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Evaluation of Various Herbicide Combinations for Weed Control in Wheat Crop

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ABSTRACT

Now a day's herbicides are important tool for weed management in wheat crop. As weeds develop resistance against herbicide, cause the serious threat to wheat growers. There is urgent need to find out the new herbicide mixture to control the weeds successfully. A research was conducted in complete randomized block design having eight herbicide mixture Sulfosulfuron (SUL) + Carfentrazone [25+20], SUL+ (Halauxifen-methyl + Florasulam) (HAL+FLO) [25+12.76], SUL+ Metsulfuron (MET) [25+4], Clodinofop (CP) + (HAL+FLO)* [60+12.76], SUL+ Pyroxsulam (PYR) [25+18], CLO+PYR [60+18], CLO+MET [60+4] and Mesosulfuron + Iodosulfuron (MES+IOD) [12+2.4] with hand weeding (20 & 40 DAS) and weedy check plot at Agricultural research farm, Banaras Hindu University in *Rabi* season of 2020-21. All the herbicide mixture recorded similar density of grassy and broad leaf weeds and dry weight of grassy weeds. However, SUL+CAR [25+20] recorded lowest dry weight of broad leaf weeds with highest weed control efficiency, weed control index and crop resistance index. All herbicide mixture recorded statistically similar grain yield.

Key words: *Wheat, Herbicide mixture, Critical period of crop weed competition.*

Introduction

Wheat is an important cereal crop for world food security (Chaves *et al.*, 2013). Wheat provides about 19 % calories and 21 % protein requirements to world population (Tadesse *et al.*, 2019). In India, after rice wheat contribute 25 % food grain production in country (FAO in India 2018 & Rai *et al.*, 2019). As the population increases at rapid rate in India. Along with no additional land resource available for increasing wheat production (Sapkota *et al.*, 2014). the only way to meet the food security to increase the production per unit area of land (Kopittke *et al.*, 2019).

Wheat productivity is a function of many abiotic and biotic factors. In biotic factors, weeds are one of them that affect the yield of wheat crop (Mani *et al.*, 2016a). Earlier records of many researchers, show that the weed reduced the yield of wheat crop up to 33.60 % percent (Singh *et al.*, 2015). Major weed flora infested the wheat crop were *Phalaris minor*, *Cynodon dactylon*, *Chenopodium album*, *Melitlotus alba*, *Parthenium hysterophorus*, *Rumex dentatus* (Mani *et al.*, 2016b). Weed flora varies with field to field according to the crop, agronomic practices involved in crop production and weed management practices (Bajwa, 2014). Weed management is not easy, it is a tedious job for farmers. Due to shortage of labor at peak time with economic infeasibility of manual weeding (Sengxua *et al.*, 2018), and development of resistance against herbicides. First case of herbicide resistance was reported from Haryana, where *Phlaris minor* shows herbicidal resistance against *isoproturon* (Malik and Singh, 1995). Alternate herbicides, viz. clodinafop, fenoxaprop and sulfosulfuron were recommended for the control of *isoproturon* resistant *P. minor* biotypes in the late 1990s. After a few years of use, *P. minor* developed multiple resistances to these herbicides. To overcome the problem of herbicidal resistance, concept of herbicide mixture gaining importance. Herbicide mixture have many advantage over sole application of herbicide for example, it provides broad spectrum weed flora control (Sahu *et al.,* 2018), delay the duration of herbicide resistance, reduces the rate of herbicide active ingredient, easy to application, economic viable and safer to environment as compare to sole application of herbicide (Sangwan *et al.,* 2018). That makes the herbicide combination more popular among farmers. However, efficacy of herbicide mixture depends upon the compatibility and mode of action of mixing herbicide. Compatible herbicide having different mode of action effectively control the weeds (Chhokar *et al.,* 2012). Keeping, these view in mind study was conducted to find out the herbicide mixture that easily control the weeds.

Materials and Methods

Research was carried out during *Rabi* 2019-20 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to evaluate the bio-efficacy of different post emergence herbicide mixture.

Soil condition

The soil of the experimental field was sandy clay loam in texture class, low in organic C (0.54%) and available nitrogen (196 kg/ha). Whereas, medium in available phosphorous (P_2O_5) 21.32 kg/ha and potassium K_2O 124.50 kg/ha. The pH and electrical conductivity of soil were 7.37 and 0.35 dSm^{-1} at 25 ^0C, respectively.

Experimental Details

Experiment was conducted in randomized block design having 10 treatments [8 herbicide mixture compared with Hand weeding (20 DAS and 40 DAS) and Weedy check] and three replications. Wheat variety HD 2967, was sown manually with row to row spacing of 20 cm on 24th December 2018. Among them herbicide combination Halauxifen+Florasulam 25+12.76 g a.i/ha and Sulfosulfuron + Metsulfuron are pre mix formulation. All the herbicide mixture applied as post emerge on 5 february, 2019 that are Mesosulfuron + Iodosulfuron 14.4 (12+2.4) g a.i/ha, Sulfosulfuron + Metsulfuron 25+4 g a.i/ha, Sulfosulfuron +Carfentrazone 25+20 g a.i/ha, sulfosulfuron+ (Halauxifen+Florasulam)* 25+12.76 g a.i/ha, Sulfosulfuron +Pyroxsulam 25+18 g a.i/ha, Clodinafop +Metsulfuron 60+4 g a.i/ha, Clodinafop+ (Halauxifen + Florasulam) 60+12.76 g a.i/ha, Clodinafop+ Pyroxsulam 60+18 g a.i/ha. All the agricultural operations were done as per standard package of practice recommended for the crop. The crop was manually harvested on 12 April 2020.

Data collection

All the data are related to crop recorded at harvest, except leaf area index, density and dry matter of weeds recorded at 60 DAS (days after sowing). Density and dry weight of weeds calculated as per the

Treatment details:

S.No.	Treatment	Rate of herbicide (g a.i. ha^{-1})	Application time
1.	Mesosulfuron + Iodosulfuron	14.4g (12+2.4)	PoE
2.	Sulfosulfuron + Metsulfuron*	25+4	PoE
3.	Sulfosulfuron +Carfentrazone	25+20	PoE
4.	Sulfosulfuron+ (Halauxifen+Florasulam)*	25+12.76	PoE
5.	Sulfosulfuron +Pyroxsulam	25+18	PoE
6.	Clodinafop +Metsulfuron	60+4	PoE
7.	Clodinafop+ (Halauxifen+Florasulam)*	60+12.76	PoE
8.	Clodinafop+ Pyroxsulam	60+18	PoE
9.	Hand weeding (20DAS and 40DAS)	——	——
10.	Weedy check	——	——

*=Pre-mix formulation, PoE = Post emergence.

method given by Singh and Saini (2008). By clubbing together all the individual weed species density and dry weight, total density and dry weight was quantified. All the weeds indices weed control efficiency, weed control index and crop resistance index were estimated as per the standard formula given by Singh *et al.* (2021).

$$\text{Weed control efficiency (WCE)} = \frac{\text{Density of weeds in weedy check plot} - \text{Density of weeds in treated plot}}{\text{Density of weeds in weedy check plot}} \times 100$$

$$\text{Weed control index (WCI)} = \frac{\text{Dry matter of weeds in weedy check plot} - \text{Dry matter of weeds in treated plot}}{\text{Dry matter yield of weeds in weedy check plot}} \times 100$$

$$\textbf{Crop Resistance Index} = \frac{\text{Crop dry matter in treatment plot}}{\text{Crop dry matter in control plot}} \times \frac{\text{Weed dry matter in control plot}}{\text{Weed dry matter in treated plot}}$$

Statistical Analysis

Before data analysis, data on weed density and biomass were transformed into square root transformation to follow the normal distribution. To make clarity the mean data also present is non transformed. Statistical analysis is done as given by Gomez and Gomez (1984) at the level of 5 % probability. Whereas, least significant difference (LSD) was used to calculate mean difference.

Effect of herbicide mixture on weeds

As per the data (Table 1), all the herbicide mixture recorded statistically similar weed density of broad leaf weeds and dry weight of grassy weeds. Whereas, density of grassy weeds was similar in all herbicide mixture. Whereas, data on weed dry biomass of broad leaf herbicide combination, SUL+CAR [25+20] recorded the lowest dry biomass (3.15 g m^{-2}) of broad leaf weeds. Performance of herbicide mixture in terms weed indices (Table 1) like weeds control efficiency, weed control index and crop resistance index. As per the data on weed control efficiency revealed that highest value recorded under SUL+CAR [25+20] (58.01 %) followed by MES+IOD [12+2.4]* (48.88 %) > SUL+PYR [25+18] (47.85 %)> CLO+MET [60+4] (44.45 %) > CLO+PYR [60+18] (44.19 %)> SUL+ (HAL+FLO)* [25+12.76] (42.65 %) > CLO+ (HAL+FLO)* [60+12.76] (41.99 %) and SUL+MET [25+4] (41.50 %). Similarly, SUL+CAR [25+20] (58.89 %) recorded the highest weed control index followed by SUL+MET [25+4] (45.74 %) > CLO+PYR [60+18] (42.58 %) > MES+IOD [12+2.4]* (37.98 %) > SUL+ (HAL+FLO)*

Table 1. Effect of herbicide mixture on weed density and biomass, weed control efficiency, weed control index and crop resistance index.

Treatments	Grass weed density(m^{-2})	Broad leaf weed density (m^{-2})	Grassy weed Dry weight (g m^{-2})	Broad leaf Weed dry weight (g m^{-2})	Weed Control efficiency (%)	Weed Control Index (%)	Crop resistance Index
MES+IOD [12+2.4]*	6.56(42.67)b	9.83 (98.67)b	4.63(21.04)b	4.80 (22.79)b	48.88	37.98	2.31
SUL+MET [25+4]	6.95(48.00)b	10.49 (113.33)b	4.83(22.92)b	4.03 (15.97)b	41.50	45.74	5.60
SUL+CAR [25+20]	6.34(40.00)b	8.70 (78.67)b	4.22(17.28)b	3.51 (12.20)c	58.01	58.59	31.65
SUL+ (HAL+FLO)* [25+12.76	6.95(48.00)b	10.60 (113.33)b	4.90(23.52)b	4.63 (20.95)b	42.65	37.48	3.48
SUL+PYR [25+18]	6.66(44.00)b	9.94 (100.00)b	4.82(22.79)b	4.11 (16.84)b	47.85	44.58	13.44
CLO+MET [60+4]	6.94(48.00)b	10.15 (102.67)b	4.86(23.20)b	4.55 (20.48)b	44.45	34.08	6.96
CLO+ (HAL+FLO)* [60+12.76]	7.50(56.00)b	10.41 (108.00)b	4.90(23.73)b	4.50 (19.92)b	41.99	35.20	2.51
CLO+PYR [60+18]	7.24(52.00)b	10.08 (102.67)b	4.85(23.07)b	4.38 (18.68)b	44.19	42.85	2.41
HW (20&40DAS)	7.28(53.33)b	0.71 (0.00)c	4.03(16.04)c	0.71 (0.00)d	80.97	77.79	6.40
Weedy check	8.57(73.33)a	14.51 (210.67)a	6.00(35.60)a	6.25 (38.60)a	0.00	0.00	1.00
SEm±	0.39	0.85	0.24	0.29	–	–	–
CD(P=0.05)	1.13	2.49	0.71	0.84	–	–	–

CAR=Carfentrazone, CLO=Clodinofop, HAL= (Halauxifen-methyl+Florasulam), HW=Hand weeding, IOD=Iodosulfuron, MES=Mesosulfuron, MET=Metsulfuron, PYR=Pyroxsulam, SUL=Sulfosulfuron, *= Pre-mix formulation. Data is to square root transformation ("x+0.5) and non-transformation data is mentioned in the parenthesis.

[25+12.76] (37.48 %) > CLO+ (HAL+FLO)* [60+12.76] (35.20 %) > CLO+MET [60+4] (34.08 %). Although, herbicide mixture SUL+CAR [25+20] (31.65) recorded the highest value of crop resistance index followed by SUL+PYR [25+18] (13.44) > CLO+MET [60+4] (6.96) > SUL+MET [25+4] (5.6) > SUL+ (HAL+FLO)* [25+12.76] (3.48) > CLO+ (HAL+FLO)* [60+12.76] (2.51) > CLO+PYR [60+18] (2.41) > MES+IOD [12+2.4]* (2.31). Overall, herbicide mixture SUL+CAR [25+20] recorded the highest value weed control efficiency, weed control index and crop resistance index were 58.01 %, 58.59 % and 31.65, respectively at 60 DAS.

Effect of herbicide mixture on crop

Growth parameters

As per the data recorded on plant growth (Table 2), plant height did not show any significant difference between all the treatments. Among herbicide mixture CLO+MET [60+4] recorded the highest LAI statistically similar to HW (20&40 DAS). However, all the herbicide mixture recorded the statistically similar LAI.

Yield attributes and yield

In plant yield attributes (Table 2), only number of grain earhead^{-1} show significant difference between herbicide mixture. Herbicide mixture SUL+MET [25+4], SUL+CAR [25+20], SUL+PYR [25+18], CLO+PYR [60+18] recorded statistically similar grain earhead^{-1} to HW (20 & 40 DAS). Whereas, herbicide mixture MES+IOD [12+2.4]*, SUL+ (HAL+FLO)* [25+12.76], CLO+MET [60+4] and CLO+ (HAL+FLO)* [60+12.76] recorded statistically similar grain earhead^{-1}. However, among herbicide mixture there was no significant difference in grain yield. Highest grain yield was recorded under HW (20 & 40 DAS) and lowest recorded under weedy check. Harvesting index also did not show any statistically significant difference.

Discussion

It is already reported by Chhokar *et al.* (2012) that Carfentrazone (20 g a.i/ha), Clodinofop (60 g a.i/ha), Mesosulfuron+ Iodosulfuron (12.24 g a.i/ha), Metsulfuron (4 g a.i/ha), Pyroxsulam (18 g a.i/ha), Sulfosulfuron (25 g a.i/ha) and Halauxifen-methyl+Florasulam (12.76 g a.i/ha) for weed control in wheat crop. All the recommended herbicide in sole application have narrow spectrum of weed control but as when they applied in combination, control broad spectrum weed flora. This is reason that all the herbicide combination controls weed efficiently. Data pertaining to our experimental plot also revealed that all the herbicide combination successfully controls the broad spectrum of weed flora. All the herbicide combination recorded the similar density and dry weight of grassy and broad leaf weeds. Except in two herbicide combination where CLO+ (HAL+FLO)* [60+12.76] recorded the statisti-

Table 2. Effect of herbicide mixture on plant growth parameters, yield attributing character, grain yield and harvesting index in wheat crop.

Treatments	Plant height (cm)	Leaf area index@.‡	Spike length(cm)	Grain yield (kg/ha)	Harvesting index
MES+IOD [12+2.4]*	89.82	2.25b	10.20	3423.42b	42.02
SUL+MET [25+4]	90.58	1.99b	9.94	3453.45b	41.19
SUL+CAR [25+20]	89.30	2.23b	9.47	3543.54b	44.45
SUL+ (HAL+FLO)* [25+12.76]	87.41	2.04b	10.30	3423.42b	43.97
SUL+PYR [25+18]	89.00	2.07b	9.80	3453.45b	41.07
CLO+MET [60+4]	88.07	2.30a	9.75	3483.45b	47.75
CLO+ (HAL+FLO)* [60+12.76]	88.10	2.00b	9.70	3393.39b	40.43
CLO+PYR [60+18]	89.13	2.21b	9.80	3423.42b	39.87
HW (20&40DAS)	88.71	2.79a	10.10	4024.02a	45.70
Weedy check	90.43	1.68c	9.39	3123.12c	46.75
SEm±	1.02	0.17	0.34	115.40	1.86
CD(P=0.05)	NS	0.49	NS	336.84	NS

CAR=Carfentrazone, CLO=Clodinofop, HAL= (Halauxifen-methyl+Florasulam), HW=Hand weeding, IOD=Iodosulfuron, MES=Mesosulfuron, MET=Metsulfuron, PYR=Pyroxsulam, SUL=Sulfosulfuron, *= Pre-mix formulation. ‡ = 60 days after sowing.

cally similar density of grassy weeds as weed free. Similarly, SUL+MET [25+4] recorded the lowest dry weight of broad leaf weeds as compare to other herbicide combination.

All the herbicide recorded similar plant height, spike length and grain yield. This is may be all herbicide are applied as post emergence during the critical period of crop weed competition. Because wheat crop faces serve weed competition and drastically reduction in grain yield. If weeds are not controlled during the critical period of crop weed competition (30 – 50 days after sowing). As the resources are ample in amount crop plant uses efficiently for vegetative growth and finally it reflects into the economic yield. All the herbicide efficiently controlled the weeds. As all herbicide control weeds efficiently wheat crop uses resources efficiently. That's why the all the herbicide combination recorded the similar plant height, spike length, grain yield and harvesting index. Similarly, Kaur *et al.* (2018) also reported that if weed control during the critical crop wed competition, availability of resources to crop is increases. Availability of resources is positively co related with the higher grain production. This is reason why all the herbicide combination recorded the higher grain yield as compare to weed check plot. Similar performance of all herbicide mixture is due to all herbicide used already recommended for weed control in wheat crop.

Conclusion

Among all herbicide mixture SUL+CAR [25+20] effectively controlled the weeds in wheat crop. Also recorded the statistically similar yield of wheat crop. This herbicide mixture may be the effective tool for weed control in wheat crop.

Conflict of Interest: None

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