Original Research Article……...

International Journal of Agricultural Invention

(online available at www.agriinventionjournal.com)

***International Journal of Agricultural Invention* 2(1): 10-15: June, 2017**

ISSN: 2456 – 1797 (P)

Effect of herbicide combinations on weed dynamics, nutrient removal and yield of Wheat (*Triticum aestivum* L.) under north western plain zone

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ARTICLE INFO

Original Research article
Received on April 07, 2017
Accepted on May 09, 2017

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PUBLICATION INFO

International Journal of Agricultural Invention (IJAI)
RNI: UPENG/2016/70091
ISSN: 2456-1797 (P)
Vol.: 2, **Issue:** 1, **Pages:** 10-15
Journal Homepage URL
http://agriinventionjournal.com/
DOI: 10.46492/IJAI/2017.2.1.3

ABSTRACT

A field experiment was conducted to study the effect of different weed control practices on weed dyanamics, nutrient uptake and yield of wheat (*Triticum aestivum* L.) in rabi seasons of 2010-11 and 2011-12 at Crop Research Centre of SVPUA&T, Meerut. The treatments comprising pre-emergence application of pendimethalin @ 1000 g/ha, post emergence application of isoproturon @1200 g/ha, isoproturon+2,4-D @ 1200+600 g/ha, isoproturon+metsulfuron methyl @ 1200+4 g/ha, fenoxaprop -p-ethyl @ 80 g/ha, fenoxa prop -p-ethyl +2,4-D @ 80+600 g/ha, fenoxa prop -p-ethyl +metsulfuron methyl @ 80+4 g/ha, clodinafop propargyl @ 60 g/ha, clodinafop propargyl+2,4-D @ 60+600 g/ha and clodinafop propargyl+metsulfuron methyl @ 60+4 g/ha were tested with weed free and weedy check. Among the herbicides, application of clodinafop propargyl+ metsulfuron (60+4 g/ha) though statistically on par with clodinafop propargyl+ 2,4-D (60+600 g/ha) reduced the weed population significantly than weedy check (97.2%), clodinafop propargyl alone (88.0%), fenoxaprop -p-ethyl alone (83.0%), isoproturon alone (80.0%), isoproturon+metsulfuron (72.2%), pendimethalin (71.4%), isoproturon+2,4-D (53.8%), fenoxa prop -p-ethyl +2,4-D (53.8%) and fenoxa prop -p-ethyl + metsulfuron (40.0%) at 60 days after sowing stage. Among the herbicides, application of Clodinafop propargyl+ metsulfuron methyl (60+4 g/ha) as post emergence resulted into highest grain yield of wheat (49.28q/ha) which was on par with weed free and clodinafop propargyl+2,4-D @ 60+600 g/ha but statistically significant than rest of the treatments. Highest NPK uptake by grain and straw of wheat was recorded in weed free conditions compared to the herbicidal treatments, except lodinafop propargyl+metsulfuron methyl and clodinafop propargyl+ 2, 4-D. Highest removal of NPK (63.6 kg/ha) by weeds was recorded in weedy check whereas, the minimum NPK uptake (28.4 kg/ha) was noticed with the application of clodinafop propargyl+metsulfuron methyl due to efficient control of weeds (weed control efficiency 84.7%), which resulted in lowest weed dry matter in this treatments.

KEYWORDS

Herbicide Combinations, Wheat, Weed Density, Weed Dry Matter, Nutrient Removal, Yield

HOW TO CITE THIS ARTICLE

Singh, A. (2017) Effect of herbicide combinations on weed dynamics, nutrient removal and yield of Wheat (*Triticum aestivum* L.) under north western plain zone, *International Journal of Agricultural Invention,* 2(**1**): 10-15. **DOI**: 10.46492/IJAI/2017.2.1.3

Weed infestation became one of the most serious problems in wheat (*Tritium aestivum* L.) growing areas with the large area adoption of dwarf varieties in India. Weed competition during the crop period resulted more than 53 percent reduction in grain yield, depending on the weed densities and type of weed flora present (Singh *et al*., 2002). Uncontrolled weeds are reported to cause up to 66% reduction in wheat grain yield (Kumar *et al.,* 2011) or even more depending upon the weed densities, type of weed flora and duration of infestation. Grassy weeds followed by broad leaf weeds emerge as a serious problem in wheat which, pose a threat to its successful cultivation in important wheat growing areas particularly in Indo-Gangetic Plains Region. Search for new herbicides like clodinafop-propargyl and fenoxaprop-p-ethyl and sulfsulfuron were recommended as an alternative to isoproturon. Likewise, Metsulfuron methyl found an alternate option to 2, 4-D application in recent time. Clodinafop propargyl and fenoxa prop-p-ethyl have been very effective against *Phalaris minor* and *Avena fatua* (Banga and Yadav, 2004 and Mahajan *et al.* 2004) but ineffective against non grassy weeds like *Chenopodium album* etc. Use of these herbicides has resulted in proliferation of non grassy weeds like *Chenopodium album*, *Melilotus spp* and *Fumeria parviflora* in wheat (Singh and Singh, 2005). 2, 4-D and metsulfuron methyl being used commonly for the control of non grassy weeds in wheat. To control the both types of weed flora (grassy and non grassy) various herbicides and their combinations were tested in different parts of the country. Therefore, it was felt necessary to screen out compatible/ suitable herbicides combination for controlling the existing weed flora of wheat in North West plain zone. Keeping above points in view, the present investigation was carried out.

MATERIALS AND METHODS

The field experiment was conducted at the research farm of SVPUA&T, Meerut during rabi seasons of 2010-11 and 2011-12. The soil was loamy sand in texture having 7.8 pH, 0.51% organic carbon, 16.2 kg/ha available phosphorus and 175 kg/ha available potassium. The treatments comprising pendimethalin at 1000 g/ha, isoproturon at 1200 g/ha, isoproturon + 2,4-D at 1200+600 g/ha, isoproturon + metsulfuron methyl at 1200+4 g/ha, fenoxa prop-p-ethyl at 80 g/ha, fenoxaprop pp-ethyl + 2,4-D at 80+600 g/ha, fenoxaprop -p-ethyl +metsulfuron methyl at 80+4 g/ha, clodinafop propargyl at 60 g/ha, clodinafop propargy l+ 2,4-D at 60+600 g/ha and clodinafop propargyl + metsulfuron methyl at 60+4 g/ha were compared with weed free and weedy check. Twelve treatments were replicated thrice in randomized block design. Wheat cv PBW-550 was sown, 22.5 cm apart, in 2nd fortnight of November during both the years *i.e.* 2010-11 and 2011-12 with the help of ferti-seed drill using 100 kg/ha of seed. Crop fertilized with N P K Zn at 120, 60, 40 and 8 kg/ha, respectively. One third of N and full dose of P K and Zn were applied as basal at the time of sowing. Rest N was top dressed in 2 equal splits, one after 1st irrigation (at the time of crown root initiation) and second at maximum tillering stage to ensure appropriate moisture level in the field. The herbicides, except pendimethalin were applied as post emergence at 35 days after sowing using 600 litres of water with knapsack sprayer fitted with flat fan nozzle. However, pendimethalin was applied as pre emergence 1 DAS. The crop was raised under irrigated condition with recommended package of practices. The population density and dry matter of weeds were recorded at 60 days after sowing stage. The data on weed density, dry matter and nutrient uptake by weeds were transformed using square root transformation prior to statistical analysis, wherever needed.

RESULTS AND DISCUSSION

Dominant Weed Flora

The dominant weed flora observed in the experimental field included *Chenopodium album* L., *Fumeria parviflora* Lam., *Melilotus indica* L. and *Anagallis arvensis* L. among broad leaf weeds and *Phalaris minor* (L) Retz. and *Avena fatua* L. among annual grasses besides *Cyperus spp*. among sedges. *Phalaris minor* was the dominant (41.3%) among grassy whereas, *Fumeria parviflora* Lam. density was recorded maximum (10.0%) under non grassy weeds. Although, some other common weeds were also there in the field but their population was marginal.

Weed Density and Dry Matter Accumulation

The weed control treatments significantly reduced the weed population and dry biomass of weeds than weedy check (Table 1). Tank mixture of clodinafop propargyl + metsulfuron methyl (60+4 g/ha) followed by clodinafop propargyl + 2,4-D (60+600 g/ha) proved most effective herbicide combination against broad leaf weeds and grassy weed flora and recorded significantly lower population of total weeds as well as the total dry matter than all other weed control treatments. Among the herbicides application of clodinafop propargyl + metsulfuron methyl (60+4 g/ha) though statistically *on par* with clodinafop propargyl + 2,4-D (60+600 g/ha) reduced the weed population significantly than weed check (97.2%), clodinafop propargyl alone (88.0%), fenoxa prop-p-ethyl alone (83.0%), isoproturon alone (80.0%), isoproturon + metsulfuron methyl (72.2%), pendimethalin (71.4%), isoproturon + 2,4-D (53.8%), fenoxa prop-p-ethyl + 2,4-D (53.8%) and fenoxa prop-p-ethyl + metsulfuron methyl (40.0%) at 60 days after sowing stage. A similar trend was observed with all the applied herbicides with respect to reduction in dry weight of weeds. The reduction in weed population as well as dry matter may be because of clodinafop propargyl is broad spectrum herbicide along with 2,4-D and metsulfuron methyl may have acted synergistically in broadening the efficacy against variety of weed flora. The results are in close conformity with those of Singh *et al.* (2015) and Bharat and Kachroo (2007).

Weed Control Efficiency

Highest weed control efficiency of 84.7% was observed (Table 2) with the application of clodinafop propargyl + metsulfuron methyl (60+4 g/ha) followed by clodinafop propargyl + 2,4-D (81.9%). Whereas, the lowest weed control efficiency (26.7%) was recorded when clodinafop propargyl (60g/ha) applied alone. Higher weed control efficiency with clodinafop propargyl +

Table 1. Effect of weed management practices 0n weed density and weed dry matter in Wheat Crops

Treatments	Dose (ga.i./h)	Application stage (DAS)	Weed density (numbers/m^2)						Weed dry matter accumulation (g/m^2)					
			Phalaris minor	*Avena fatua*	*Chinopodium album*	*Fumeria parviflora*	Others	Total	*Phalaris minor*	*Avena fatua*	*Chinopodium album*	*Fumeria parviflora*	Others	Total
Weedy			6.73 (45)	2.73(7)	3.08(9)	3.24 (10)	5.77(38)	11.2 (109)	3.57 (12.3)	3.71 (13.2)	2.54(6.0)	4.03 (15.8)	5.32 (28.6)	9.72 (75.7)
Weed free			0.7 (0)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	0.7(0)
Pendimethalin	1000	1	3.38 (11)	0.7(0)	1.22(1)	2.34(5)	2.11(4)	4.6 (21)	3.1 (8.5)	0.7(0)	1.04(0.6)	2.88(7.8)	3.01 (8.7)	4.72 (22.6)
Isoproturon	1200	35	3.24 (10)	1.21(1)	1.58(2)	2.34(5)	3.65(13)	5.68 (31)	2.22 (4.5)	1.3 (1.2)	1.58(2.0)	3.2(9.8)	4.62 (22.2)	6.31 (39.7)
Isoproturon+2,4-D	1200+600	35	3.08 (9)	1.58(2)	0.7(0)	0.7(0)	1.58(2)	3.67 (13)	3.1(8.5)	2.06 (2.8)	0.7(0)	0.7(0)	2.14 (4.3)	3.98 (15.6)
Isoproturon+metsulfuronmethyl	1200+4	35	3.38 (11)	1.58(2)	1.22(1)	0.7(0)	2.73(7)	4.62 (22)	3.15 (8.6)	1.86 (3.0)	1.22(1.0)	0.7(0)	3.95 (15.2)	4.78 (27.8)
Fenoxa prop-p-ethyl	80	35	3.24 (10)	1.84(3)	1.84(3)	3.24(10)	5.3(27)	7.31 (53)	1.96 (3.3)	2.18 (4.3)	2.34 (5.0)	4.21 (15.0)	4.79 (24.5)	5.58 (34.1)
Fenoxa prop-p-ethyl +2,4-D	80+600	35	3.38 (11)	1.22(1)	1.22(1)	0.7(0)	1.58(2)	3.67 (13)	2.98 (8.4)	1.45 (1.6)	0.7(0)	0.7(0)	3.48 (11.7)	4.67 (21.7)
Fenoxa prop-p-ethyl +metsulfuron methyl	80+4	35	2.73 (7)	1.55(2)	1.22(1)	0.7(0)	2.55(6)	3.24 (10)	3.5 (11.8)	1.73 (2.5)	1.13(0.8)	0.7(0)	4.13 (16.8)	5.36 (31.9)
Clodinafop propargyl	60	35	3.23 (90)	1.55(2)	1.84(3)	2.34(5)	5.54(35)	7.41 (54)	1.91 (2.3)	1.7 (2.4)	2.24(4.8)	3.72(13.8)	5.63 (30.7)	7.41 (55.5)
Clodinafop propargyl+2,4-D	60+600	35	2.91 (8)	1.22(1)	0.7(0)	0.7(0)	0.7(0)	3.08 (9)	3.54 (12.1)	1.45 (1.6)	0.7(0)	0.7(0)	0.7(0)	3.7 (13.7)
Clodinafop propargyl+metsulfuron methyl	60+4	35	2.55 (6)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	2.55 (6)	3.5 (11.6)	0.7(0)	0.7(0)	0.7(0)	0.7(0)	3.51 (11.6)
CD(P=0.05)			0.4	0.37	0.14	0.12	0.16	0.48	0.34	0.25	0.18	0.18	0.22	0.33

Table 2. Effect of weed management practices on wheat yield and nutrient removal by wheat and associated weeds

Treatments	Dose (g a.i./ha)	Yield (q/ha)		WCE (%)	WI (%)	Nutrient removal by wheat (kg/ha)			Nutrient removal by weeds (kg/ha)		
		Grains	Straw			N	P	K	N	P	K
Weedy		27.04	38.25	-	47.9	88.2	15.5	95.2	5.40(28.7)	3.77(13.4)	4.62(21.5)
Weed free		51.92	68.15	-	-	126.2	25.3	130.0	0.70(0.0)	0.70(0.0)	0.70(0.0)
Pendimethalin	1000	43.12	57.05	70.1	16.9	118.8	22.0	120.8	4.01(15.6)	2.87(7.8)	3.64(12.8)
Isoproturon	1200	33.77	45.07	47.6	35.0	115.1	19.8	118.3	4.43(19.2)	3.11(9.2)	3.78(13.8)
Isoproturon+2,4-D	1200+600	46.31	60.05	79.4	10.8	121.9	23.2	124.3	3.63(12.4)	2.86(7.7)	3.33(10.6)
Isoproturon+metsulfuronmethyl	1200+4	42.68	55.94	63.3	17.8	117.4	21.3	122.4	4.22(17.4)	3.08(9.0)	3.66(12.6)
Fenoxa prop-p-ethyl	80	38.06	49.28	55.0	26.7	115.4	21.4	118.1	4.32(18.2)	3.21(9.8)	3.75(13.6)
Fenoxa prop-p-ethyl +2,4-D	80+600	45.76	64.60	71.3	11.9	120.6	22.6	124.7	3.68(12.8)	3.02(8.7)	3.58(12.3)
Fenoxa prop-p-ethyl +metsulfuron methyl	80+4	39.82	56.61	57.9	23.3	115.8	21.7	118.8	4.30(17.8)	3.14(9.4)	3.66(12.9)
Clodinafop propargyl	60	33.44	47.06	26.7	35.6	112.5	19.4	116.9	4.60(20.4)	3.18(9.6)	3.88(14.6)
Clodinafop propargyl+2,4-D	60+600	46.97	61.72	81.9	9.5	123.0	23.6	127.9	3.46(11.5)	2.77(7.2)	3.48(11.6)
Clodinafop propargyl+metsulfuron methyl	60+4	49.28	65.27	84.7	5.1	123.3	24.2	128.4	3.40(10.8)	2.82(7.4)	3.27(10.2)
CD(P=0.05)		5.31	4.22	-	-	5.1	2.2	5.3	0.30	0.28	0.31

metsulfuron methyl (60+4 g/ha) may be attributed to the production of lower dry weight of weeds in this treatment that clearly indicates the better control of weeds in the same.

Yields

Herbicide application had significant effect on wheat grain and straw yield (Table 2). A highest grain yield of wheat (51.92 q/ha) was recorded in weed free plot, because no any weed was observed in this condition, which may have resulted in increased nutrients, water, space and light supply to the wheat crop and there was almost no crop-weed competition. This might have resulted in greater photosynthesis and hence better translocation of photosynthates besides longer and stronger sink size as reflected maximum values of yield attributes and finally the yield. Among the herbicides, clodinafop propargyl + metsulfuron methyl (60+4 g/ha) applied as post emergence, being on par with clodinafop propargyl + 2,4,-D (60+600 g/ha) and weed free produced the significantly more grain(49.28q/ha) and straw (65.27q/ha) yield of wheat than rest of the herbicides applied either as alone or in combination. This treatment also out-yielded Pendimethalin alone (1000 g/ha), isoproturon alone (1200 g/ha) and in combination with isoproturon + 2,4,-D (1200+600 g/ha) by 14.3, 45.9 and 6.4 per cent, respectively. The higher yield in these treatments was mainly due to the fact that reduced weed population in these treatments shifted the competition for nutrients, moisture, space and light in favour of the crop rather than the weeds. The similar results have also been reported by Singh *et al.* (1998), Azad *et al.* (2003) and Kumar *et al.* (2011). The low yields in weedy check may be due to poor root growth and higher weed population which could have competed with wheat crop for space, nutrients, light, water and CO_2, thereby adversely affecting the grain and straw yields. Paighan *et al*. (2013) also made similar observations.

Weed Index

The weed index due to various weed management practices in wheat varied from 47.9 to 5.1, being highest in weedy check and the lowest weed index (5.1%) was observed in clodinafop propargyl + metsulfuron methyl (60 + 4 g/ha) followed by clodinafop propargyl + 2,4-D (9.5%).The lowest weed index was mainly due to more yield in this treatment combination which was statistically similar to weed free conditions.

Nutrient Uptake by Weeds

Maximum removal of NPK was recorded in weedy check, due to higher weed density as well as dry matter of weeds which enabled them to absorb more nutrients and minimum depletion of NPK was recorded with herbicide mixture of clodinafop propargyl + metsulfuron methyl due to efficient control of weeds (84.7%), which resulted in lowest weed dry matter in this treatments (Table 2). Under herbicidal treatments, *viz*., pendimethalin, isoproturon, isoproturon + 2,4-D, isoproturon + metsulfuron methyl, fenoxaprop-p-ethyl, fenoxaprop-p-ethyl + 2,4-D, fenoxaprop-p-ethyl + metsulfuron methyl, clodinafop propargyl, clodinafop propargyl + 2,4-D and clodinafop propargyl + metsulfuron methyl depleted 42.5, 33.6, 51.7, 38.7, 34.6, 46.8, 37.0, 30.0, 52.3 and 55.3 % less NPK over weedy check. Singh *et al*. 2015, also reported more nutrient depletion under weedy check over herbicidal treatments. The results clearly indicate the differential efficacy of herbicides in controlling weeds consequently resulted in differential depletion of NPK.

Nutrient Uptake by Crop

Significantly higher uptake of NPK by grains and straw of wheat was recorded in weed free conditions compared to all the herbicidal treatments, except clodinafop propargyl + metsulfuron methyl and clodinafop propargyl + 2, 4-D (Table 2), which remained *on par* to each other. Although, the total uptake of nitrogen, phosphorus and potassium by wheat due to different herbicides and/or varied between 112.5-123.3, 19.4-24.2 and 116.9-128.4 kg/ha, respectively. However, all the herbicidal treatments recorded significantly higher total nutrient uptakes than weedy check. The lowest total nutrient uptake by wheat in weedy check seems to be mainly due to the increase in weed dry matter accumulation coupled with more nutrient content in grains and straw. The results are in corroborating with the finding of Pandey *et al.* (2001) and Kumar *et al.* (2011).

CONCLUSION

It can be concluded from the above study that application of clodinafop propargyl + metsulfuron methyl @ (60 + 4 g/ha) in combination as post emergence (35 DAS) reduced the weed population and weed dry weight by 97.2 and 84.8 %, respectively over weedy check, besides producing 4.93 t/ha of wheat grains which, was *at par* with weed free under north west plain zone. The next best option in this regard was the post emergence application of clodinafop propargyl + 2,4-D (60 + 600 g/ha).

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Manuscript received on April 07, 2017, Accepted for publication on May 09, 2017