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Short Communication

Efficacy of pre and post-emergence herbicides on growth and yield of Wheat (*Triticum aestivum* L.) under Doon Valley of Uttarakhand

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ABSTRACT
A field experiment was directed during *Rabi* season 2018-2019 at experimental farm of Doon (P.G.) College of Agriculture Science and Technology, Selaqui, Dehradun (Uttarakhand) using pre-and post-emergence herbicides combined with Hand Weeding for successfully controlling of weeds, their result on yield and production economics on Wheat (*Triticum asetivum* L.) variety used 'Unnat PBW-343'. The dominant weed species present in field were *Phalaris minor, Cynodon dactylon* (L.) amongst dicot weeds like as *Chenopodium album, Coronopus didymus, Fumaria parviflor, Medicago denticulate, Malva praviflora Vicia, Sativa Rumex debtatus, Sisymbrium irio* among monocot, were observed during growing period. Lowest weed dry weight was observed in hand weeding at 30 and 60 Days after sowing. Higher Weed control efficiency up to (86.31 %) was recorded by Hand weeding at 30 and 60 Days after sowing. The treatment pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E at 2 DAS and PoE at 30 DAS (T_6) recorded greater yield attributes and seed and Stover yield (2540 kg/ha and 2668 kg/ha) and maximum net monetary return (Rs 36250) and Benefit: Cost ratio and 1.86.
Keywords: Weed, weed dry weight, Leaf area index, yield

INTRODUCTION
Wheat (*Triticum aestivum* L.) is an important grain food constituent and is a very chief commodity among cereal crops (Montazeri et al., 2005). In India about 29.58 million hectares area of under wheat with the production of 99.70 million tonnes and the productivity of 33.71q/ha (Anonymous, 2018). Uttarakhand consists of mountainous tracts as well as Tarai areas where wheat is the main crop during rabi. It has a contribution of 1.51% towards state production from 1.07% of the wheat-growing area of the nation with a productivity of 1.9 tonnes/ha. This is due to the fact that wheat in mountains is mainly rainfed as associated with irrigated crops in the Tarai. The total area under wheat is 0.4 million ha, with a total production of 0.8 tonnes and productivity of 1.9 tonnes/ha, above the last five years.

Weeds infestation is one of the main barriers responsible for the small productivity of irrigated wheat because, some grassy and wide leaved weeds infest wheat affecting severe race for sunlight, moisture, essential nutrients, and space which leads decrease in wheat yield and also its value (Chhokar et al., 2012; Chopra et al., 2015). The unrestrained growth of weeds on average affected about a 48 % drop in grain yield of wheat when matched with weed-free conditions (Singh et al., 2012. Physical and mechanical methods are laborious, tiresome, and luxurious to increase the cost of labor, draft animals and apparatuses and weed cannot efficiently be managed purely due to crop mimicry. Consequently, the use of chemical weed controllers has become essential (Marwat et al., 2008). Chemical weed management methods are the most perfect, useful, actual, time-saving, and efficient means of dipping early weed competition and crop production injuries (Ashiq et al., 2007). But, the limited dependent on herbicide and certain weed species becoming resistant and inter – and – intraspecific modification.

All kinds of weeds are not killed or controlled by alone herbicide and the repeated use of a single herbicide result in weed shifts and the development of herbicide resistance. The presence of diverse weed flora permits the combined use of chemical control measures. This showed the need for interference of herbicides with diverse modes of action in the rotation or sequential application for control of complex weed flora in wheat. Tank-mix or pre-mix use of different herbicide chemistries or successive application of pre-and post-emergence herbicides at dissimilar times showed real

weed control (Baghestani et al. 2008). Also managing mixed weed flora, the combined use of herbicides may help in managing herbicide resistance problems. Consequently current study, Efficacy of pre and post-emergence herbicides on growth and yield of wheat. Was undertaken.

MATERIALS AND METHODS

Site description

A field trial was led out in rabi season 2018-2019 at the experimental farm of Doon (P.G) College of Agriculture Science and Technology, Selaqui, Dehradun (Uttarakhand). The soil of this location was sandy loam having a pH of 7.7. Geographically, Selaqui is located at 20 km west from the Dehradun, the state capital of Uttarakhand, India, which is situated at 30°19'05" N and latitude 78°01'44" E/30.318°N 78.029° longitude and at an altitude of 516 m above mean sea level (MSL).

Climate of site

The climate of the site is subtropical and having the hottest months of the year are April, May, and June, when the extreme temperature goes upper as 37-38°C and the coolest months from November to February with the lowest temperature of 3 to 10°C and always chiller. The normal annual precipitation of the site is 2170.96 mm. Monthly climatological data of the trial location throughout the cropping period was expected from Forest Research Institute (FRI) Dehradun.

Experimental design and treatments

The experiment was laid out by Randomized block design thru three replications. Eleven herbicide treatments included of post emergence with and without surfactant at dissimilar doses viz. T1 PE pendimethalin @ 1 kg/ha + hand weeding at 30 days after sowing, T2 PE metribuzin @ 0.21 kg/ha at 2 DAS, T3 PoE,sulfosulfuron @ 0.025 kg/ha 30 days after sowing, T4 PoE, codinafop @ 0.06 kg/ha 30 days after sowing, T5 PE, pendimethalin + metribuzin @ 1 + 0.175 kg/ha at 2 days after sowing, T6 PE, pendimethalin + PoE, sulfosulfuron @ 1 + 0.018 kg/ha at 2 days after sowing and 30 days after sowing, T7 PoE, sulfosulfuron + metsulfuron @ 0.03 + 0.002 kg/ha 30 days after sowing, T8 PoE, mesosulfuron + iodosulfuron @ 0.012 + 0.0024 kg/ha 30 days after sowing, T9 PoE, clodinafop + metsulfuron @ 0.06 + 0.004 kg/ha 30 days after sowing, T10 2 Hand Weeding (30 and 60 days after sowing) and T11 Un-Weeded control

Crop management

Wheat variety 'Unnat PBW-343' were manually sown with an Optional dose of fertilizers Nitrogen (120 kg/ha), Phosphorus (60 kg/ha), and Potash (40 kg/ha) stood applied over DAP and MOP, respectively. Various intercultural operations such as re-sowing, thinning, irrigation, and plant shield methods like spraying pesticides were done permitting the necessities through crop growing seasons.

Observations

Data on weed density, weed control efficiency, and weed dry weight at 30, 60, 90 days after sowing, and at harvest stage were recorded by 0.5 x 0.5 m size quadrate. Biometrical observations like Weed counts intended by small quadrants (0.1m2) relative density weeds measure by the number of species in a unit area. The dry weight of weeds and crop were recorded dried the crop and weed sample in the oven at 105 0 cat 30 and 60 days after sowing and at harvest. Growth and yield attribute parameters, seed and stover yield noted, and economics like B: C was also intended by dividing gross return by the total cost of cultivation of wheat based on local market value.

Statistical analysis

The final values were showing to square root transformation $\sqrt{(x+0.5)}$ formerly statistical analysis to normalize the distribution. Data of seed and stover yield and harvest index were also to doing by the cost of inputs and marketing price of crop obtained after processing of harvested material. All the data were statistically analyzed using the F-test technique. Critical difference value at P=0.05 was only used to determine the consequence of variances between treatment means.

RESULTS AND DISCUSSION

Weed flora

At present investigation the experimental field was infested with different weed species such as monocot weed species *Phalaris minor, Cynodon dactylon* (L.) amongst dicot weeds like as *Chenopodium album, Coronopus didymus, Fumaria parviflor, Medicago denticulate, Malva praviflora Vicia, Sativa Rumex debtatus, Sisymbrium irio* were present.

Weed density and weed dry weight

Data pertinent to total weed density at 60 days and weed dry weight and weed control efficiency at harvest influenced by various weed control treatments and is presented in table 1.

At 60 days after sowing among the weed control treatments, hand weeding twice at 30 and 60 DAS (T_{10}) record significantly lowest weed density per m^{-2} (3.48) whereas un-weeded control record maximum weed density per m^{-2} (11.92). among herbicidal treatments, minimum weed density per m^{-2} (4.30) was recorded with pendimethalin @ 1 kg $a.i.ha^{-1}$ PE + hand weeding at 30 DAS (T_1) being at par with pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg $a.i.ha^{-1}$ P.E and PoE (T_6) being at par with clodinafop @ 0.06 kg $a.i.ha^{-1}$ PoE 35 DAS (T_4) and was found significantly lower over rest of treatments. At 60 days after sowing, among weed control treatments hand weeding treatment showed that

only hand weeding can totally control of weeds was only possible manually. This is in conformity with the findings of Bhullar et al. (2012) and Singh et al., (2015).

The data pertaining to weed dry weight at 60 days after sowing was significantly influenced by different weed control treatments and it's presented in table 1. At 60 days after sowing hand weeding twice at 30 and 60 DAS (**T_{10}**) observed minimum weed dry weight per m^{-2} (4.59) whereas weedy check exhibited maximum weed dry weight per m^{-2} (15.45). Among herbicidal treatments, minimum weed dry weight (5.24) was recorded under pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) being at par with pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) and was initiate significantly lesser above rest of the treatments. At 60 days stage, weedy check noted suggestively maximum weed counts and dry weight that was mostly due to advanced and continuous growth of weeds that made greatest consumption of resources. On the next side, lowermost weed counts and dry weight was recorded in hand weeding treatment noted minimum value than rest of the treatments at 60 days stages. That shows control of weeds physically at 30 and 60 days intermissions, which caused in reduced dry matter of weeds. These results are in similar with Pisal et al., (2013) and Amare et al., (2016). At 60 days after sowing among the weed control treatments, hand weeding twice at 30 and 60 DAS (T_{10}) record significantly lowest weed density per m^{-2} (3.48) whereas un-weeded control record maximum weed density per m^{-2} (11.92). among herbicidal treatments, minimum weed density per m^{-2} (4.30) was recorded with pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) being at par with pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) being at par with clodinafop @ 0.06 kg a.i.ha^{-1} PoE 35 DAS (T_4) and was found significantly lower over rest of treatments. At 60 days after sowing, among weed control treatments hand weeding treatment showed that only hand weeding can totally control of weeds was only possible manually. This is in conformity with the findings of Bhullar et al. (2012) and Singh et al., (2015).

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Table 1. Different weed control treatments in wheat crop

Treatment	Total weed density 60 DAS	Weed dry weight 60 DAS	Weed control efficiency at harvest	Weed index %	Plant height at harvest (cm)	Number of tillers at harvest
T_1 - Pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS	4.30 (18.00)	5.24 (27.00)	82.38	3.37	89.32	340.25
T_2 - Metribuzin @ 0.21 kg a.i.ha^{-1} PE at 2 DAS	5.43 (29.00)	9.49 (90.33)	78.82	8.22	86.43	335.2
T_3 - Sulfosulfuron @ 0.025 kg a.i.ha^{-1} PoE 30 DAS	5.85 (34.33)	8.59 (73.33)	79.93	7.25	87.02	332.27
T_4 - Clodinafop @ 0.06 kg a.i.ha^{-1} PoE 30 DAS	4.78 (22.33)	7.38 (54.00)	76.59	11.32	84.32	336.12
T_5 - Pendimethalin + Metribuzin @ 1 + 0.175 kg a.i.ha^{-1} P.E at 2 DAS	6.52 (42.00)	7.82 (60.67)	73.57	11.63	88.72	333.89
T_6 - Pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E at 2 DAS and PoE 30 DAS	4.52 (20.00)	5.56 (32.10)	84.34	1.32	93.06	338.21
T_7 - Sulfosulfuron + Metsulfuron @ 0.03 + 0.002 kg a.i.ha^{-1} PoE 30 DAS	5.96 (35.00)	8.63 (74.00)	81.10	9.72	87.20	337.88
T_8 - Mesosulfuron + Iodosulfuron @ 0.012 + 0.0024 kg a.i.ha^{-1} PoE 30 DAS	5.97 (35.33)	9.06 (81.67)	73.26	1.68	85.52	335.28
T_9 - Clodinafop + Metsulfuron @ 0.06 + 0.004 kg ha.i.ha^{-1} PoE 30 DAS	6.59 (43.00)	6.91 (47.67)	76.21	13.27	86.89	335.96
T_{10} - 2 Hand Weeding (30 and 60 DAS)	3.48 (5.67)	4.59 (20.67)	86.31	0.00	96.32	344.64
T_{11} - Un-Weeded control	11.92 (140.10)	15.45 (238.00)	0.00	32.78	84.33	325.12
LSD (p=00.05)	0.190	Ns	1.527	0.223	3.44	6.968

*All Figures are subjected to transformed values to square root (√x+0.5). * DAS (days after sowing), PE (Pre Emergence)

Among herbicidal treatments, minimum weed dry weight (5.24) was recorded under pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) being at par with pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) and was initiate significantly lesser above rest of the treatments. At 60 days stage, weedy check noted suggestively maximum weed counts and dry weight that was mostly due to advanced and continuous growth of weeds that made greatest consumption of resources. On the next side, lowermost weed counts and dry weight was recorded in hand weeding treatment noted minimum value than rest of the treatments at 60 days stages. That shows control of weeds physically at 30 and 60 days intermissions, which caused in reduced dry matter of weeds. These results are in similar with Pisal et al., (2013) and Amare et al., (2016).

Weed control efficiency and weed index

Weed control efficiency was intended at harvest on the base of weed dry weight and stated as %. Data associated to weed control efficiency and weed index was suggestively influenced by various weed controlling treatments and is presented in Table 1. At harvest, amongst weed control treatments, hand weeding twice at 30 and 60 DAS (**T_{10}**) recorded maximum weed control efficiency (86.31%) whereas weedy check recorded zero value. Amongst herbicidal treatments, maximum weed control efficiency (84.34%) was recorded pendimethalin *fb* Sulfosulfuron @1+ 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) being at par with pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) and was significantly superior over rest of the treatments. The zero weed index was recorded in treatment t hand weeding twice at 30 and 60 DAS (**T_{10}**) whereas weedy check recorded (32.78%) among the chemical treatments pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) being at par with pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1). These results are in similar with Kaur et al., (2017), Devi et al., (2018) Kumar and Singh (2018)**.**

Plant height and number of tillers

At harvest, amongst weed control treatments, hand weeding twice at 30 and 60 DAS (T_{10}) recorded highest plant height (96.32) whereas weedy check recorded (84.33). Amongst herbicidal treatments, maximum. Plant height was recorded in treatment pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) being at par with pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) and was significantly superior over rest of the treatments. Significantly

Table 2. Different weed management practices economics in wheat crop

Treatment	Crop dry weight at harvest (g)	Leaf area index at harvest	Number of grains per spike	Test weight (g)	Seed yield (kg/ha)	Net returns (Rs/ha)	B: C ratio
T_1 - Pendimethalin @ 1 kg a.i.ha^{-1} PE+ hand weeding at 30 DAS	10.94	3.69	33.88	42.59	2490	30569	1.82
T_2 - Metribuzin @ 0.21 kg a.i.ha^{-1} PE at 2 DAS	7.42	2.63	31.12	39.33	2310	31090	1.72
T_3 - Sulfosulfuron @ 0.025 kg a.i.ha^{-1} PoE 30 DAS	6.49	3.12	30.22	41.22	3268	32246	1.77
T_4 - Clodinafop @ 0.06 kg a.i.ha^{-1} PoE 30 DAS	9.88	2.99	32.01	42.10	2398	32456	1.80
T_5 - Pendimethalin + Metribuzin @ 1 + 0.175 kg a.i.ha^{-1} P.E 2 DAS	8.53	2.76	31.86	40.87	2346	32487	1.74
T_6 - Pendimethalin *fb* Sulfosulfuron @ 1 +0.018 kg a.i.ha^{-1} P.E AT 2 DAS and PoE 30 DAS	11.65	3.84	34.96	43.21	2540	36250	1.86
T_7 - Sulfosulfuron + Metsulfuron @ 0.03 + 0.002 kg a.i.ha^{-1} PoE 30 DAS	7.71	2.95	33.10	40.18	2212	28251	1.77
T_8 - Mesosulfuron + Iodosulfuron @ 0.012 + 0.0024 kg a.i.ha^{-1} PoE 30 DAS	8.96	2.73	32.18	39.66	2430	31980	173
T_9 - Clodinafop + Metsulfuron @ 0.06 + 0.004 kg ha.i.ha^{-1} PoE 30 DAS	9.71	3.31	33.03	41.09	2310	30670	1.78
T_{10} - 2 Hand Weeding (30 and 60 DAS)	12.96	3.41	33.24	41.43	2478	34698	1.79
T_{11} - Un-Weeded control	8.21	1.85	27.21	26.33	1895	16530	1..39
LSD (p=00.05)	1.08	0.109	0.761	0.289	3.210	-	-

*All Figures are subjected to transformed values to square root (√x+0.5). * DAS (days after sowing), PE (Pre Emergence)

number of tillers as influenced by weed management practices, the maximum number of tillers were observed per m^{-2} in treatment hand weeding twice at 30 and 60 DAS (T_{10}) (344.164) whereas weedy check recorded (325.12) tillers per m^{-2}. Amongst herbicidal treatments, maximum. Number of tiller per m^{-2} was recorded in treatment pendimethalin @ 1 kg a.i.ha^{-1} PE +hand weeding at 30 DAS (T_1) being at par with pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) These results are in similar with Biradar (2016) and Kumar et al., (2018).

Crop dry weight and Leaf area index

Data pertaining to crop dry weight and Leaf area index at harvest was significantly influenced by different weed control treatments and is presented in Table 2. At harvest the data showing, hand weeding twice at 30 and 60 DAS (**T_{10}**) recorded highest crop dry weight (12.96) whereas weedy check recorded (8.21). Amongst herbicidal treatments, maximum. Dry weight was recorded in treatment pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) being at par with pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1). Significantly maximum leaf area index at harvest is receded in treatment pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) *fb* pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) among the hand weeding twice at 30 and 60 DAS (T_{10}) recorded (3.41). Pradhan and Chakraborti (2010) and Chahal et al. (2003).

Number of grains/ spike and test weight (g)

Data of Number of grains/ spike and test weight (g) wheat was significantly influenced by different weed control treatments and are expressed in Table 2. Amongst weed management treatments, hand weeding twice at 30 and 60 DAS (T_1) recorded highest grain /spike (34.24 grains $spike^{-1}$) of wheat whereas weedy check recorded (27.21 grains $spike^{-1}$) among herbicidal treatments pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) being at par with pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1). Significantly maximum test weight was recorded in treatment pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) (43.21g) *fb* pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) in hand weeding twice at 30 and 60 DAS (T_1) (41.43 g) recorded as compare to herbicidal treatment. This result match with Tiwari et al., (2015) and Kumar and Singh (2018).

Seed yield

Data of seed yield of wheat was significantly influenced by different weed management practices and are presented in Table 2. Among weed control treatments, pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) (2540kg ha^{-1}) being at par with pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) (2490 kg ha^{-1}). hand weeding twice at 30 and 60 DAS recorded maximum grain yield (2478 q ha^{-1}) and was significantly greater than the treatments comprising a weedy check (1895kg ha^{-1}). It was mostly due to reduced weed crop competition in this treatments, though, weedy check shown their poorer value.

Net returns

Data on net return was significantly influenced by several weed management practices and are offered in Table 2. The data exposed that significantly the maximum net return (Rs.36250 ha^{-1}) was ensued with pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} P.E and PoE (T_6) which was mostly due to higher gross returns noted in this treatment as a consequence of greater economic yield of wheat. This was at par with hand weeding twice at 30 and 60 DAS (T_0), pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1) (2490 kg ha^{-1}) was superior over rest of treatments.

Benefit: cost ratio

Data on benefit: cost ratio is calculated from net return and cost of cultivation of each treatment and was expressively influenced by various weed management practices and is presented in Table 2. Uppermost benefit: cost ratio (1.86) was found with pendimethalin *fb* Sulfosulfuron @ 1+0.018 kg a.i.ha^{-1} P.E and PoE (T_6) which was found at par with pendimethalin @ 1 kg a.i.ha^{-1} PE + hand weeding at 30 DAS (T_1), Clodinafop @ 0.06 kg a.i.ha^{-1} PoE 35 DAS (T_4) *fb* hand weeding twice at 30 and 60 DAS (T_{10}). Which was mostly due to greater economic yield and net returns in these treatments and was expressively greater over rest of the treatments and weedy check which presented difference between themselves. This result is in conformity with the findings of Choudhary et al. (2016) and Kaur et al. (2017).

CONCLUSION

From the outcomes of present study, it may be concluded that treatment hand weeding twice at 30 and 60 DAS (T_{10}), recorded significantly lowest weed density & weed dry weight at 60 days after sowing and highest weed control efficiency at harvest, being at par with pendimethalin *fb* Sulfosulfuron @ 1 + 0.018 kg a.i.ha^{-1} PE at 2 DAS and PoE at 30 DAS (T_6) which also recorded significantly highest grain yield, net returns and B: C ratio in wheat.

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