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Comparative Efficacy of Herbicides Applied in Wheat and their Residual Effect on the Succeeding Crops

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ABSTRACT

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The field experiment conducted at research farm, RARI, Durgapura for two consecutive years during *rabi* seasons 2013-14 and 2014-15. Results revealed that maximum reduction in weed density at 25 DAS was recorded with pendimethalin pre emergence @ 0.750 kg/ha and at 50 DAS with 2, 4-D ester @ 0.5 kg/ha, clodinafop propargyl 15 % + metsulfuran methyl 1 % @ 64 g a.i./ha and metsulfuran methyl @ 4 g a.i./ha. All the weed control treatments produced significantly higher grain and straw yield compared to weedy check. Hand weeding, except weed free produced the maximum grain and straw yield of 46.40 and 56.20 q/ha and thus out yielded over rest of the treatment. Being at par with clodinafop propargyl 15 % + metsulfuran methyl 1 % @ 64 g a.i./ha and sulfosulfuran 75 % +metsulfuran methyl 5 WG @ 32 g a.i./ha, application of clodinafop propargyl 15 % + metsulfuran methyl 1 % @ 64 g a.i./ha registered an increase of 32.6 and 35.1 per cent in grain and straw yield, respectively over weedy check and thus found as the next superior herbicidal treatment. Further, none of the applied herbicides/mixtures in *rabi* season (wheat) had residual toxicity on germination of predominant crops (pearlmillet, mungbean and clusterbean) grown in *kharif* season.

Introduction

Weeds are known to be a major biotic constraint in agricultural production systems. Estimates reveal that more than one-third of the total field losses due to biotic stresses are caused by weeds alone which often go unnoticed due to their multipronged hidden effects on plant growth (Sharma *et al.*, 2016). Weeds have better adaptability to the

changing environments by virtue of greater genetic diversity in comparison to crops. Weed management is likely to become more complex in future due to increase in their invasiveness, weed shifts, herbicides resistance in weeds and their residue hazards under changing climate (Kumar *et al.*, 2016). Increasing interest towards conservation agricultural and shortage of labour due to implementation of different development

programme in the country are increasing the acceptance of herbicides to tackle the dynamic problem of weed management. Herbicides play an important role for weed control in close spaced crops wheat, where manual or mechanical weeding is difficult. Also the mimicry weeds can hardly be weeded out by hand weeding or other mechanical methods. Chemical weed control is most suitable option to overcome this problem.

Materials and Methods

The field experiment conducted at research farm, RARI, Durgapura for two consecutive years during *rabi* seasons 2013-14 and 2014-15 on loamy sand soil. The experiment comprised of eleven weed control treatments i.e. Weedy check (T₁), Hand weeding at 30-35 DAS (T₂), 2,4-D ester @ 0.5 kg/ha at 30-35 DAS (T₃), Sulfosulfuron @ 25 g a. i. at 30-35 DAS (T₄), Metsulfuron methyl @ 4 g/ha at 30-35 DAS (T₅), Sulfosulfuron 75% + Metsulfuron methyl 5% WG @ 32g at 30-35 DAS (T₆), Piroxofop- propargyl 15% WP @60g a. i./ha 30-35 DAS (T₇), Clodinafop-propargyl15% + Metsulfuron methyl 1% @ 64g a.i./ha at 30-35 DAS (T₈), Carfentrazone ethyl @15 g/ha at 30-35 DAS (T₉), Pendimethalin pre emergence (T₁₀) and Weed free (T₁₁) were laid out in randomized block design and replicated four times. Weed density of weed species was taken at 25 and 50 DAS from five random spots in each plot by counting the number of weeds per quadrat of 0.25 m² and the average was computed. Weed density is also known as absolute density of a species. In order to draw valid conclusion, the weed count data were subjected to square root transformation ($\sqrt{x+0.5}$) as suggested by (Gomez and Gomez, 1984) before subjecting to statistical analysis. After complete sun drying, the produce of each net plot was threshed and after proper cleaning, it was weighed and

converted into quintals per hectare. The straw yield was calculated by subtracting the corresponding grain yield from the biological yield and then converted into quintals per hectare. To see the residual effect of herbicide on next crop, the counted seeds of pearl millet crop were sown just after harvesting of wheat crop. Germinating plants were counted in each row after 15 days of sowing and germination percentage was calculated by the following formula:-

Germination percentage (%) =

$$\frac{\text{Seeds germinated}}{\text{Seeds sown}} \times 100$$

Results and Discussion

Effect of different weed control practices on weed count

A perusal of data presented in Table 1 revealed that pre emergence application of pendimethalin reduced the weed count significantly at this stage of crop growth in comparison to weedy check and other treatments (as they were not applied before 25 days) during both the years as well as in pooled analysis. Pooled results indicated that pendimethalin pre emergence @ 0.750 kg/ha were found the most superior treatment that recorded significantly lower weed count of 2.72 per m² at 25 DAS, respectively than rest of the treatments except weed free. In this way, this treatment reduced the weed count to the extent of 92.5 per cent in comparison to weedy check. The data presented in Table 1 further showed that the number of monocot weeds per m² at 50 DAS was significantly influenced due to various treatments tried in the present experiment. Significantly less number of monocot weeds (5.38 m²) was recorded under treatment hand weeding (HW) plots. Hand weeding reduced the weed count

to the extent of 86.1 per cent in comparison to weedy check. Among difference post emergence herbicides, mixtures proved superior to individual molecules e.g. T8 and T6.

Dicot weeds

An appraisal of data (Table 2) revealed that pre emergence application of pendimethalin reduced the weed count significantly at this stage of crop growth in comparison to weedy check during both the years as well as in pooled analysis. Pooled results indicated that dicot weeds per m² at 25 DAS significantly differed due to different weed control treatments. Among the different treatments tried, except weed free treatment (0.00), the second best treatment emerged out from the study was pendimethalin pre emergence @ 0.750 kg/ha where significantly least number of dicot weed (6.14) was observed. This treatment reduced the weed count to the extent of 93.04 per cent, in comparison to weedy check. Perusal of data (Table 2) further indicated that all the weed control treatments either mechanical or herbicidal reduced the weed count at this stage of crop growth in comparison to weedy check during both the years as well as in pooled analysis.

Pooled data indicated that hand weeding was proved most superior which was statistically at par with post emergence application of clodinafop propargyl 15% + metsulfuran methyl 1% @ 64 g a.i./ha and 2,4-D ester @ 0.5 kg a.i./ha. Polled weed count recorded under these treatment were 4.51, 5.81, 5.97 and 6.93 per cent, respectively and reduction in dicot weed count due to these treatments were 89.06, 85.90, 85.51 and 83.18 per cent, respectively compared to weed check.. Heavy infestation of weeds under weedy check has also been reported by Agarwal and Jain (1998), Sardana *et al.*, (2001) and Singh and Singh (2005).

Effect of different weed control practices on crop productivity

Except piroxofop-propargyl 15 % WP 60 g a.i./ha all the weed control treatments significantly improved the grain yield of wheat in comparison to weedy check during both the years as well as in pooled analysis (Table 3). Pooled results showed that weed free produced the maximum grain yield of 47.72 q/ha which was statistically at par with grain yield under sulfosulfuran 75 % + metsulfuran methyl 5% WG @ 32 g a.i./ha hand weeding and clodinafoppropargyl 15 % + metsulfuran methyl 1 % @ 64 g a.i./ha and significantly superior over rest of the treatments. It registered remarkable increase in grain yield to the extent of 2.8, 4.7, 6.4, 10.7, 12.3, 15.9, 19.3, 23.2, 27.9 and 38.9 per cent over hand weeding, clodinafoppropargyl 15 % +metsulfuran methyl 1 % @ 64 g a.i./ha, sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i./ha, carfentrazone ethyl 40 % DF @ 20 g a.i./ha, metsulfuran methyl @ 4 g a.i./ ha, 2,4-D ester @ 0.5 kg/ha, sulfosulfuran @ 25 gm a.i./ha, pendimethalin pre emergence, piroxofop-propargyl 15 % WP 60 g a.i./ha and weedy check treatments, respectively. Application of hand weeding was found to next best treatment. It provided the grain yield of 4640 kg/ha that was 7.7, 9.6 12.7, 16.0, 19.8, 24.3 and 35.11 per cent more than carfentrazone ethyl 40 % DF @ 20 g a.i./ha, metsulfuran methyl @ 4 g a.i./ ha, 2,4-D ester @ 0.5 kg/ha, sulfosulfuran @ 25 gm a.i./ha, pendimethalin pre emergence, piroxofop-propargyl 15 % WP 60 g a.i./ha and weedy check treatments, respectively. However, it was found at par with clodinafoppropargyl 15 % +metsulfuran methyl 1 % @ 64 g a.i./ha (4555 kg /ha) and sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i./ha (44.85 kg /ha). The corresponding increase in grain yield due to clodinafoppropargyl 15 % +metsulfuran methyl 1 % @ 64 g a.i./ha and

sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i./ha was 5.7 and 4.1 per cent over carfentrazone ethyl 40 % DF @ 20 g a.i./ha, 7.2 and 5.5 per cent over metsulfuran methyl @ 4 g a.i./ ha, 10.6 and 8.9 per cent over 2,4-D ester @ 0.5 kg/ha, 13.8 and 12.1 per cent over sulfosulfuran @ 25 gm a.i./ha, 17.6 and 15.8 per cent over pendimethalin pre emergence, 22.1 and 20.2 per cent over piroxofop-propargyl 15 % WP 60 g a.i./ha and 32.6 and 30.6 weedy check treatments. carfentrazone ethyl 40% DF @ 20 g a.i./ha, metsulfuran methyl @ 4 g a.i./ ha, 2,4-D ester @ 0.5 kg/ha, sulfosulfuran @ 25 gm a.i./ha, pendimethalin pre emergence and piroxofop-propargyl 15 % WP 60 g a.i./ha also gave 25.4, 23.7, 19.8, 16.4, 12.7 and 8.6 per cent more grain yield than weedy check but they were noted less effective than above described treatments. Similar findings were also reported by Nadeem *et al.*, (2007) and Surin *et al.*, (2013) and Kumar *et al.*, (2010).

A critical examination of the data presented in Table 3 revealed that straw yield of wheat was also influenced in same manner due to different weed control treatments as in the grain yield. Pooled results showed that weed free produced the maximum straw yield (5729 kg/ha) which was higher of 1.09, 1.83, 2.77, 6.22, 6.68, 8.37, 8.73, 9.80, 12.31 and 16.23 q/ha over hand weeding, clodinafoppropargyl 15 % + metsulfuran methyl 1 % @ 64 g a.i./ha, sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i./ha, carfentrazone ethyl 40 % DF @ 20 g a.i./ha, metsulfuran methyl @ 4 g a.i./ ha, 2,4-D ester @ 0.5 kg/ha, sulfosulfuran @ 25 gm a.i./ha, pendimethalin pre emergence, piroxofop-propargyl 15 % WP 60 g a.i./ha and weedy check treatments, respectively. Application of hand weeding, clodinafoppropargyl 15 % + metsulfuran methyl 1 % @ 64 g a.i./ha and sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i./ha were found the next superior and equally effective treatments in

enhancing straw yield of wheat. These treatments improved the straw yield to the extent of 36.8, 35.0 and 32.0 per cent over control. Carfentrazone ethyl 40 % DF @ 20 g a.i./ha, metsulfuran methyl @ 4 g a.i./ ha, 2,4-D ester @ 0.5 kg/ha, sulfosulfuran @ 25 gm a.i./ha, pendimethalin pre emergence and piroxofop-propargyl 15 % WP 60 g a.i./ha also enhanced the straw yield by margin of 24.3, 23.2, 19.1, 18.2, 15.6 and 9.5 per cent. Similar findings were also reported by Nadeem *et al.*, (2007) and Surin *et al.*, (2013).

Residual effect of different weed control practices on germination of various succeeding crops

Pearl millet

A perusal of pooled data of two years (Table 4) revealed that highest germination per cent (98%) was reported in plots that were weed free plot, hand weeded and receiving clodinafop propargyl 15 % + metsulfuran methyl 1 % @ 64 g a.i./ha in previous season followed by 2,4-D ester @ 0.5 kg/ha, sulfosulfuran @ 25 gm a.i./ha and metsulfuran methyl @ 4 g a.i./ ha. These treatments attained 97 per cent germination. However, the lowest germination per cent was observed in plots of weedy check plots *i.e.* 94 per cent.

Mungbean

A perusal of pooled data of two years (Table 4) revealed that highest germination per cent (97%) was reported for 2,4-D ester @ 0.5 kg/ha, sulfosulfuran @ 25 gm a.i./ha, metsulfuran methyl @ 4 g a.i./ ha, carfentrazone Ethyl 40 % DF @ 20 g a.i./ha and pendimethalin pre emergence followed by hand weeding, clodinafop propargyl 15 % +metsulfuran methyl 1 % @ 64 g a.i./ha and sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i./ha.

Table.1 Effect of weed control treatments on monocot weed population at 25 and 50 DAS of wheat

Treatments	Monocot weed population (No m ⁻²)					
	25 DAS			50 DAS		
	2014	2015	Pooled	2014	2015	Pooled
Weedy check	36.19	36.39	36.29	38.76	38.81	38.79
	(6.06)	(6.07)	(6.07)	(6.27)	(6.27)	(6.27)
Hand weeding at 30 – 35 DAS	35.67	36.15	35.91	5.37	5.39	5.38
	(6.01)	(6.05)	(6.03)	(2.42)	(2.43)	(2.42)
2,4-D ester @ 0.5 kg/ha at 30 – 35 DAS	29.82	30.22	30.02	32.07	33.17	32.62
	(5.51)	(5.54)	(5.52)	(5.71)	(5.8)	(5.75)
Sulfosulfuran @ 25 gm a.i./ha at 30 – 35 DAS	30.78	30.79	30.79	10.37	10.75	10.56
	(5.59)	(5.59)	(5.59)	(3.3)	(3.35)	(3.33)
Metsulfuran Methyl @ 4 g a.i. / ha at 30 – 35 DAS	30.67	31.17	30.92	31.67	32.62	32.15
	(5.58)	(5.63)	(5.61)	(5.67)	(5.75)	(5.71)
Sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i. /ha at 30 – 35 DAS	31.87	32.88	32.38	9.11	9.59	9.35
	(5.69)	(5.78)	(5.73)	(3.1)	(3.18)	(3.14)
Piroxofop-Propargyl 15 % WP 60 g a.i. /ha at 30 – 35 DAS	33.67	34.07	33.87	11.92	12.1	12.01
	(5.85)	(5.88)	(5.86)	(3.52)	(3.55)	(3.54)
Clodinafoppropargyl15 % +metsulfuran methyl 1 % @ 64 g a.i. /ha at 30 – 35 DAS	33.09	34.19	33.64	7.92	7.99	7.96
	(5.8)	(5.89)	(5.84)	(2.9)	(2.91)	(2.91)
Carfentrazone Ethyl 40 % DF @ 20 g a.i./ha at 30 – 35 DAS	30.9	30.00	30.45	33.9	34	34.03
	(5.6)	(5.52)	(5.56)	(5.87)	(5.89)	(5.88)
Pendimethalin pre emergence	2.68	2.75	2.72	22.03	22.23	22.13
	(1.78)	(1.80)	(1.79)	(4.75)	(4.77)	(4.76)
Weed free	0	0	0	0	0	0
	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)
SEm₊	1.11	1.31	0.86	0.88	0.81	0.60
CD (P=0.05)	3.20	3.79	2.43	2.53	2.33	1.68

Table.2 Effect of weed control treatments on dicot weed population at 25 and 50 DAS of wheat

Treatments	Dicot Weed population (No m ⁻²)					
	25 DAS			50 DAS		
	2014	2015	Pooled	2014	2015	Pooled
Weedy check	36.13	38.03	37.08	41.13	41.28	41.21
	(6.3)	(6.37)	(6.33)	(6.45)	(6.46)	(6.46)
Hand weeding at 30 – 35 DAS	35.18	34.82	35.00	4.36	4.66	4.51
	(5.97)	(5.94)	(5.96)	(2.20)	(2.27)	(2.24)
2,4-D ester @ 0.5 kg/ha at 30 – 35 DAS	34.78	36.43	35.61	6.80	7.05	6.93
	(5.94)	(6.08)	(6.01)	(2.70)	(2.75)	(2.72)
Sulfosulfuran @ 25 gm a.i./ha at 30 – 35 DAS	35.16	37.00	36.08	36.7	37.17	36.94
	(5.97)	(6.12)	(6.05)	(6.10)	(6.14)	(6.12)
Metsulfuran Methyl @ 4 g a.i. / ha at 30 – 35 DAS	31.92	33.17	32.55	5.93	6.00	5.97
	(5.69)	(5.8)	(5.75)	(2.54)	(2.55)	(2.54)
Sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i. /ha at 30 – 35 DAS	35.04	36.92	35.98	7.93	8.13	8.03
	(5.96)	(6.12)	(6.04)	(2.90)	(2.94)	(2.92)
Piroxofop-Propargyl 15 % WP 60 g a.i. /ha at 30 – 35 DAS	35.16	35.11	35.14	36.78	36.88	36.83
	(5.97)	(5.97)	(5.97)	(6.11)	(6.11)	(6.11)
Clodinafop-propargyl15 % +metsulfuran methyl 1 % @ 64 g a.i. /ha at 30 – 35 DAS	34.92	35.15	35.04	5.73	5.89	5.81
	(5.95)	(5.97)	(5.96)	(2.50)	(2.53)	(2.51)
Carfentrazone Ethyl 40 % DF @ 20 g a.i./ha at 30 – 35 DAS	32.67	33.00	32.92	6.87	7.00	6.93
	(5.76)	(5.8)	(5.78)	(2.71)	(2.74)	(2.73)
Pendimethalin pre emergence	6.16	6.12	6.14	25.43	25.81	25.62
	(2.58)	(2.57)	(2.58)	(5.09)	(5.13)	(5.11)
Weed free	0	0	0	0	0	0
	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)
SEm+	1.46	1.49	1.04	0.67	0.89	0.56
CD (P=0.05)	4.21	4.29	2.94	1.94	2.58	1.58

Table.3 Effect of weed control treatments on grain and straw yield of wheat

Treatments	Grain yield (q/ha)			Straw yield (q/ha)		
	2014	2015	Pooled	2014	2015	Pooled
Weedy check	34.22	34.46	34.34	40.77	41.35	41.06
Hand weeding at 30 – 35 DAS	45.81	46.99	46.40	56.06	56.33	56.20
2,4-D ester @ 0.5 kg/ha at 30 – 35 DAS	40.73	41.56	41.15	48.80	49.04	48.92
Sulfosulfuran @ 25 gm a.i./ha at 30 – 35 DAS	39.63	40.37	40.00	48.69	48.42	48.56
Metsulfuran Methyl @ 4 g a.i. / ha at 30 – 35 DAS	41.38	43.58	42.48	50.07	51.16	50.61
Sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i. /ha at 30 – 35 DAS	43.98	45.71	44.85	53.61	55.43	54.52
Piroxofop-Propargyl 15 % WP 60 g a.i. /ha at 30 – 35 DAS	37.03	37.56	37.30	43.87	46.09	44.98
Clodinafop-propargyl 15 % +metsulfuran methyl 1 % @ 64 g a.i. /ha at 30 – 35 DAS	44.91	46.19	45.55	54.98	55.94	55.46
Carfentrazone Ethyl 40 % DF @ 20 g a.i./ha at 30 – 35 DAS	42.01	44.15	43.08	50.40	51.74	51.07
Pendimethalin pre emergence	38.33	39.11	38.72	46.75	48.22	47.49
Weed free	46.75	48.69	47.72	56.17	58.40	57.29
SEm±	1.40	1.60	1.06	2.03	2.34	1.55
CD (P=0.05)	4.03	4.62	3.00	5.88	6.76	4.39

Table.4 Residual effect of weed control treatments on germination of succeeding crops

Treatments	Germination% (Pearlmillet)			Germination% (Moongbean)			Germination% (Clusterbean)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Weedy check	94	94	94	94	94	94	94	95	94
Hand weeding at 30 – 35 DAS	98	98	98	95	97	96	95	95	95
2,4-D ester @ 0.5 kg/ha at 30 – 35 DAS	97	96	97	97	97	97	97	97	97
Sulfosulfuran @ 25 gm a.i./ha at 30 – 35 DAS	97	97	97	97	97	97	97	97	97
Metsulfuran Methyl @ 4 g a.i. / ha at 30 – 35 DAS	97	97	97	97	97	97	96	97	96
Sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i. /ha at 30 – 35 DAS	96	96	96	96	96	96	96	96	96
Piroxofop-Propargyl 15 % WP 60 g a.i. /ha at 30 – 35 DAS	95	95	95	95	95	95	94	95	95
Clodinafop-propargyl 15 % +metsulfuran methyl 1 % @ 64 g a.i. /ha at 30 – 35 DAS	98	98	98	95	96	96	95	94	95
Carfentrazone Ethyl 40 % DF @ 20 g a.i./ha at 30 – 35 DAS	96	96	96	96	97	97	96	96	96
Pendimethalin pre emergence	95	95	95	96	97	97	96	96	96
Weed free	98	98	98	94	93	94	96	94	95

These treatments attained 96 per cent germination. However, the minimum germination per cent was depicted by weed free and weedy check plots i.e. 94 per cent.

Clusterbean

A perusal of pooled data of two years (Table 4) revealed that highest germination per cent (97%) was reported for 2, 4-D ester @ 0.5 kg/ha and sulfosulfuran @ 25 gm a.i./ha followed by carfentrazone Ethyl 40 % DF @ 20 g a.i./ha, pendimethalin pre emergence, metsulfuran methyl @ 4 g a.i./ ha and sulfosulfuran 75 % +metsulfuran methyl 5% WG @ 32 g a.i./ha. These treatments attained 96 per cent germination. However, the lowest germination per cent was depicted by weedy check plots i.e. 94 per cent. These results are in line with those of Yadav *et al.*, (2003), Singh and Ali (2004), Chopra and Chopra (2005), Vala (2005) and Singh *et al.*, (2012).

Based on the results of two years experimentation, it is concluded that conventional method of hand weeding is the most effective and remunerative weed control measure in wheat. Amongst herbicides, clodinafop propargyl 15 % + metsulfuran methyl 1 % @ 64 g a.i./ha or sulfosulfuran 75 % + metsulfuran methyl 5 WG @ 32 g a.i./ha found best option for weed control in wheat under especially in labour scarce regions. Further, none of the applied herbicides/mixtures applied in *rabi* season (wheat) had residual toxicity on predominant crops (pearlmillet, mungbean and clusterbean) grown in *kharif* season.

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