 °C.

The soil at the test site was a silty loam with good drainage capabilities and a pH reaction of 8.5, low organic carbon (0.32%), low available nitrogen (180.00 kg ha^{-1}), medium available phosphorus (14.70 kg ha^{-1}) and high available potassium (280.5 kg ha^{-1}).

The experiment was involved twelve treatments *i.e.* Sulfosulfuron @ 25 g *a.i.* ha^{-1}, Metsulfuron @ 4 g *a.i.* ha^{-1}, Clodinafop @ 60 g *a.i.* ha^{-1}, Metribuzin @ 210 g *a.i.* ha^{-1}, Sulfosulfuron + Metsulfuron (30+2) @ 32 g *a.i.* ha^{-1}, Sulfosulfuron + Metribuzin (25+210) @ 235 g *a.i.* ha^{-1}, Clodinafop + Metsulfuron (60+4) @ 64 g *a.i.* ha^{-1}, Fenoxaprop –p – ethyl @ 120 g *a.i.* ha^{-1}, Fenoxaprop-p-ethyl + Metsulfuron (120+4) @ 124 g *a.i.* ha^{-1}, two hand weeding (20 and 40 DAS), weedy check and weed free. In order to ensure that the findings were reliable, three replications were performed. All of the treatments were sprayed in accordance with the prescribed procedures, i.e., all herbicides were applied as post-emergence at 30 DAS using a knap-sack sprayer equipped with a flat-fan nozzle and a 250 L ha^{-1} water spray volume and hand weeding was carried out at 20 and 40 DAS.

With the aid of a cultivator, harrowed (twice) and planking, the field's seed bed was thoroughly crushed. Following that, the plots were demarcated in accordance with the layout plan and correctly levelled with a spade. The experimental crop acquired consistent fertilisation of 120 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} in the forms of urea, DAP and MOP, respectively. As a base dressing, a third dose of nitrogen and the full doses of phosphate and potassium were used. After the initial irrigation and panicle start stage, the remaining two thirds of the nitrogen dose by urea were top dressed in two equal splits. On November 28, 2018, crop wheat of the PBW-154 type was seeded using a seed drill at a distance of 20 cm and a seed rate of 100 kg ha^{-1}. For optimal germination and well establishment, one pre-sown watering was used. Five irrigations were performed at stress conditions (no water stress) after seeding.

Weeds, including dominated *i.e. Phalaris minor*, *Chenopodium album*, *Convolvulus arvensis* and *Melilotus indica* and other weeds, were all cut down to the ground level in each plot separately and collected for the dry matter accumulation. The samples were initially dried in the sun before being baked for 48 hours at 70°C ± 2°C difference to produce a constant weight. Weighing the dried samples, the total dry weight of the weeds was calculated and given in g m^2.

In order to count the number of tillers, one m^{-2} was marked twice in each plot. At 30, 60 and 90 DAS stages as well as during harvest, the number of tillers was counted, averaged and expressed as number m^{-2}. Each plot five tagged plants were selected for recorded plant height at 30, 60, 90 DAS and harvest. With the aid of a metre scale, at 30, 60, 90 DAS the height was measured from the plant's base to the top of its tallest leaf, up to the emergence of the spike and at harvest measured plant height up to the tip of the spike, average and expressed in cm.

The plant samples were collected to measure the buildup of dry matter at 30, 60, 90 DAS and harvest. The plant was cut near to the ground from a 0.5 m row length for this experiment and placed in paper bags. The samples were air dried at 70°C ± 2°C for 72 hours or until the constant weight was reached after being sun dried for 48 hours, weighing and expressed in g 0.5 m^{-1} row length. For the purpose of calculating the leaf area index, the leaf area was measured at 30, 60 and 90 DAS. Each leaf was divided into three sizes: tiny, medium, and huge. Each group was given five leaves, and the surface area of each leaf was calculated. The total leaf area was calculated by multiplying the average area of five leaves by the appropriate leaf number of a group. The following formula was used to calculate the LAI:

$$\text{Leaf area index} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Land area (cm}^2\text{)}}$$

The data collected from various observations were statistically analysed using the analysis of variance (ANOVA) method, as recommended by Gomez and Gomez (1984) [4]. When the F-test indicated that the treatments should be compared, a critical difference at 0.05 probability level was calculated. Standard error of the mean (SEm±) and crucial differences (CD) should be calculated as follows for each significant case.

Results and Discussion

Effect of weed management practices on dry matter of weeds at different growth stages of crop

A perusal of data in Table 1 showed that dry matter of weeds at 60 and 90 DAS was reduced significantly with weed free plot, which was at par with two hand weeding at 20 and 40 DAS. Among herbicidal treatments, the most efficient post-emergence treatment to reduce weed dry weight at 60 and 90 DAS was Clodinafop + Metsulfuron @ 60 + 4 g ha^{-1}, which was shown to be comparable to post-emergence treatment with Sulfosulfuron + Metsulfuron @ 30 + 2 g ha^{-1}. It could be because these treatments resulted in a minimal weed density and a decrease in weed dry weight. Singh *et al*. (2010) [9], Singh *et al*. (2011) [10] and Meena and Singh (2011) [6] all reported similar findings. The minimum dry matter of weeds at 30 DAS was found in weed free plot followed by two hand weeding at 20 and 40 DAS. However, among herbicidal treatments was not reduce the weed dry matter at 30 DAS. This might be due to all the herbicides was applied as post emergence *i.e.* 30 DAS.

Effect of weed management practices on growth parameters of crop

Plant height: The plant height increased significantly by the different weed management practices at 60, 90 DAS and harvest. Tallest plant at 60, 90 DAS and harvest was recorded under weed free, which was being at par with post emergence application of Clodinafop + Metsulfuron @ 60 +4 g ha^{-1} and Sulfosulfuron + Metsulfuron @ 30+2 g ha^{-1}. Due to the increased availability of weed-free space, plants of all growth phases grew voluminously, contributing to the increase in plant height. Also, Pandey *et al*. (2007) [7] and Meena and Singh (2011) [6] have reported on the same of this study. At 30 DAS, maximum plant height was found under weed free plot, being at par with two hand weeding over herbicidal treatments.

Dry matter accumulation: Data in Table 2 revealed that the dry matter accumulation at 60, 90 DAS and harvest increased significantly with weed management practices. Wheat was found to more accumulate its dry matter under weed-free plots at 60, 90 DAS and harvest. This was comparable to post-emergence applications of Clodinafop + Metsulfuron @

60 + 4 g ha^{-1}, Sulfosulfuron + Metsulfuron @ 30 + 2 g ha^{-1} and two hand weeding. This could be explained by the fact that plants in less weedy environments synthesise more food materials. Paswan *et al*. (2012) [8] also reported that using herbicides increased dry matter yield when compared to weedy control. The accumulation of dry matter in wheat at 30 DAS was unaffected by weed management techniques.

Number of tillers: The number of tillers m^{-2} increased up to 90 DAS of crop growth. In comparison to weedy check at different growth stages, the number of tillers m^{-2} rise dramatically under various weed management practises. Weed free plot recorded significantly more tillers m^{-2} than other weed management techniques except two hand weeding. Post-emergence applications of Clodinafop + Metsulfuron @ 60 + 4 g ha^{-1}, Sulfosulfuron + Metsulfuron @ 30 + 2 g ha^{-1} and Fenoxaprop-p-ethyl + Metrubuzin @ 120 + 210 g ha^{-1} also significantly increased the number of tillers. It might be explained by the fact that well-managed plots had improved nutrient availability, which led to a higher number of tillers m^{-2} than other treatments. Tomar and Vivek (2003) [12] and Bibi *et al*. (2008) [2] were also observed similar results.

Leaf area index: The leaf area grew as crop age increased up to 90 DAS, after that declining, primarily because of senescence. The leaf area index increased significantly as a result of various weed management techniques, with the weed-free treatment having the greatest leaf area index, which was at par with two-hand weeding at 20 and 40 DAS, Clodinafop + Metsulfuron @ 60 + 4 g ha^{-1}, Sulfosulfuron + Metsulfuron @ 30 + 2 g ha^{-1}. The greater leaf area index with these treatments could be the consequence of better growth, *i.e.*, increased leaf area and leaf area index, as a result of better growth, *i.e.*, sufficient moisture, space and nutrient availability due to less weed density. Leaf area index at 30 DAS was unchanged by weed management techniques.

Effect of weed management practices on yield

The weed-free plot produced highest grain and straw yield, followed by two hand weeding at 20 and 40 DAS, which were similarly noticeably superior to the other weed control strategies. This yield was similar to that obtained by two-hand weeding, Clodinafop + Metsulfuron @ 60 +4 g ha^{-1} and Sulfosulfuron + Metsulfuron @ 30 +2 g ha^{-1} application as post-emergence. It can be as a result of the suffocating effects of the various weed management strategies. This increased the yield by moving more food in an ethical manner from the point of origin to the washbasin. Similar results were also found by Malik *et al*. (2013) [5] and Tomar & Tomar (2014) [11].

Table 1: Effect of weed management practices on weed density in wheat crop

Treatment	Weed dry matter (g m^{-2})			Yield (q ha^{-1})	
	30 DAS	60 DAS	90 DAS	Grain	Straw
Sulfosulfuron @ 25 g *a.i.* ha^{-1}	5.76 (32.30)	5.92 (34.10)	6.00 (35.10)	46.20	60.45
Metsulfuron @ 4 g *a.i.* ha^{-1}	5.85 (33.10)	6.63 (43.00)	6.59 (42.53)	45.80	59.10
Clodinafop @ 60 g *a.i.* ha^{-1}	5.71 (31.75)	6.83 (45.75)	6.90 (46.75)	44.50	58.20
Metribuzin @ 210 g *a.i.* ha^{-1}	5.89 (33.75)	6.77 (45.10)	6.74 (44.50)	45.00	58.75
Sulfosulfuron + Metsulfuron (30+2) @ 32 g *a.i.* ha^{-1}	5.76 (32.25)	5.26 (24.11)	5.30 (27.15)	50.20	64.50
Sulfosulfuron + Metribuzin (25+210) @ 235 g *a.i.* ha^{-1}	5.60 (30.71)	6.36 (39.72)	6.29 (38.78)	47.10	61.15
Clodinafop + Metsulfuron (60+4) @ 64 g *a.i.* ha^{-1}	5.65 (31.05)	4.74 (21.50)	5.10 (25.05)	51.10	64.10
Fenoxaprop –p – ethyl @ 120 g *a.i.* ha^{-1}	5.96 (34.60)	6.86 (46.34)	7.16 (50.35)	43.18	58.65
Fenoxaprop-p-ethyl + Metsulfuron (120+4) @ 124 g *a.i.* ha^{-1}	5.54 (29.85)	6.29 (38.75)	6.27 (38.75)	47.50	61.50
Two hand weeding (20 and 40 DAS)	4.09 (15.75)	5.14 (25.50)	5.40 (28.20)	49.80	64.95
Weedy check	5.51 (29.47)	9.53 (91.05)	16.62 (275.35)	32.50	47.90
Weed free	3.66 (12.50)	1.00 (0.00)	1.00 (0.00)	52.50	66.45
S.Em±	0.15	0.18	0.11	1.33	1.03
CD (P ≥0.05%)	0.47	0.58	0.35	3.98	2.98

Table 2: Effect of weed management practices on weed density in wheat crop

Treatment	Plant height				Dry matter accumulation			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Sulfosulfuron @ 25 g *a.i.* ha^{-1}	28.00	61.65	95.68	97.64	94.09	345.20	660.16	1068.66
Metsulfuron @ 4 g *a.i.* ha^{-1}	27.60	61.59	95.29	97.48	93.75	338.60	652.63	1050.20
Clodinafop @ 60 g *a.i.* ha^{-1}	28.30	60.42	93.71	95.65	93.67	285.90	648.36	1028.67
Metribuzin @ 210 g *a.i.* ha^{-1}	25.54	61.14	94.96	96.85	94.81	295.50	646.80	1046.54
Sulfosulfuron + Metsulfuron (30+2) @ 32 g *a.i.* ha^{-1}	28.88	63.36	95.92	101.74	95.50	360.95	792.25	1136.91
Sulfosulfuron + Metribuzin (25+210) @ 235 g *a.i.* ha^{-1}	28.40	62.50	95.87	97.81	94.77	347.40	694.20	1086.21
Clodinafop + Metsulfuron (60+4) @ 64 g *a.i.* ha^{-1}	28.35	64.15	97.20	102.36	94.99	365.60	795.20	1154.31
Fenoxaprop –p – ethyl @ 120 g *a.i.* ha^{-1}	26.60	60.68	94.18	94.85	93.54	291.70	647.30	1015.39
Fenoxaprop-p-ethyl + Metsulfuron (120+4) @ 124 g *a.i.* ha^{-1}	28.15	63.10	96.50	99.74	94.81	357.50	721.36	1087.81
Two hand weeding (20 and 40 DAS)	30.57	65.81	99.70	101.37	95.55	366.50	796.00	1132.43
Weedy check	27.50	59.11	85.01	87.4	93.42	270.50	556.60	806.42
Weed free	31.14	66.96	100.48	104.5	95.60	370.00	728.50	1170.47
S.Em±	0.74	1.02	1.10	1.46	0.75	1.57	1.16	13.15
CD (P ≥0.05%)	2.32	3.01	3.26	4.32	NS	4.68	3.43	38.85

Table 3: Effect of weed management practices on weed density in wheat crop

Treatment	Number of tillers				Leaf area index		
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS
Sulfosulfuron @ 25 g *a.i.* ha^{-1}	178.32	361.67	366.50	362.48	1.41	3.68	3.75
Metsulfuron @ 4 g *a.i.* ha^{-1}	181.59	360.96	364.68	360.00	1.40	3.61	3.71
Clodinafop @ 60 g *a.i.* ha^{-1}	180.12	342.34	361.15	350.81	1.38	3.42	3.58
Metribuzin @ 210 g *a.i.* ha^{-1}	178.47	344.36	362.15	355.15	1.39	3.58	3.67
Sulfosulfuron + Metsulfuron (30+2) @ 32 g *a.i.* ha^{-1}	181.84	379.58	401.14	390.49	1.44	3.79	4.13
Sulfosulfuron + Metribuzin (25+210) @ 235 g *a.i.* ha^{-1}	181.23	362.51	378.81	371.19	1.41	3.72	3.77
Clodinafop + Metsulfuron (60+4) @ 64 g *a.i.* ha^{-1}	180.89	382.60	404.31	392.88	1.45	3.81	4.14
Fenoxaprop –p – ethyl @ 120 g *a.i.* ha^{-1}	179.54	329.26	348.17	336.99	1.42	3.31	3.54
Fenoxaprop-p-ethyl + Metsulfuron (120+4) @ 124 g *a.i.* ha^{-1}	178.99	355.25	381.75	386.12	1.43	3.76	3.95
Two hand weeding (20 and 40 DAS)	183.97	382.15	405.00	388.25	1.43	3.78	4.14
Weedy check	183.82	273.85	289.56	277.78	1.44	2.71	3.14
Weed free	185.98	393.78	415.97	405.47	1.46	3.87	4.21
S.Em±	2.55	10.33	10.30	6.17	0.15	0.12	0.03
CD (P ≥0.05%)	NS	30.48	30.38	18.19	NS	0.34	0.08

Conclusion

From the our one year research results, all the weed management practices, it could conclude that weed free plot and hand weeding at 20 and 40 DAS was reduce weed dry matter at all growth stage followed by Clodinafop + Metsulfuron @ 60 +4 g ha^{-1}. These practices also enhanced growth parameters as well as yield of wheat crop.

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