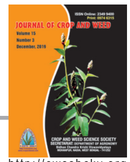
Journal of Crop and Weed, 17(1): 235-241 (2021)

ISSN- O : 2349 9400 ; P : 0974 6315



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Comparative analysis of different weedicides against various weed flora, crop growth and yield in wheat (*Triticum aestivum* L.)

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Received : 19.12.2019 ; Revised : 22.12.2020 ; Accepted : 26.12.2020

DOI : https://doi.org/10.22271/09746315.2021.v17.i1.1430

ABSTRACT

Mostly weeds are ubiquotous and repugnant in nature which competes with crops for water, nutrients and sunlight, so weed infestation is one of the major threats to crop. Present investigation was aimed to assess the impact of different weedicides for weed management in wheat crop under agro-climatic conditions of Faridabad. This experiment was conducted at Dayalpur, Mohna village of Faridabad. The experiment was carried out in a Randomised block design (RBD) with three replications. Different weedicides were used for weed management in wheat crop. These include application of 2, 4-D @ 750 g ai/ha, Pendimethalin @1.0 kg a i ha^{-1}, Fenoxaprop ethyl @100 g a i ha^{-1}, Clodinafop @ 60 g a i ha^{-1}, Sulfosulfuron@25 g a i ha^{-1}. For comparison among weedicides, control (weedy check) were also included. In each replication, six treatments of these five weedicides including control were taken. The significantly affected parameters were density and dry weight, weed control efficiency (%), weed index of weeds taken from sedges, grasses and BLW where statistical analysis showed that maximum weed control efficiency (84%) was recorded with 2, 4-D followed by Sulfosulfuron whereas minimum value (37%) was with control (weedy check). Similarly maximum number of tillers m^{-2} (250) was recorded for 2, 4-D followed by Sulfosulfuron and minimum (133) in control (weedy check). The herbicide 2, 4-D followed by Sulfosulfuron weedicide was applied at post emergence performed well and exhibited effectively weed control and better yield in wheat.

Keywords: Weedicides, weed index, W.C.E., weed flora, wheat yield.

Wheat (*Triticum aestivum* L.) is one of the most important staple food crops of the India. In Haryana, wheat is cultivated in 2.52 m ha with a production of 11.78 mt and productivity of 4.67 t ha^{-1} (Anon., 2018). Even though, we have almost reached a plateau in wheat productivity per unit area due to various biotic and abiotic factors, yet wheat is considered as most important crop of the Haryana, which is essential for country's nutritional security (FAO, 2018). Wheat is a chiefly rabi season crop; therefore, it fits well for sowing at the 1st week of November. At present, wheat is grown in about 15 countries of the world on a wide range of soils and agro climatic conditions (Kamboj *et al*., 2017). In Faridabad district, it is grown as an irrigated crop (November to February) in the villages of Dayalpur and Mohna. There are several constraints in wheat production, of which weeds often pose a serious problem. It is a very good competitor with weeds because of good agronomic practices in the initial emergence phase. The yield reduction due to weeds in wheat is estimated to be as high as 10 to 80 per cent (Pandey *et al*., 2006).

So, control of weeds in the initial stages appears imperative as it plays an important role in maximizing the ear (yield) production (Dev *et al*., 2013). Timely weed control may not be possible manually due to non-availability of labours and high rate of wages during peak period of farm operations (Mukherjee, 2018). Hence, chemical weed control appears to hold a great promise in dealing with effective, timely and economic weed suppression (Ravikumar *et al*., 2017).

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2018 at Dayalpur and Mohna, Faridabad, Haryana. The experimental site is geographically situated in the Northern Transitional Zone (Zone - 7) of Haryana and located between 12º 13' and 13º 33' N Latitude and 75º 33' and 76º 38' E Longitude at an altitude of 827 m above Mean Sea Level (MSL). The soil of the experimental site was red sandy loam. The experiment was laid out in randomized block design (RBD) with six treatments and replicated three times. The treatments comprised of five herbicide levels and control (weedy check). The data was statistically analyzed following methods of Gomez and Gomez (1984). The observations on weed growth like weed density and weed dry weight were recorded at 20, 40, 60, 80 DAS and at harvest. Data on weed count and weed dry weight showed high variation. The wheat variety taken for sowing purpose was PBW 502, an irrigated timely sown variety in Haryana. To make the analysis of variance more valid the data on weed count and weed dry weight was subjected to square root transformation by using formula $\sqrt{x + 0.5}$ (Chandel, 1984). Critical difference for the significant source of variation was calculated at five per cent level of significance.

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Observations on weed

1. Statistical Analysis

Data were taken for the year 2018-2019 and after that combine mean was calculated. The data of all the parameters were then individually subjected to ANOVA technique by using CD for the separation of means.

1.1 Weed control efficiency (%)

Data analysis showed that different weedicides significantly affected the weed control efficiency. The data of weed control efficiency was calculated on dry weight basis by the following formula :

$$\text{WCE}\left(\%\right) = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

Where,

WCE = Weed control efficiency (%)

DWC = Dry weight of weeds in control (weedy check plot) (g m^{-2})

DWT = Dry weight of weeds in treated plot (g m^{-2})

The maximum weed efficiency (93.62) was recorded for 2, 4-D followed by Sulfosulfuron while the minimum value (84.29) was recorded for control (weedy check).

1.2 Fresh Weed Biomass (Kg ha^{-1})

Fresh weed biomass was significantly affected by different weedicides application. Data of fresh weed biomass showed that maximum fresh weed biomass (3177 kg ha^{-1}) was reported in the plot of control (weedy check) while minimum weed biomass (1010 kg ha^{-1}) was reported in the 2, 4-D followed by Sulfosulfuron (1130 kg ha^{-1}).

1.3 No. of weed count (No. m^{-2})

In each treatment a quadrant of 0.5 m x 0.5 m was earmarked in the net plot for recording weed count. From the quadrant weeds were removed and number of sedges, grasses and broad leaf weeds were counted and recorded. Later the original values were transformed to square root transformation ($\sqrt{X+0.5}$) and subjected to statistical analysis.

1.4 Dry weight of weed (g m^{-2})

The weeds present within the quadrant area were uprooted, and transferred to brown envelope. After air drying again weeds were dried in the hot air oven at 70^{o} C till the constant weights obtained.

1.5 Weed index (%)

It is an index expressing the reduction in yield due to presence of weeds in comparison with weed free situation where weedicides were applied. It was expressed in percent and calculated by using the formula given below:

$$\text{WI}\left(\%\right) = \frac{\text{Maximum grain yield} - \text{Grain yield in a treatment}}{\text{Maximum grain yield}} \times 100$$

Observations on crop plant

2. Statistical Analysis

Data were taken for the 2018-2019 and after that combine mean was calculated. The data of all the parameters were then individually subjected to ANOVA technique by using CD for the separation of means.

2.1 Plant height (cm.) & LAI

Growth is proportional to plant height and LAI. Maximum plant height was observed with 2, 4-D followed by Sulfosulfuron while the minimum value was recorded for control (weedy check).

2.2 Effective tillers (no. m^{-2}) & earhead length (cm.)

Effective tillers & earhead length was significantly affected by different weedicides application. Data showed that maximum **effective tillers & earhead length** at 60 DAS was reported in the plot of 2, 4-D followed by Sulfosulfuron while minimum was reported in the control (weedy check).

2.3 Grain yield (t ha^{-1}) and total biomass production (t ha^{-1})

Yield is an expression of plant growth. There will be reduction in yield and biomass production due to presence of weeds. Maximum yield and biomass were observed with 2, 4-D followed by Sulfosulfuron while the minimum value was recorded for control (weedy check).

RESULTS AND DISCUSSION

Effect of weed management practices on weed growth

The major weed flora observed in the experimental fields were *Cannabis sativa* (cannabiaceae), *Cynodon dactylon* (poaceae), *Fumaria indica* (papaveraceae), *Chenopodium album* and *Chenopodium murales* (Chenopodiaceae). Other weeds noticed in lower densities were *Sida acuta* (malvaceae), *Achyranthus aspera* (initial 30 DAP), *Euphorbia hirta* (initial 60 DAP). Weed management practices significantly influenced the sedge, grass, broad leaf weeds and total weed density at harvest (Table 1). Among the different weedicides, BLW density and dry weight was significantly lower in 2, 4-D followed by Sulfosulfuron as post-emergent application. However, significantly higher BLW density and dry weight was found in control (Weedy check). So, herbicidal action plays a significant role in controlling the weed density and dry weight of weeds by enzyme activity inhibition and caused for the disruption of protein synthesis and other subsequent bio-chemical reactions which in turn inhibited the weed growth and lower density and dry weight of BLW. The results are in conformity with the findings of Fahad *et al.* (2013).

Among the different weedicides application 2, 4-D followed by Sulfosulfuron as early post emergent recorded significantly lower broad leaved and total weed density (43.1 and 40.2), lower weed dry weight (40.2 and 35.5) and it was followed by Sulfosulfuron as early post emergent. Significantly higher grasses, broad leaved and weed density, weed dry weight were recorded in control (weedy check). The lower density and dry weight of weeds at plots of 2, 4-D followed by Sulfosulfuron was due to the competitive inhibition of the acetyl coenzyme A carboxylase (ACCase) enzyme in susceptible grass plants thereby blocking lipid biosynthesis. The results are in conformity with the findings of Khan *et al.,* (2003). There was strong positive linear relationship between grain yield and density of weeds in 2018 with R^2=0.47 (Fig. 1).

Table 1: Efficacy of different weedicides on density of weeds

Treatment	Density of weeds (no. m^{-2})		
	Sedges	**Grasses**	**BLW**
2,4-D @ 750 g ai/ha	1.5 (31.0)	1.6 (34.2)	1.9 (43.1)
Sulfosulfuron@ 25 g ai/ha	1.4 (24.7)	1.4 (21.3)	1.8 (40.2)
Fenoxaprop @100 g ai/ha	1.4 (23.7)	1.3 (18.7)	1.8 (39.1)
Cladinofop @60 g ai/ha	1.3 (20.5)	1.3 (18.5)	1.7 (34.5)
Pendimethalin @1 kg ai/ha	1.3 (19.6)	1.2 (15.3)	1.6 (33.8)
Control (weedy check)	0.30 (0.0)	0.30 (0.0)	0.30 (0.0)
SEm (±)	**0.03**	**0.03**	**0.03**
LSD (0.05)	**0.09**	**0.10**	**0.08**

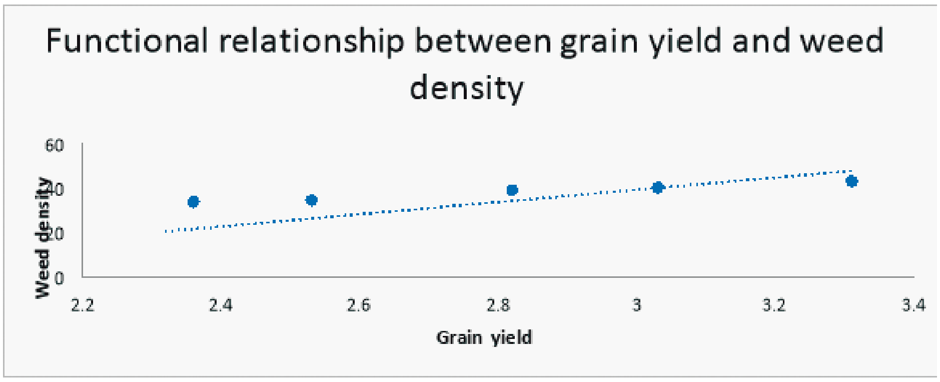

Fig. 1: Functional relationship between grain yield and weed dry matter

Table 2: Efficacy of different weedicides on dry weight of weeds

Treatment	Dry weight of weeds		
	Sedges	**Grasses**	**BLW**
2,4-D @ 750 g a i ha^{-1}	5.4 (29.8)	5.9 (33.6)	6.4 (40.2)
Sulfosulfuron@ 25 g a i ha^{-1}	3.6 (14.9)	4.6 (31.2)	5.2 (35.5)
Fenoxaprop @100 g a i ha^{-1}	3.4 (13.7)	3.8 (22.0)	4.0 (28.1)
Cladinofop @60 g a i ha^{-1}	3.3 (11.5)	3.6 (18.6)	3.7 (22.5)
Pendimethalin @1 kg a i ha^{-1}	3.1 (9.6)	3.3 (15.3)	3.5 (19.8)
Control (weedy check)	0.30 (0.0)	0.30 (0.0)	0.30 (0.0)
SEm (±)	**0.08**	**0.11**	**0.10**
LSD (0.05)	**0.25**	**0.34**	**0.30**

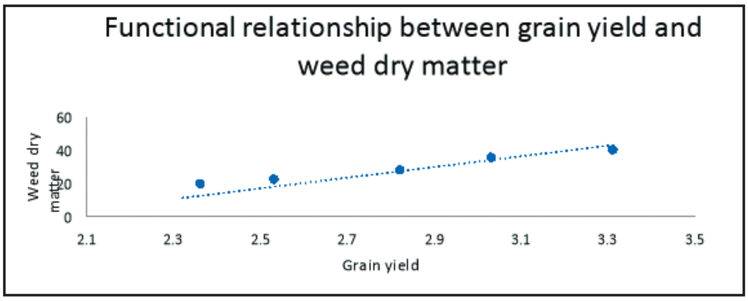

Fig. 1: Functional relationship between grain yield and weed dry matter

Category wise weed density (no. m^{-2}) and category wise weed dry weight (g m^{-2}) at harvest in potato as influenced by weed management practices. Data within parentheses are original values and data analyzed using square root (x+1) transformation;

Note : BLW- Broad leaf weeds DAP- Days After Planting.

Effect of weed management practices on weed control efficiency

Weed control efficiency is a measure of the efficiency of weed control methods in restricting the weed growth (Shiland *et al*., 2018). The crop yield is directly proportional to weed control efficiency (WCE) and inversely related to weed index (WI). Application of 2, 4-D as early post emergent recorded higher weed control efficiency (93.62 %) followed by Sulfosulfuron (84.29 %) at 60 DAP. This was due to better control of weeds during crop growth period which lowered the total weed population and its dry weight (Table 3). Application of 2, 4-D as early post emergent registered lower weed index (19.29 %) followed by Sulfosulfuron (28.50 %) may be due to significant reduction in the weed dry weight as a result of broad spectrum weed control and elimination of competition from weeds during critical period of crop weed competition. These results are in accordance with Singh *et al*., (2010). Growth attributes and crop quality depend on effective application of weedicides. Inadequate quantity of chemical wastes time, money and materials. An overdose adds to the cost, may damage the crop, and can cause environmental pollution. Proper selection, use and application on particular stage is prerequisite for the killing of unwanted plant in the crop field.

Table 3: Efficacy of different weedicides on weed control efficiency and weed index

Treatments	Weed control efficiency	Weed index
2,4-D @ 750 g ai/ha	93.62	19.29
Sulfosulfuron@ 25 g ai/ha	84.29	28.50
Fenoxaprop @100 g ai/ha	80.13	31.52
Cladinofop @60 g ai/ha	70.62	33.55
Pendimethalin @1 kg ai/ha	68.91	35.69
Control (weedy check)	-	57.22
SEm (±)	**2.41**	**3.58**
LSD (0.05)	**7.01**	**9.45**

Crop growth parameters

Plant biometric parameters such as plant height, leaf area index (LAI), effective tiller (no. m^{-2}) and earhead length (cm.) were significantly ($p<0.05$) influenced by weed control treatments (Table 1, 2 and 3) and found to be higher in plots treated with 2,4-D followed by Sulfosulfuron and least plant height, leaf area index (LAI), effective tiller (no. m^{-2}) and earhead length (cm.) were obtained at control (weedy check). The wheat crop was taller in treated plots at harvest, leaf area index at 90 DAS was higher which would increased the photosynthetic assimilates thereby increased effective tillers (no. m^{-2}) at 60 DAS. Earhead length was found to increase at 60 DAS which is ultimately responsible for the increase in grain yield of wheat and total biomass production (t ha^{-1}) in 2,4-D followed by Sulfosulfuron and least grain yield and biomass production (t ha^{-1}) were obtained at control (weedy check). There was strong positive linear relationship between grain yield and weed density (t ha^{-1}) in 2018 with R^2=0.47 (Fig. 1).

Yield attributes

Wheat grain yield was significantly ($p<0.05$) affected by weed control treatments .The highest grain yield 3.31 t ha^{-1} and total biomass production 5.69 t ha^{-1} in 2018 was remarkably found in the plots treated with 2, 4-D and subsequently it was followed by Sulfosulfuron with 3.03 t ha^{-1} grain yield and 5.31 t ha^{-1} total biomass production including grain and straw. The lowest wheat grain yield was recorded at control (weedy check) where least grain yield 2.11 t ha^{-1} and lower biomass production including grain and straw 4.02 t ha^{-1} were obtained. Wheat grain yield and biomass production had showed a positive linear relationship with coefficient of regression of 0.99 (Figure 2).

Table 1. Plant height (cm.)

Treatment	Plant height (cm.)			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
2,4-D @ 750 g ai/ha	49.86	69.99	87.16	87.99
Sulfosulfuron@ 25 g ai/ha	43.25	62.01	82.49	81.05
Fenoxaprop @100 g ai/ha	40.29	58.62	78.66	77.92
Cladinofop @60 g ai/ha	36.95	54.04	75.85	75.16
Pendimethalin @1 kg ai/ha	34.82	51.68	73.21	72.71
Control (weedy check)	31.69	48.99	70.66	70.22
SEm (±)	1.53	1.73	1.71	1.76
LSD (0.05)	3.99	4.25	4.16	4.31

Table 2. Leaf area index

Treatment	Leaf Area Index			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
2,4-D @ 750 g ai/ha	2.76	3.10	3.22	3.20
Sulfosulfuron@ 25 g ai/ha	2.52	2.91	2.95	2.91
Fenoxaprop @ 100 g ai/ha	2.31	2.49	2.53	2.50
Cladinofop @ 60 g ai/ha	2.01	2.10	2.14	2.11
Pendimethalin @ 1 kg ai/ha	1.92	2.06	2.09	2.06
Control (weedy check)	1.83	2.00	2.03	2.01
SEm (±)	5.11	0.06	0.08	0.09
LSD (0.05)	15.72	0.17	0.29	0.31

Table 3. No. of effective tillers (no. m^{-2})

Treatment	Effective tillers (no. m^{-2})			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
2,4-D @ 750 g ai/ha	148.21	187.18	169.48	163.12
Sulfosulfuron@ 25 g ai/ha	136.42	180.57	161.23	156.35
Fenoxaprop @100 g ai/ha	129.11	172.63	158.21	152.86
Cladinofop @60 g ai/ha	122.86	165.67	149.99	144.23
Sulfosulfuron@ 25 g ai/ha	118.41	177.15	162.42	157.88
Control (weedy check)	109.69	152.81	144.23	138.62
SEm (±)	5.11	9.07	6.57	5.82
LSD (0.05)	15.72	27.81	19.69	17.55

Table 4: Earhead length (cm.)

Treatment	Earhead length (cm.)			
	30 DAS	60 DAS	90 DAS	At harvest
2,4-D @ 750 g a i ha^{-1}	8.96	9.24	9.16	9.11
Sulfosulfuron@ 25 g a i ha^{-1}	8.55	8.86	8.78	8.75
Fenoxaprop @100 g a i ha^{-1}	8.51	8.72	8.64	8.63
Cladinofop @60 g a i ha^{-1}	8.22	8.56	8.48	8.45
Pendimethalin @1 kg a i ha^{-1}	8.01	8.44	8.36	8.33
Control (weedy check)	7.59	7.95	7.87	7.83
SEm (±)	0.18	0.22	0.23	0.25
LSD (0.05)	NS	0.58	NS	NS

Table 5: Efficacy of different weedicides on grain yield and total biomass production (t ha^{-1})

Treatments	Grain yield(t ha^{-1})	Total biomass production(t ha^{-1})
2,4-D @ 750 g a i ha^{-1}	3.31	5.69
Sulfosulfuron@ 25 g a i ha^{-1}	3.03	5.31
Fenoxaprop @100 g a i ha^{-1}	2.82	4.96
Cladinofop @60 g a i ha^{-1}	2.53	4.60
Pendimethalin @1 kg a i ha^{-1}	2.36	4.26
Control (weedy check)	2.11	4.02
SEm (±)	0.12	0.21
LSD (0.05)	0.35	0.68

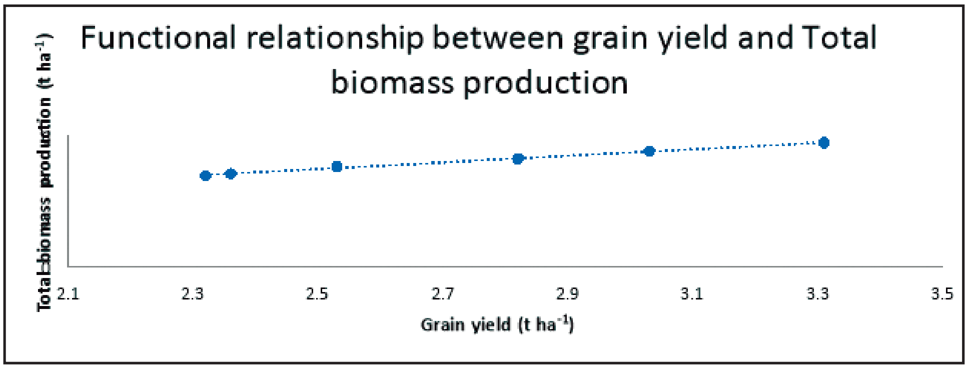

Fig. 2: Functional relationship between grain yield and total biomass production

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