Research Article

Bioefficacy of Herbicides in Relation to Planting Techniques in Wheat

Sudesh Devi*, Virender Singh Hooda, Navish Kumar Kamboj and Jagdev Singh

Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana-125004

Abstract

A field experiment was conducted to understand the effect of planting techniques and herbicides on weed management and wheat productivity in split plot design with three replications. The planting techniques had no effect on total weed density, weed control index, weed index, weed persistence index and crop resistance index. Drill sowing at 18 cm recorded maximum LAD, NAR and yield than other planting techniques while lowest total weed density was recorded in 16 cm row spacing. The tank mix application of pinoxaden (50 g/ha)+RM of carfentrazone and metsulfuron (25 g/ha) recorded lowest total weed density, weed index and weed persistence index, and highest value of weed control index, crop resistance index and yield over other herbicidal treatments. To obtain higher yield, drill sowing at 18 cm combined with tank mix application of pinoxaden and RM of carfentrazone and metsulfuron should be practiced.

Keywords: Planting Techniques, Herbicide treatments, weed control, wheat productivity, LAD, NAR

***Correspondence**
Author: Sudesh Devi
Email: drmalik107@gmail.com

Introduction

Wheat, in India, is second most staple crop grown after rice; its production increased from a mere 11 million tons during 1960-61 to 97.4 million tons during 2016-17 [1]. Rice-wheat rotation is the principal cropping system in the Indo-Gangetic plains with more than 13.5 m ha area under its cultivation. The wheat is considered most assured crop in the country which is essential for our food security, but there are many biotic and abiotic factors responsible for stagnation of wheat productivity under rice wheat cropping system in last decade. The high nutrient and water requisite along with less aggressive nature of the high yielding varieties have provided favorable environment for weed infestation [2], which caused about complete failure of crop in extreme cases [3].

Among different improved package of agronomic techniques, optimal row spacing is one of several important agronomic approaches that can be used to boost up the wheat productivity by optimizing the capacity of tillering of wheat and efficient utilization of other available resources [4, 5]. Inefficient utilization of available sources by plants, particularly solar radiation under a wider row spacing, and severe inter-row competition among plants in narrow rows have compelled researchers to optimize proper row spacing for attaining better production of different crops and even varieties within the same species [5, 6]. Optimum row spacing ensures better light interception and penetration into the crop canopy and enhances light utilization efficiency in crop plants [7]. Bed planting method improves water use efficiency, lowers seed rate, reduce crop lodging, production cost and fuel consumption, and control root diseases [8-10].

Because of higher economic cost of labour for manual weeding and its lower efficacy, farmers are relying heavily on herbicides for effective weed control in different crops including wheat. With the changing pattern of social living and work culture along with intensified agriculture, chemical weed control has become an unavoidable necessity in crop production. The weeds showed multiple herbicide resistance due to continuous use of herbicide having same mode of action and/or class [11].

Now a day, herbicide resistance is becoming the major cause of yield losses in crops. Therefore, effective weed management requires an integrated approach using both chemical and non-chemical approaches. The number of market entry of herbicides with new mode of action has reduced. For effective management of complex weed flora, there is need to use mixture of existing herbicides, which should have a wide spectrum of weed control without crop injury and residual effect on succeeding sensitive crops after wheat [12, 13]. Herbicides mixture increases weed control efficacy against complex weed flora [14], and also helpful in delaying herbicide resistance [15]. Integration of improved agronomic practices along with chemical methods will help in increasing the life of existing herbicides and make the weed management cost-effective and efficient. The present study was conducted to assess the effects of different planting techniques and herbicides on weed and wheat productivity.

Materials and Methods

The present study was conducted during 2012-13 at Agronomy Research Farm, CCS Haryana Agricultural University, Hisar. The soil of the experimental site was sandy loam in texture with 60.5% sand, 22.2% silt and 17.3% clay. The soil pH and EC were 8.3 and 0.31 dSm^{-1} at 25ºC, respectively. Organic matter, total nitrogen, available phosphorus and potassium were 0.33%, 182.4 kg/ha, 13.3 kg/ha and 365.3 kg/ha, respectively. The experiment was comprised of five planting techniques viz., drill sowing at 16 (S3), 18 (S2) and 20 cm (S1) and bed planting with two (S5) and three rows (S4) in main plots and five weed management treatments *viz.*, pinoxaden (50 g/ha) (H1), ready mix (RM) of carfentrazone and metsulfuron (25 g/ha) (H2), pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha) (H3), weed free (H4), weedy check (H5). The sowing of wheat cultivar WH-711 was done on 10th December, 2012 and other practices were followed as per package of practices given by CCS HAU, Hisar. The crop of wheat was manually harvested at physiological maturity on 25th April, 2013, by leaving appropriate border rows, tied into bundles and sun dried for a week in respective plots. Total wheat dry biomass was recorded for each treatment and crop was threshed thereafter.

The density of weeds was recorded with quadrates measuring 0.25 m^2 area randomly at three places in each plot. The data on weeds density were subjected to square-root transformation before statistical analysis. Weed dry weight, weed population and crop yield in treated and weedy check plots were used in calculation of weed control index [16], weed index [17] and weed persistence index [18]. Crop resistance index (CRI) was calculated by following formula:

$$CRI = \left(\frac{CDMT}{CDMC}\right) \times \left(\frac{WDMC}{WDMt}\right)$$

where, CDMT- crop dry matter in treated plots (g/m^2), CDMC- crop dry matter in control plot (g/m^2), WDMC- weed dry matter in control plot (g/m^2), WDMt- weed dry matter in treated plots (g/m^2).

The relative weed dry matter and relative weed density of grassy/ broad leaved weeds was calculated by following formula:

$$RDW = \left\{\frac{DW\ of\ GW\ or\ BLW\ (g/m^2)}{\text{DW of composite weed in that unit area}}\right\} \times 100$$

$$RD = \left\{\frac{D\ of\ GW\ or\ BLW\ (No./m^2)}{\text{D of composite weed in that unit area}}\right\} \times 100$$

where, RDW- relative dry weight, DW- dry weight, GW- grassy weeds, BLW- broad leaved weeds, RD- relative density and D- density. Leaf area indices were used to calculate leaf area duration (LAD) of wheat crop. Furthermore, net assimilation rate (NAR; $g/m^2/d$) was also computed at different growth stages of crop as the ratio of TDM (g/m^2) and LAD [19]. The experiment was triplicated in split-plot design with planting techniques as main plots and weed management treatments as the sub-plots. Analyses of variance were performed with all data to confirm variability of data and validity of results by employing Fisher's analysis of variance technique. The differences amongst treatments were separated using critical difference (CD) at 0.05 probability level.

Results and Discussions

The interaction effects between planting techniques and weed control treatments for all parameters in study was found non-significant.

Weed Studies

Fourteen weed species belonging to seven families were found to infest the experimental wheat crop as presented in **Table 1**. The major important weeds were *Phalaris minor*, *Avena ludoviciana*, *Chenopodium album*, *Melilotus indicus and Anagalis arvensis.* The similar type of weed flora was recorded by many researchers under wheat crop [20-23].

The planting techniques did not significantly influence the total weed density, relative weed density and dry weight (of grassy as well as broad leaved weeds), weed control index, weed index and weed persistence index (**Table 2**). At 60 DAS, significantly lower total weed density was recorded under drill sowing at 16 cm row spacing;

this may be due to less availability of space for growth of weeds. Higher total weed density was reported under bed planting with two rows of wheat due to availability of more space and resources between and on the beds. The lower weed population was reported under narrow row spacing as compared to wide row spacing [24]. Drill sowing at 18 & 20 cm row spacings and bed planting with three rows of wheat were at par with each other in respect to total weed density.

Table 1 Weed species found in the experimental field of wheat

Sr. No.	Local Name	Common Name	Scientific Name	Family	Habit and Characteristics
1	Gullidanda/ Gehusa	Little canary grass	*Phalaris minor*	Poaceae	Decumbent annual grass herb
2	Jangli Jai	Wild oat	*Avena ludoviciana*	Poaceae	Erect annual grass herb
3	Bathua	Common lambsquarter	*Chenopodium album*	Chenopodiaceae	Erect annual broad leaved herb
4	Sengi	Yellow sweet clover	*Melilotus indicus*	Fabaceae	Annual broad leaved herb
5	krishnneel	Red pimpernel	*Anagalis arvensis*	Primulaceae	Annual prostrate broad leaved herb
6	Pitpapda	Swine cress	*Coronopus didymus*	Brassicaceae	Prostrately grown annual broad leaved herb
7	Chatari-matari	Wild pea	*Lathyrus aphaca*	Fabaceae	Annual broad leaved herb
8	Katili	Canada thistle	*Cirsium arvense*	Asteraceae	Erect perennial leafy spiny broad leaved herb with pink or white flower
9	-	Black medic	*Medicago denticulate*	Fabaceae	Annual broad leaved herb
10	-	Tooth burclover	*Medicago hispida*	Fabaceae	Annual broad leaved herb
11	Gazari	Fumitory	*Fumeria parviflora*	Fumariaceae	Annual broad leaved prostrate herb
12	Doob	Bermudagrass	*Cynodon dactylon,*	Poaceae	Perennial hardy branched usually prostrate herb
13	Akari	Tiny vetch	*Vicia hirsuta*	Fabaceae	Annual broad leaved herb
14	Tripatra	Strawberry clover	*Trifolium flagiferum*	Fabaceae	Perennial broad leaved herb

Table 2 Effect of planting techniques and weed control treatments on total weed density, relative density of weed, relative dry weight, weed index, weed control index and weed persistence index in wheat

Treat ments	Total Weed density (No./m^2)		Relative weed density		Relative Dry weight		WCI	WI	Weed Persistence Index			
	30DAS	60DAS	GW	BLW	GW	BLW			60 DAS	90 DAS	120 DAS	At harvest
Planting Techniques												
S1	8.29 (81.07)	7.80 (101.11)	0.159	0.641	18.76	61.25	60.93	3.55	1.15	1.23	1.16	1.18
S2	8.23 (79.60)	7.72 (99.77)	0.155	0.645	16.96	63.04	60.93	7.34	1.29	1.28	1.25	1.09
S3	8.29 (80.93)	7.12 (83.03)	0.155	0.645	18.44	61.57	61.68	7.06	1.22	1.24	1.23	1.01
S4	8.25 (80.20)	7.92 (102.40)	0.162	0.638	19.03	60.97	60.68	8.82	1.31	1.30	1.29	1.23
S5	8.33 (81.77)	8.29 (116.60)	0.156	0.644	20.99	59.01	60.60	6.01	1.12	1.27	1.22	1.28
SEm±	0.030	0.04	0.01	0.01	1.32	1.31	0.27	1.19	0.08	0.05	0.07	0.05
CD at 5%	NS	0.12	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed Control Treatments												
H1	10.06 (100.27)	15.45 (232.00)	0.185	0.815	5.55	87.45	22.01	7.76	2.80	3.21	2.97	2.98
H2	10.07 (100.33)	3.38 (10.67)	0.206	0.794	29.29	60.71	87.80	4.87	2.09	1.91	1.93	1.63
H3	10.14 (101.80)	3.47 (11.23)	0.182	0.785	3.73	40.39	95.02	2.72	0.20	0.22	0.25	0.17
H4	1.00 (0.00)	1.00 (0.00)	0.00	0.00	0.00	0.00	100.00	0.00	-	-	-	-
H5	10.11 (101.17)	15.54 (249.01)	0.215	0.818	55.61	117.27	0.00	17.43	1.00	1.00	1.00	1.00
SEm±	0.028	0.30	0.01	0.01	1.94	1.95	1.38	1.20	0.15	0.11	0.12	0.09
CD at 5%	0.08	0.66	0.03	0.04	5.58	5.59	3.96	3.43	0.42	0.32	0.35	0.26

Original data given in parenthesis was subjected to square root ($\sqrt{x+1}$) transformation before analysis. **DAS**- Days After Sowing, **GW**- Grassy Weeds, **BLW-** Broad Leaved Weeds, **NS**- Non-Significant, **WCI-** Weed Control Index, **WI-** Weed Index

After herbicide spray at 35 DAS, the tank mix application of pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha) recorded significantly lower total weed density and weed index value compared to alone application of pinoxaden (50 g/ha); this was at par with individual application of RM of carfentrazone and metsulfuron (25 g/ha); because the experimental field was dominantly infested by broad leaved weeds (Table 1).

Total weed density and dry matter accumulation of broad leaved weeds decreased with the application of premix of carfentrazone+metsulfuron with or without surfactant [14]. The weed control treatments significantly influenced the relative weed density and dry weight of grassy as well as broad leaved weeds (Table 2). The tank mix application of pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha) significantly lowered the relative weed density and dry weight of grassy as well as broad leaved weeds. Pinoxaden (50 g/ha) recorded lower relative density and dry weight of grassy weeds; this was at par with tank mix application of pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha). The RM of carfentrazone and metsulfuron (25 g/ha) reported significantly lower relative weed density and dry weight of broad leaved weeds. Weedy check recorded maximum relative weed density and dry weight of both types of weeds. Weed free treatment resulted in significantly higher weed control index followed by tank mix application of pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha); then by alone application of RM of carfentrazone and metsulfuron (25 g/ha) and pinoxaden (50 g/ha) (Table 2). Among weed control treatments, higher value of weed persistence index was reported under pinoxaden (50 g/ha) followed by RM application of carfentrazone and metsulfuron. The tank mix application of pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha) recorded lower value of weed persistence index (Table 2).

Crop Studies

At all crop growth stages, significantly lower crop (wheat) dry matter accumulation (gram per meter running length) was recorded under drill sowing at 16 cm (**Table 3**). Other planting techniques viz. drill sowing at 18 & 20 cm and bed planting with 2 & 3 rows of wheat were at par with each other in respect of crop dry matter accumulation (g/mrl) at all crop growth stages. This might be due to availability of more nutrients, radiation and moisture to plants under wider spacing. This indicates that narrow spacing escorts more inter row competition among the plants as compared to wider row spacing. Among different row spacings, 20 cm row spacing accumulated maximum dry matter which was at par with 22.5 cm row spacing and significantly higher over 17.5 and 15 cm in wheat [25]. Planting techniques were failed to influence the crop resistance index of wheat at all crop growth stages.

Table 3 Effect of planting techniques and weed control treatments on dry matter accumulation, crop resistance index, NAR, LAD and grain yield in wheat

Treatments	Dry matter accumulation (g/mrl)			Crop Resistance Index				NAR (g/m^2/day)		LAD (Days)		Yield (kg/ha)
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	60 DAS	90 DAS	
Planting Techniques												
S1	68.48	176.27	226.67	7.19	5.98	7.14	8.09	3.60	6.23	47.10	106.41	5202
S2	70.02	181.55	233.14	7.22	6.28	6.42	6.94	3.71	6.30	47.20	106.95	5330
S3	64.07	168.72	216.37	6.05	4.42	5.10	6.29	3.21	6.02	44.61	100.44	4937
S4	69.87	181.20	232.70	6.74	5.67	6.18	6.59	3.53	6.21	47.06	106.27	5196
S5	69.39	178.37	229.06	7.01	5.79	6.14	6.72	3.20	6.00	44.44	100.28	4853
SEm±	0.93	2.42	3.11	0.42	0.42	0.93	0.40	0.06	0.03	0.07	0.18	74
CD at 5%	3.09	8.02	10.31	NS	NS	NS	NS	0.25	0.09	0.24	0.72	242
Weed Control Treatments												
H1	67.00	173.74	223.11	1.`13	1.16	1.15	1.37	3.10	6.15	44.90	99.13	5039
H2	67.50	175.44	225.31	10.10	6.86	8.56	9.42	3.56	6.17	45.78	100.13	5191
H3	70.67	182.77	234.72	21.98	19.11	20.26	22.83	3.75	6.23	48.28	113.03	5316
H4	72.37	187.64	240.96	-	-	-	-	3.86	6.24	49.66	113.63	5466
H5	64.22	166.52	213.84	1.00	1.00	1.00	1.00	2.99	5.99	41.78	94.58	4506
SEm±	0.84	2.18	2.79	0.94	0.56	0.78	0.55	0.06	0.02	0.05	0.09	67
CD at 5%	2.41	6.24	8.01	2.71	1.61	2.25	1.59	0.18	0.05	1.16	1.28	191

g/mrl- gram/meter running length, **NAR**- net assimilation rate, **LAD**- leaf area duration, **DAS**- Days After Sowing, **NS-** Non-Significant

Significantly lower net assimilation rate (NAR) and leaf area duration (LAD) were recorded under drill sowing at 16 cm (Table 3); this was at par with bed planting with two rows of wheat at all crop growth stages. Other planting techniques *viz*. drill sowing at 18 & 20 cm and bed planting with three rows of wheat were at par with each other in respect of NAR and LAD. This may be due to better assimilatory system (green leaves) and higher accumulation of assimilates in optimum plant population. Amongst different row spacing, growing of wheat at 20 cm row spacing recorded highest dry matter and net assimilation rate (NAR) over other row spacing.

Weed free treatment recorded highest LAD, NAR and dry matter accumulation at different growth stages of wheat; this was at par with tank mix application of pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha) (Table 3). Individual application of pinoxaden (50 g/ha) and RM of carfentrazone and metsulfuron (25 g/ha) produced significantly lower LAD, NAR and dry matter accumulation than their combined application and weed free treatments. Significantly lower LAD, NAR and dry matter accumulation was recorded under weedy check from 60 DAS to harvest. The improvement in crop dry matter accumulation due to combined application of pinoxaden + RM of carfentrazone and metsulfuron can be attributed to effective control of both types of weeds.

The tank mix application of pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha) recorded significantly higher value of crop resistance index over other weed control treatments (Table 3). Because combined application of pinoxaden + RM of carfentrazone and metsulfuron effectively controlled both grassy as well as broad leaved weeds. The alone application of pinoxaden only controlled grassy weeds [26] that's why reported lower value of crop resistance index. The alone application of RM of carfentrazone and metsulfuron only controlled broad leaved weeds [14], thus recorded lower of crop resistance index than combined application of herbicides.

Crop yield

Among different planting techniques, drill sowing at 18 cm in wheat recorded maximum grain yield, which was statistically at par with the drill sowing at 20 cm and bed planting with three rows of wheat (Table 3). Lowest grain yield was recorded under two rows bed planting which was statistically at par with 16 cm row spacing due to low plant population and higher inter plant competition, respectively. Higher grain yield of wheat has been reported in wider row spacing than narrow (15 cm) row spacing [27].

Weed free treatment registered maximum grain yield (5466 kg/ha), which was at par with tank mix application of pinoxaden (50 g/ha) + RM of carfentrazone and metsulfuron (25 g/ha) (Table 3). Grain yield under individual application of pinoxaden (50 g/ha) and RM of carfentrazone and metsulfuron (25 g/ha) were at par with each other. Researchers found that highest grain yield of wheat was with premix of carfentrazone+metsulfuron at 25 g/ha rate tank mixed with 0.2% NIS, which was higher over untreated weedy plots [14]. The yield attributes under application of tank mix of pinoxaden (50 g/ha) + carfentrazone (20 g/ ha) and pinoxaden (50 g/ha) + metsulfuron (4g/ ha) were at par and significantly higher than sole application of pinoxaden (50 g/ha and 75 g/ha), carfentrazone (20 g/ha) and metsulfuron (4 g/ha) in wheat crop [28].

Conclusion

Present investigation shows that 18 cm row spacing resulted in the highest grain yield with higher LAD, NAR and dry matter accumulation as compared to other planting techniques. The pinoxaden (50 g/ha) application @ 35 DAS effectively controlled the grassy weeds (*Phalaris minor*, *Avena* spps. etc), whereas ready mix of carfentrazone and metsulfuron-methyl (25 g/ha) effectively controlled the broad-leaved weeds (*C. album*, *M. indicus* etc). Their tank mix application effectively controlled both type of weeds in wheat crop and recorded higher grain yield, which was at par to weed free treatment.

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