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Performance of Different Herbicide on Broadleaved Weeds and Growth Pattern of Wheat

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ABSTRACT

A field experiment was conducted during *rabi* season 2016-2017 at Kalyani, under Bidhan Chandra Krishi Vishwavidyalaya to find out optimum dose of effective herbicides for controlling broadleaved weeds and improve wheat productivity. The experiment was laid out in Randomized Block Design with 3 replication and 11 treatments.Amongst the various herbicidal treatments minimum BLW weed population at 60 days after sowing (DAS) found with the 2, 4-D Na +carfentrazone @ 400+20 g ha^{-1} and were at par with metsulfuron + carfentrazone @ 4+20 g ha^{-1}, 2,4-D E + carfentrazone @ 400+20 g ha^{-1}, halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1} and carfentrazone 40DF @ 20 g ha^{-1}. Moreover, more dry weight at 60 DAS registered with the metsulfuron + carfentrazone @ 4+20 g ha^{-1} and showed parity with the 2, 4-D Na +carfentrazone @ 400+20 g ha^{-1}. Further, highest value of LAI and CGR was observed with metsulfuron + carfentrazone @ 4+20 g ha^{-1} and halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1} at different growth stages. More grain yield observed with the metsulfuron + carfentrazone @ 4+20 g ha^{-1} (47.07 q ha^{-1}) and showed parity with weed free situation. Moreover, highest grain yield was observed with weed free and registered, 6.35% more grain yield over the metsulfuron + carfentrazone @ 4+20 g ha^{-1}treated plot, which was significantly better than other treatments. The highest net return (Rs.40,086 ha^{-1}) and B:C ratio observed with metsulfuron +carfentrazone @ 4+20 g ha^{-1}(1.92), and was followed by halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}. From the study, it was concluded that use of metsulfuron +carfentrazone @ 4+20 g ha^{-1}were found to be most effective in controlling weeds and resulted more grain yield followed by halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}.

Keywords Broad- leaf weed, Herbicides,Wheat, Yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops grown in India across the exceptionally diverse range of environments (Goswami *et al.* 2020). India is the second largest producer of wheat, accounting 12% of the global production (Mondal *et al.* 2020). Today, wheat is grown on

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more land area than any other commercial crop and continues to be the most important food grain source for humans. Its production leads all crops, including rice, maize and potatoes. Wheat production reached to 102.19 million tonnes with an approximate national productivity of 3,371 kg ha^{-1} during 2019 (Director's Report 2019, IIWBR, Karnal). But for West Bengal, wheat grain contributes only 5.15% to the total food grain production and 3.1% to national production. Hence, there is an urgent need to increase wheat productivity in order to meet the food requirements of this region, realizing rapid population growth and dietary preference of Bengal people. Among the different factors which adversely impact the productivity of wheat weed infestation is the most harmful one but less manageable.Weed infestation is one of the major biotic constraints in production of wheat in new alluvial zone of West Bengal. Weed infestation in wheat become prominent and it reduce wheat yield to the tune of 31–64% (Phillips 2018). Weeds are notorious yield reducers that are, in many situations, economically more important than insects, fungi or other pest organisms (Savary *et al*. 2000). However, the magnitude of weed-related losses depends on the type and density of a particular weed species, its time of emergence and the duration of the interference (Kundu *et al*. 2020).Weed control is essential for its quality and yield. Quality of harvested grain due to poor plant growth and harvest efficiency is also affected by weed particularly broad leaved weed (BLW). Most of the BLW produced large amounts of green vegetation that hinder harvest equipment, increase moisture and foreign matter and lead to dockage. In this situation manual removal of weeds in wheat crop is a laborious, time consuming and expensive proposition due to higher rate of labor wages, non-availability of labor. Therefore, chemical control of weeds with nominal dose is the only option. Keeping in view the losses due to BLW and manual labor problem, the present study was under taken to test the relative efficacy of some new generation post emergence herbicide formulations for control of broad leaf weed and enhance the wheat productivity by improving crop growth under this zone.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season 2016-2017 at Kalyani, Nadia which come under new alluvial zone of West Bengal.The soil of the experimental field was loamy in texture, rich in organic matter with good drainage capacity. The percentage of sand, silt and clay were 48.0%, 30.3% and 21.7%, respectively as estimated by international pipette method (Piper 1966). The available N: P: K was 281.00, 24.01, 192.53 kg ha^{-1} with pH 7.1. The experimental field had fairly levelled topography and good drainage system. With the objectives to find out optimum dose of effective herbicides for controlling broadleaved weeds and to compare efficacy of different herbicides with traditional practice of hand weeding. The experiment was conducted with three replication under Randomized Block Design comprising 11 treatments combination viz.,halauxifen-methyl ester + florasulam@ 12.76 g ha^{-1}, metsulfuron methyl @ 4 g ha^{-1}, carfentrazone 40 DF @ 20 g ha^{-1}, 2, 4-D Na @ 500 g ha^{-1}, 2, 4-D E 38 EC @ g ha^{-1}, metsulfuron + carfentrazone @ 4+20 g ha^{-1}, 2, 4-D Na + carfentrazone @ 400+20 g ha^{-1}, 2, 4-D E + carfentrazone @ 400+20 g ha^{-1}, halauxifen-methyl + florasulam + carfentrazone @ 10.21+20 g ha^{-1}, weedy check and weed free. Hand weeding was done frequently in weed free plot to keep the weed free for the entire experiment. The variety of wheat (HD-2967) was sown in recommended spacing 20 cm × 15 cm by using 100 kg ha^{-1} seeds during *rabi* season on 15th Nov 2016. Necessary intercultural operations irrigation and pest management were done as and when required. All the herbicidal treatments were applied at 24 DAS with the help of knapsack sprayer. To count population of different types of broadleaved weeds m^{-2} in different plots, a quadrate having dimension of 0.5m × 0.5m was placed randomly at three places in each plot and the number of different types of weeds were counted at different intervals. Weeds obtained from each plot were washed thoroughly with tap water and labelled specifically and kept in a drier at a temperature at 70° C for a period till a constant weight is attained and then the dry weights of these weed samples were recorded separately. The data on weed density was subjected to square root transformation[√x+0.5] to normalize their distribution.

RESULTS AND DISCUSSION

Weed flora

Weed flora mainly BLW were *Chenopodium album,*

Table 1. Effect of different treatments on Broad-leaf weed density, Broad-leaf weed biomass, WCE% and WI% at different stages of crop growth. [Original figures in parentheses was subjected to square root transformation before statistical analyses] DAS: Days after sowing.

Treatments	Broad-leaf weed density (Numbers m^{-2})		Broad-leaf weed dry weight (gm^{-2})		WCE (%)		
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	WI (%)
Halauxifen - methyl Ester + Florasulam 40.85% WG @ 12.76 g/ha	6.37(40.33)	7.18(51.33)	5.72(31.89)	8.14(66.39)	79.31	76.11	18.56
Metsulfuron methyl 20WG @ 4 g/ha	6.62(43.33)	6.91(48.33)	5.55(31.50)	7.55(56.12)	80.02	79.82	13.82
Carfentrazone 40DF @ 20 g/ha	6.93(47.66)	7.73(59.33)	6.44(40.64)	8.51(72.12)	74.22	70.91	28.43
2,4-D Na (80 WP) @ 500 g/ha	7.54(57.33)	7.83(62.00)	6.66(43.92)	9.00(80.78)	72.14	74.04	32.53
2,4-D E 38 EC @ 500 g/ha	7.29(52.66)	7.32(53.33)	5.81(33.38)	8.37(71.41)	78.82	74.31	25.64
Metsulfuron + Carfentrazone @ 4+20 g/ha	5.17(26.33)	5.53(30.00)	4.91(23.17)	6.7(44.42)	85.31	84.01	6.83
2,4-D Na + Carfentrazone @ 400+20 g/ha	5.11(25.66)	6.75(45.00)	5.43(29.21)	7.27(51.91)	81.47	81.31	9.29
2,4-D E + Carfentrazone @ 400+20 g/ha	5.14(26.00)	5.86(33.66)	5.27(26.81)	7.24(51.57)	82.99	81.40	11.79
Halauxifen methyl + Florasulam+ Carfentrazone @ 10.21+20 g/ha	6.53(43.66)	5.75(33.33)	5.10(25.79)	7.02(48.64)	83.61	82.49	13.58
Weedy check	11.17(126.33)		11.72(139.33)	12.59(157.70)	16.69(277.89)		0.00
0.00	75.06						
Weed free	0.71(0.00)	0.71(0.00)	0.71 (0.00)	0.71(0.00)	100	100	-
CD (p = 0.05)	1.61	1.60	1.22	1.43			

Physalis minima, Fumaria parviflora, Amaranthus spinosus, Amaranthus viridis, Anagallis arvensis, Vicia sativa, Argemone mexicana L..

Weed density

The analysis of the data showed that there were significant effects of different herbicides on weed control. The data regarding total BLW population is presented in (Table 1) ranged from 0.00 to 126.33 and 0.00 to 139.33 m^{-2} at 60 and 90 DAS. Hhighest BLW was recorded in weedy check plot, whereas lowest density obtained in weed free plot both at 60 and 90 DAS. At 60 DAS, amongst the various herbicidal treatments the lowest weed population was recorded with 2,4-D Na + carfentrazone @ 400+20 g ha-1and significantly better to other options. At 90 DAS, with various herbicidal treatments the lowest weed population was observed with metsulfuron + carfentrazone @ 4+20g ha^{-1} and halauxifenmethyl + florasulam @ 10.21 + 20 g ha^{-1}. From the above findings, it was absolutely clear that amongst various chemical treatments, combined application of metsulfuron + carfentrazone @ 4+20 g ha^{-1} showed best performance in respect of controlling broad leaved weeds. Similar results were reported by (Chhokar *et al.* 2015). Also, halauxifen + florasulam @ 12.76 g ha^{-1}, metsulfuron @ 4 g ha^{-1} and metsulfuron + carfentrazone @ 4 + 20 g ha^{-1} provided good control at BLW population in our field.

Weed biomass

The statistical analysis of the data revealed that there was significant effect of different herbicides on weed dry weight. It was measured that the weed dry weight ranged from 0.00-157.70 g m^{-2} at 60 DAS and 0.00-277.89 g m^{-2} at 90 DAS (Table 1). Amongst herbicidal treatments, the lowest dry weight was recorded with metsulfuron + carfentrazone @ 4+20 g ha^{-1} and was at par with the halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1} and 2, 4-D E @ 500 g ha^{-1} both at 60 and 90 DAS. Data in the Table 1 revealed that, at 60 DAS, the highest weed control efficiency with various chemical treatments observed with the metsulfuron + carfentrazone @ 4+20 g ha^{-1} (85.3% and 84.01%) followed by combined application of halauxifen methyl + florasulam + carfentrazone @ 10.21+20 g ha^{-1} (83.61% and 82.49%) at both 60 and 90 DAS, respectively over the control.

Weed index

Observation from Table 1, revealed that, lowest weed indext observed with the metsulfuron + carfentrazone @ 4+20 g ha^{-1} and was followed by 2, 4-D Na + carfentrazone @ 400+20 g ha^{-1} and halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}. Lowest weed index might be due to better efficacy

Table 2. Effect of different herbicides on growth parameter at different stages of crop growth *rabi* season 2016-2017. DAS: Days after sowing.

Treatments	Plant height	LAI		CGR		
	90 DAS	60 DAS	75 DAS	30-60 DAS	61-90 DAS	Crop biomass
Halauxifen - methyl Ester + Florasulam 40.85% WG @12.76 g/ha	95.30	2.71	3.81	5.82	6.15	112.80
Metsulfuron methyl 20WG @ 4 g/ha	96.26	2.78	3.86	5.83	6.17	120.85
Carfentrazone 40DF @ 20 g/ha	93.86	2.72	3.68	5.80	6.11	109.32
2, 4-D Na (80 WP) @ 500 g/ha	91.96	2.54	3.66	5.80	6.05	103.25
2, 4-D E 38 EC @ 500 g/ha	94.53	2.71	3.79	5.81	6.13	109.61
Metsulfuron + Carfentrazone @ 4+20 g/ha	99.90	3.07	4.03	6.05	6.32	125.98
2, 4-D Na + Carfentrazone @ 400+20 g/ha	97.06	2.80	3.90	5.84	6.28	114.09
2, 4-D E + Carfentrazone @ 400+20 g/ha	97.45	2.79	3.93	5.89	6.30	121.66
Halauxifen methyl + Florasulam+ Carfentrazone @ 10.21+20 g/ha	98.13	2.82	4.00	5.91	6.31	119.56
Weedy check	76.51	2.56	3.62	5.71	6.05	36.27
Weed free	101.79	2.87	4.10	6.27	6.39	144.07
CD (p = 0.05)	5.97	0.16	0.15	0.15	0.14	14.07

of different herbicide and effective control of various dominant BLW.

Growth parameters

The data presented in (Table 2) revealed that among the treatments, highest plant height (99.90 cm) was recorded with metsulfuron + carfentrazone @ 4+20 g ha^{-1} followed by combined application of halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}, 2,4-D E + carfentrazone @ 400+20 g ha^{-1}, 2,4-D E + carfentrazone @ 400+20 g ha^{-1}, metsulfuron methyl 20WG @ 4 g ha-1 and halauxifen - methyl Ester + florasulam 40.85% WG @12.76 g ha^{-1}. They were at par to each other and statistically better to all other treatments except weed free situation. Leaf area index were significantly influenced by various treatments, and more LAI at 60 DAS, more observed with the metsulfuron + carfentrazone @ 4+20 g ha^{-1} and significantly better to all other treatments. However at 75DAS, highest LAI observed with weed free which was statistically at par with halauxifen - methyl ester + florasulam 40.85% WG @ 12.76 g ha^{-1} and Metsulfuron + Carfentrazone @ 4+20 g ha^{-1} and significantly better to other treatments. LAI varied from 3.62 to 4.10 and weedy check recorded lowest while weed free recorded highest LAI. This corroborate with the finding of Paswan *et al.* (2012). It is evident from the data that crop growth rate (CGR) differ significantly in different treatments at both the time interval (30-60 DAS and 61-90 DAS). At the time interval 30-60 DAS, the CGR was found maximum with weed free plot and minimum at weedy check plot. In weed free plot CGR is 8.9% higher than weedy check plot. Among the chemical treatments, it was found highest at metsulfuron + carfentrazone @ 4+20 g ha^{-1} (6.05) followed by halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}(5.91) and 2,4-D E + carfentrazone @ 400+20 g ha^{-1} (5.89). However, halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1} and 0.3% higher than 2,4-D E + carfentrazone @ 400+20 g ha^{-1} due to increase efficacy of halauxifen-methyl + florasulam + carfentrazone10.21+20 g ha^{-1}. At 61-90 DAS, CGR was found highest at weed free (6.39) followed by metsulfuron + carfentrazone @ 4+20 g ha^{-1} (6.32), 2,4-D E + carfentrazone @ 400+20 g ha^{-1} (6.30) and halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1} (6.31) and this were at par to each other. This mainly due to lesser weed competition and better crop growth. Further, the lowest CGR at 61-90 DAS observed with weedy check (6.05), because here crop-weed competition was much more than any other plots. The highest CGR value was observed with weed free plots during both the growth interval (6.27 and 6.39). This might be due to the fact that in weed free plots almost all weeds were removed totally and turn promotes the vigor and higher number of tillers of crop in comparison to other allotted assignment.

Table 3. Yield and yield attributes and production economics as influenced by different treatments in wheat during *rabi* season 2016-2017. NS: Non-significant.

Treatments	Effective tillers (at harvest)	Grains per earhead (No.m^{-1})	1000 grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Net income (Rs.)	B:C ratio
Halauxifen - methyl Ester + Florasulam 40.85% WG @ 12.76 g/ha	293.66	42.00	37.96	40.93	71.87	36.28	25837	1.62
Metsulfuron methyl 20WG @ 4 g/ha	306.66	42.33	38.40	43.31	77.54	35.83	30962	1.79
Carfentrazone 40DF @ 20 g/ha	284.33	35.33	37.70	35.97	73.35	32.90	23116	1.58
2, 4-D Na (80 WP) @ 500 g/ha	280.33	33.33	36.43	33.91	69.34	32.84	17506	1.41
2, 4-D E 38 EC @ 500 g/ha	285.00	35.66	37.93	37.37	72.24	34.09	22229	1.51
Metsulfuron + Carfentrazone @ 4+20 g/ha	335.33	47.33	39.73	47.07	78.91	37.36	40086	1.92
2, 4-D Na + Carfentrazone @ 400+20 g/ha	320.66	42.66	38.43	43.43	70.66	38.06	27080	1.62
2, 4-D E + Carfentrazone @ 400+20 g/ha	325.00	43.66	38.50	44.33	78.33	36.43	32278	1.76
Halauxifen methyl + Florasulam + Carfentrazone @ 10.21+20 g/ha	328.33	46.66	39.10	45.59	73.97	38.13	33676	1.78
Weedy check	247.33	33.00	36.40	12.53	23.74	34.54	13250	1.37
Weed free	347.66	54.00	40.06	50.26	93.81	34.88	33965	1.62
CD (p = 0.05)	25.29	6.50	NS	3.51	6.89	-		

Yield attributes and yield

Yield attributes such as effective tillers, grains per ear head and 1000 grain weight were influenced by different weed control measures during the experiments (Table 3). It was observed that highest effective tillers, more grain per earhead and 1000 grain weight were observed in weed free at harvest and the lowest effective tillers, grains per earhead and 1000 grain weight was recorded in weedy check among all the treatments. Among the herbicide applied treatments, application of metsulfuron + carfentrazone @ 4+20 g/ha improves these parameters followed by halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}. More effective tiller and grain per earhead observed with the metsulfuron + carfentrazone @ 4+20 g ha^{-1} and was at par with the 2,4-D E + carfentrazone @ 400+20 g ha^{-1}, halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1} and 2,4-D Na + carfentrazone @ 400+20 g ha^{-1} and significantly superior to other. Further, test weight failed to produce any statistical difference however highest observed with weed free situation and followed by metsulfuron + carfentrazone @ 4+20 g ha^{-1}.

Wheat grain yield was significantly ($p<0.05$) affected by the weed control treatments (Table 3). The highest grain yield (50.26 q ha^{-1}) and straw yield (93.81q ha^{-1}) was recorded with weed free and the lowest grain yield (12.53q ha^{-1}) and straw yield (23.74 q ha^{-1}) was indicated with weedy check. Among the herbicidal treatments, combined application of metsulfuron + carfentrazone @ 4+20 g ha^{-1} attained highest grain yield (47.07 kg ha^{-1}) and straw yield (78.91 kg ha^{-1}) followed by halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}. They were at par to each other. However, it was recorded that the application of single herbicide 2,4-D Na (80 WP) @ 500 g ha^{-1} showed lowest grain yield (33.91q ha^{-1}) but it was better over weedy check. With all chemical treatments only halauxifen methyl + florasulam + carfentrazone @ 10.21+20 g ha^{-1} showed parity with the metsulfuron + carfentrazone @ 4+20 g ha^{-1} and statistically better to other sole or mixed application of herbicides. The finding of this experiment is supported by (Singh *et al*. 2011) who concluded that the reduction on the dry weight of weed by 98-99%, increasing tiller numbers by 26%, biological yield by 28% and grain yield of wheat by 31% over untreated control and produced 41% higher tillers of wheat over untreated check. The result also gets a positive support from the findings of (Chhokar *et al.* 2015) who found that metsulfuron-methyl + carfentrazone-ethyl effectively controlled BLW and leading to increased wheat yield. The data on harvest index presented in the (Table 3) indicate that over all the treatments used, maximum was obtained with halauxifen-methyl + florasulam + carfentrazone @ 10.21+20 g ha^{-1} (38.13%) and was closely followed by 2,4-D Na + carfentrazone @ 400+20 g ha^{-1} (38.06%), metsulfuron + carfentrazone

@ 4+20 g ha^{-1} (37.36%) and 2,4-D E + carfentrazone @ 400+20 g ha^{-1} (36.43%) and the lowest was observed with (2,4-D Na @ 500 g ha^{-1}), respectively.

Economics

Data presented in (Table 3) showed that the economics of weed free and weedy check was quite distinct and this was mainly due to more intercultural operation in weed free condition. Amongst various treatments highest net return of Rs 40,086/- found with metsulfuron + carfentrazone @ 4+20 g ha^{-1} and was followed by weed free and halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}. However maximum gross income resulted from weed free and was followed by metsulfuron + carfentrazone @ 4+20 g ha^{-1} and halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}. Further, parameter of B:C ratio revealed that highest was observed with metsulfuron + carfentrazone @ 4+20 g ha^{-1} (1.92) and was followed by metsulfuron methyl @ 4 g ha^{-1} (1.79), halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1} (1.78) and 2, 4-D E + carfentrazone @ 400+20 g ha^{-1} (1.76).The result of this experiment gets a positive support from (Sidhu *et al*. 2014).

CONCLUSION

From this experiment, it can be concluded that metsulfuron + carfentrazone @ 4+20 g ha^{-1}, halauxifen methyl + florasulam+ carfentrazone @ 10.21+20 g ha^{-1}, 2,4-D E + carfentrazone @ 400+20 g ha^{-1} and 2, 4-D Na + carfentrazone @ 400+20 g ha^{-1} were found to be most effective in controlling weeds and resulted more growth of wheat which ultimately leads to higher grain yield with more economic returns in the Gangetic belt of West Bengal.

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