www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(5): 546-551

www.thepharmajournal.com
Received: 09-03-2022
Accepted: 16-04-2022

Vishal Vikram Singh
Ph.D., Scholar, Department of Agronomy, T.D.P.G. College, Jaunpur, Uttar Pradesh, India

Shrish Kumar Singh
Associate Professor and Head, Department of Agronomy, T.D.P.G. College, Jaunpur, Uttar Pradesh, India

Susheel Kumar Srivastava
Ph.D., Scholar, Department of Agronomy, T.D.P.G. College, Jaunpur, Uttar Pradesh, India

Tej Pratap
Senior Research Officer, Department of Agronomy, G.B. Pant University of Agriculture and Technology, Pantnagar U.S. Nagar, Uttarakhand, India

Corresponding Author:
Vishal Vikram Singh
Ph.D., Scholar, Department of Agronomy, T.D.P.G. College, Jaunpur, Uttar Pradesh, India

Two novel herbicide molecules are being evaluated in a tank mix with conventional herbicides for use against complex weed flora and nutrient uptake in irrigated wheat (*Triticum aestivum* L.)

Vishal Vikram Singh, Shrish Kumar Singh, Susheel Kumar Srivastava and Tej Pratap

Abstract
A field study was carried out during *Rabi* season of 2019-20 and 2020-2021 at main experiment station (Agronomy) of Pili Kothi Farm, T.D.P.G. College, Jaunpur Dist. Jaunpur (Uttar Pradesh) to study the efficacy of eight herbicide tank mix treatment with weed free and control in managing weed community dominated by dicot weeds and improving the growth and yield of wheat. Total weed density and weed dry weight at 60 days after sowing was recorded minimum with Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha at 30 DAS followed by Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25 + 23.96 g/ha at 30 DAS and considerably better than all other control measures except weed free situation. Highest grain yield of wheat was observed in weed free (4.5 t/ha) and was at par with Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha (4.4 t/ha) and significantly better than other treatments. All the herbicidal treatments recorded significantly higher grain yield and nutrient uptake by wheat as compared to control treatment. Total nutrient uptake by crop was highest in weed free followed by Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha at 30 DAS and significantly better to other treatments. From the study it was concluded that use of Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha at 30 DAS gave highest herbicide efficiency index (HEI) and Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP 60+4 g/ha gave highest weed persistence index (WPI).

Keywords: Herbicides, wheat, yield, net return, B:C ratio

Introduction
India's population is expanding at a rapid pace, largely due to raised industrialization and urbanization causing threat to food security. Wheat is one of the most important cereal crops and staple food in India after rice. Its assured production and supply are necessary for food security in the country. The global average wheat yield will have to rise from 2.6 to 3.5 tons per hectare over the next 25 years, while demand for wheat in developing countries is expected to rise 60% by 2050 Rosegrant and Agcaoili (2010) [16]. It accounts 17% of the world's cultivated land and contributes 35% of the food grain production, and hold an indispensable part on worldwide food security Tesfay *et al*., (2014) [22]. Globally, area under wheat crop about 222 million hectare and 774 million tons of production USDA (2020) [23]. India is the second-largest wheat-producing country in the world FAOSTAT (2020) [6]. It having growing area under wheat crop about 30.60 million hectares with 107.2 million tons of production and 34.24 q/ha national productivity GOI (2021) [7]. There are many factors responsible for the stagnation of wheat productivity and contribution of weeds is a major factor among them. If agronomic practices are fine- turned and weeds are managed properly, the wheat productivity can be enhanced.

Weeds are a major impediment to crop production and are accountable for maximum losses caused by all pests. They compete with crop plants for moisture, nutrients, light and space, thereby depriving the crop of vital inputs. Wheat is generally infested with both grassy and broad-leaf weeds, depending on environmental conditions like humidity, temperature and moisture availability, type of soil, cultural practices and crop rotation adopted. Among the weed- control measures, herbicidal control plays an important role in close row crops, where manual or mechanical weeding is not feasible. Broad-leaf weeds become a problem, where herbicides alone are used for combating the grass weed problem.

Clodinafop and sulfosulfuron are two major herbicides being used by wheat grower in north western Indian plains Chhokar and Malik (2002) and Chhokar and Sharma (2008) [3, 4]. Clodinafop controls grasses and not effective against broad-leaved weeds, whereas, sulfosulfuron controls several grasses and broad-leaved weeds. Sulfosulfuron is also not effective against some of the broad-leaved weeds.

Weeds emerge with crop if not controlled in the critical stages of crop growth and these may cause reduction in yield from 17 to 30% depending upon the intensity and kind of weed infestation in crop Bisen *et al*., (2006) [2]. Weed control by manual weeding is highly expansive which can't be feasible and also non availability of agricultural labour is another crucial issue. Therefore, we need to select the suitable chemical / herbicidal management in wheat based production system to sustain the profitability at reasonable cost and labour-saving method Kumar (2009) [10]. Herbicides offer most ideal, practical, effective and economical means of reducing early weed competition and crop production losses. However, continuous use of the some herbicides leads to built up of resistance in weeds, weed shift and their residue hazards under changing climate Barman *et al*., (2014) [1]. It is therefore, necessary to combine or change the method and strategies of weed control.

Materials and Methods

A field experiment was carried out at main experiment station (Agronomy) of Pili kothi Farm, T.D.P.G. College, Jaunpur. Distt. Jaunpur (Uttar Pradesh) during *Rabi* of 2019-20 and 2020-2021. Wheat (UP 2565) was shown on 2nd fortnight of November by using seed rate of 100 kg/ha at 5 cm depth with rows 20 cm apart. The experiment was laid out in randomized block design (RBD) with three replications comprising ten treatments, *viz*. weedy check, weed free, Sulfosulfuron 75% + Metsulfuron-methyl 20% WP 25+4 g/ha, Sulfosulfuron 75% + Carfentrazone- ethyl 40% DF 25+20 g/ha, Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25+12.76 g/ha, Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25+23.96 g/ha, Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP 60+4 g/ha, Clodinafop-propargyl 15% WP + Carfentrazone- ethyl 40% DF 60+20 g/ha, Clodinafop-propargyl 15% WP + (Arylex 20.85% + Florasulam 20%) 60 + 12.76 g/ha and Clodinafop-propargyl 15% WP + (Arylex 6.95% + Pyroxsulam 25%) 60 + 23.96 g/ha were sprayed (30 days after sowing). The crop was fertilized with recommended doses of N-P-K of 120- 60-40 kg/ha through urea, single superphosphate and murate of potash, respectively. Half dose of nitrogen and full dose of P_2O_5 and K_2O were applied as basal dose rest dose of nitrogen were applied in two equal splits at maximum tillering and panicle initiation stages. Herbicides were applied as post-emergence was at 30 DAS with manually operated knapsack sprayer with spray volume of 500 liter/ha. Weed population and weed dry weight was recorded in each plot in quadrate of 0.5 x 0.5 m^2 and subjected to square root transformation before analysis. Data on wheat yield and yield parameters were also recorded at crop maturity. Data were recorded on following parameters of growth, yield attributes and yields as per the standard procedure. The field data obtained for 2 years were pooled and statistically analyzed using F-test Gomez and Gomez (1984) [8]. Test of significance of the treatment differences were done on the basis of t-test. The significant difference between treatment means were compared with critical differences at 5% levels of probability. Major weed flora in experiment included *Phalaris minor*, *Chenopodium album*, *Medicago denticulate*, *Anagelis arvensis*, *Fumaria pariviplora*, *Cyperus rotendus* and *Coronopus didymus* during both the years. Therefore, keeping these facts in mind, the work was conducted to find out the efficacy of different tank mix herbicide against complex weed flora in wheat.

For calculating weed dry weight of weeds, the weeds taken with a quadrate were oven-dried at 70±5^{0}C, till they attained constant weight. The observation on weeds at 60 days of sowing and dry weight of weed and grain yield at harvest have been presented in (Figure 1). Weed control efficiency (WCE), Herbicide efficiency index (HEI) and weed persistence index (WPI) was calculated by using the standard formulae.

Weed control efficiency (WCE): Indicates the efficiency of any weed control treatments in comparison of any weed control treatment in comparison to weedy treatment. To adjudge the efficiency of weed control treatments, weed control efficiency (WCE) was calculated Mani *et al*., (1973) [11]: Das (2008) [5] as follows

$$\text{WCE (\%)} = \frac{\text{Weed dry weight in control plot} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in control plot}} \text{X } 100$$

Weed persistence index (WPI): Indicates the resistance in weeds against the tested treatments and confirms the effectiveness of the selected herbicides and the same was computed using the given formula as suggested by Mishra and Mishra (1997) [13].

$$\text{WPI} = \frac{\text{Weed dry weight in treated plot}}{\text{Weed dry weight in control plot}} \text{ X } \frac{\text{Weed count in control plot}}{\text{Weed count in treated plot}}$$

Herbicide efficiency index (HEI): Indicates the weed killing potential of a herbicide treatment and its phytotoxicity on the crop and the same was computed using the given formula as suggested by Krishnamurthy *et al*., (1975) [9]

$$\text{HEI} = \frac{\frac{\text{Yield of treatment} - \text{Yield of control}}{\text{Yield of treatment}} \text{X } 100}{\frac{\text{Weed weight in treatment}}{\text{Weed weight in control}} \text{ X } 100}$$

Results and Discussion

Effect on density and dry weight of weeds

Monocot weeds

The result revealed that, all herbicidal treatments effectively controlled population of weeds (Table 1) as compared to weedy check plots at 60 DAS during both the years. Tank mix (PoE) application of Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha reduced the weed count significantly at this stage of crop growth in comparison to weedy check and other treatments. Pooled results indicated that tank mix (PoE) application of Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha were found the most superior treatment that recorded significantly lower weed count followed by Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25+23.96 g/ha and and Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP 60+4 g/ha, Clodinafop-propargyl 15% WP + (Arylex 20.85% + Florasulam) 20%) 60+12.76 g/ha than rest of the

treatments except weed free. All the herbicidal treatments significantly reduced the dry-matter of monocot weeds. Tank mix (PoE) application of Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha highest reduction in dry-matter accumulation by monocot weeds and it differed significantly with control, but at par with Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25+23.96 g/ha and Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP 60+4 g/ha. Our results confirm the finding of Singh *et al*., (2022). Singh *et al*., (2011a) [21, 18] also reported that sulfosulfuron has been reported to be very effective against the grassy weeds and to some extent against BLWs.

Dicot weeds

An appraisal of data Table 1 revealed that tank mix (PoE) application of Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha 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 60 DAS significantly differed due to different weed control treatments. Among the different treatments tried, except weed free treatment the second best treatment emerged out from the study was Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha where significantly least number of dicot weed (2.4) was observed. Pooled data indicated that Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha was proved most superior which was statistically at par with post emergence application of Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25+23.96 g/ha. Heavy infestation of weeds under weedy check has also been reported by Singh and Singh (2005) [20]. In case of weed dry weight, similar pattern was also observed.

Weed persistence index (WPI): Weed persistence index indicating relative dry matter accumulation of weeds per count in comparison to control (Table 2) indicated that tank mix application of Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP (TM) resulted in higher persistence index (1.34) closely followed by Clodinafop-propargyl 15% WP + (Arylex 20.85% + Florasulam) 20%) (1.23), Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) (1.22), Sulfosulfuron 75% + Metsulfuron-methyl 20% WP (1.17) and Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) (1.14) indicating restance of escaped weeds to control measures. Whereas, Clodinafop-propargyl 15% WP + Carfentrazone- ethyl 40% DF (1.04) and Sulfosulfuron 75% + Carfentrazone- ethyl 40% DF (1.07) have recorded lower persistence of escaped weeds indicating broad spectrum effect in controlling the weeds.

Herbicide efficiency index (HEI): Tank mix application of Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) produced highest HEI (1.74) followed by Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) (1.15).

Weed control efficiency (WCE)

Among the herbicidal treatment, Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha recorded highest weed control efficiency of monocot and dicot weeds in pooled data of two years (Table 2). This was closely followed by Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25+23.96 g/ha. However, other herbicidal treatment showed lower WCE, indicating that there may be problem of lower efficacy of herbicide. Highest WCE indicates its relative performance of particular set of treatment Verma *et al*., (2015). Meena and Singh (2013) [24, 12] also reported higher WCE with tank-mix application of herbicides over their sole application.

Effect of different weed control practices on crop yield

Grain yield was significantly affected with different weed control treatments (Figure 1). Pooled results showed that weed free produced the maximum grain yield of 4.5 t/ha which was statistically at par with Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha. Application of Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25+23.96 g/ha was found to next best treatment. These treatments were significantly better than control plots. The higher grain yield with the application of herbicides could be ascribed to reduction in weed intensity which ultimately helped the crop to utilize nutrients, moisture, light and space more efficiently and hence increased the grain yield. Similar findings were also reported by Sarita *et al*., (2021) [17].

Nutrients uptake by crop

Wheat grain contained higher phosphorus content than wheat straw, whereas potassium content was higher in wheat straw as compared to wheat grains. Results indicated that the weed control treatments influenced the nutrient content (N, P and K) of grains and straw significantly (Table 3). However, the herbicidal treatment recorded slightly higher nutrient content in grains as well as straw than control (Unweeded). Pooled results showed N, P and K uptake by wheat crop (grain + straw) was higher with the application of Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25 + 12.76 g/ha followed by Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25+23.96 g/ha. Higher N, P and K uptake by wheat crop under herbicidal treatments as compared to control (Unweeded) treatment was also reported by Pandey *et al*., (2001) [15]. It could be attributed to better growing conditions during growth and development of crop which helped in better utilization of nutrients, thereby resulting in highest yield and nutrient uptake. The results are in line with the findings of Singh *et al*., (2011) [19]. Significantly the highest nutrients uptake was recorded under weed free situation due to higher grain and straw yield of wheat. Higher NPK uptake by crops in weed free plots was also reported by Monsefi *et al*., (2016) [14].

Table 1: Effect of weed control treatments on density and dry matter accumulation of weeds at 60 DAS (pooled data of two year)

Treatments	Dose (g/ha)	Weed density (no./m^2)		Weed dry weight (g/m^2)	
		Monocot	Dicot	Monocot	Dicot
Sulfosulfuron 75% + Metsulfuron-methyl 20% WP (TM)	25+4	4.5 (19.3)	3.7 (13.0)	3.3 (10.1)	3.0 (8.3)
Sulfosulfuron 75% + Carfentrazone- ethyl 40% DF (TM)	25+20	5.6 (30.3)	4.7 (21.3)	4.0 (15.5)	3.5 (11.8)
Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) (TM)	25+12.76	3.7 (13.0)	2.4 (5.0)	2.8 (7.2)	2.0 (3.1)
Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) (TM)	25+23.96	4.0 (15.7)	3.0 (8.3)	3.2 (9.4)	2.4 (5.0)
Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP (TM)	60+4	4.2 (17.0)	3.4 (10.7)	3.4 (10.8)	2.8 (7.3)
Clodinafop-propargyl 15% WP + Carfentrazone- ethyl 40% DF (TM)	60+20	5.5 (29.7)	5.8 (32.7)	4.0 (14.9)	4.2 (16.7)
Clodinafop-propargyl 15% WP + (Arylex 20.85% + Florasulam) 20%) (TM)	60+12.76	4.2 (17.0)	3.8 (15.0)	3.2 (9.7)	3.1 (9.4)
Clodinafop-propargyl 15% WP + (Arylex 6.95% + Pyroxsulam 25%) (TM)	60+23.96	4.7 (21.3)	5.0 (24.0)	3.4 (10.6)	3.7 (12.7)
Weed Free	-	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Weedy Check	-	8.3 (68.3)	8.4 (69.0)	5.9 (34.3)	5.8 (33.5)
S.Em±		0.14	0.21	0.12	0.14
LSD (P=0.05)		0.42	0.61	0.36	0.40

TM- Tank mix, Value in parentheses were original and transformed to square root $\sqrt{X+1}$ for analysis

Table 2: Effect of weed control treatments on weed persistence index and herbicide efficiency index and weed control efficiency at 60 DAS

Treatments	Dose (g/ha)	WPI	HEI	WCI (%)	
				Monocot	Dicot
Sulfosulfuron 75% + Metsulfuron-methyl 20% WP (TM)	25+4	1.17	0.86	70.5	75.0
Sulfosulfuron 75% + Carfentrazone- ethyl 40% DF (TM)	25+20	1.07	0.47	53.9	65.5
Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) (TM)	25+12.76	1.14	1.74	78.6	90.8
Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) (TM)	25+23.96	1.22	1.15	72.1	85.3
Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP (TM)	60+4	1.34	0.86	67.6	78.6
Clodinafop-propargyl 15% WP + Carfentrazone- ethyl 40% DF (TM)	60+20	1.04	0.41	54.6	49.8
Clodinafop-propargyl 15% WP + (Arylex 20.85% + Florasulam) 20%) (TM)	60+12.76	1.23	0.77	72.1	72.8
Clodinafop-propargyl 15% WP + (Arylex 6.95% + Pyroxsulam 25%) (TM)	60+23.96	1.04	0.55	68.5	62.5
Weed Free	-	-	-	100.0	100.0
Weedy Check	-	-	-	-	-

TM- Tank mix

Table 3: Effect of weed management practices on nutrient uptake (Pooled data of two years)

Treatments	Dose (g/ha)	Nutrient uptake by grain			Nutrient uptake by straw			Uptake by crop		
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Sulfosulfuron 75% + Metsulfuron-methyl 20% WP (TM)	25+4	49.39	9.92	15.53	25.42	9.38	68.74	74.81	19.30	84.27
Sulfosulfuron 75% + Carfentrazone- ethyl 40% DF (TM)	25+20	44.03	8.39	14.60	23.38	8.37	64.62	67.41	16.75	79.22
Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) (TM)	25+12.76	54.08	11.88	18.15	30.60	11.11	73.16	84.68	22.99	91.31
Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) (TM)	25+23.96	51.33	8.57	14.68	27.47	9.05	71.20	78.80	17.62	85.88
Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP (TM)	60+4	50.11	10.87	16.56	27.60	7.94	68.33	77.71	18.81	84.89
Clodinafop-propargyl 15% WP + Carfentrazone- ethyl 40% DF (TM)	60+20	44.79	8.46	13.60	23.72	7.62	65.42	68.51	16.08	79.02
Clodinafop-propargyl 15% WP + (Arylex 20.85% + Florasulam) 20%) (TM)	60+12.76	46.14	7.93	14.34	23.18	8.23	64.81	69.32	16.16	79.15
Clodinafop-propargyl 15% WP + (Arylex 6.95% + Pyroxsulam 25%) (TM)	60+23.96	43.46	7.00	12.63	21.40	7.12	62.49	64.86	14.12	75.11
Weed Free	-	57.39	13.25	18.77	34.18	13.54	78.50	91.57	26.80	97.28
Weedy Check	-	31.50	5.41	11.16	14.21	4.70	52.53	45.71	10.10	63.69
S.Em±		0.66	0.56	0.43	1.53	0.74	1.46	1.80	0.99	1.65
LSD (P=0.05)		1.89	1.60	1.24	4.36	2.11	4.17	5.15	2.83	4.73

TM- Tank mix

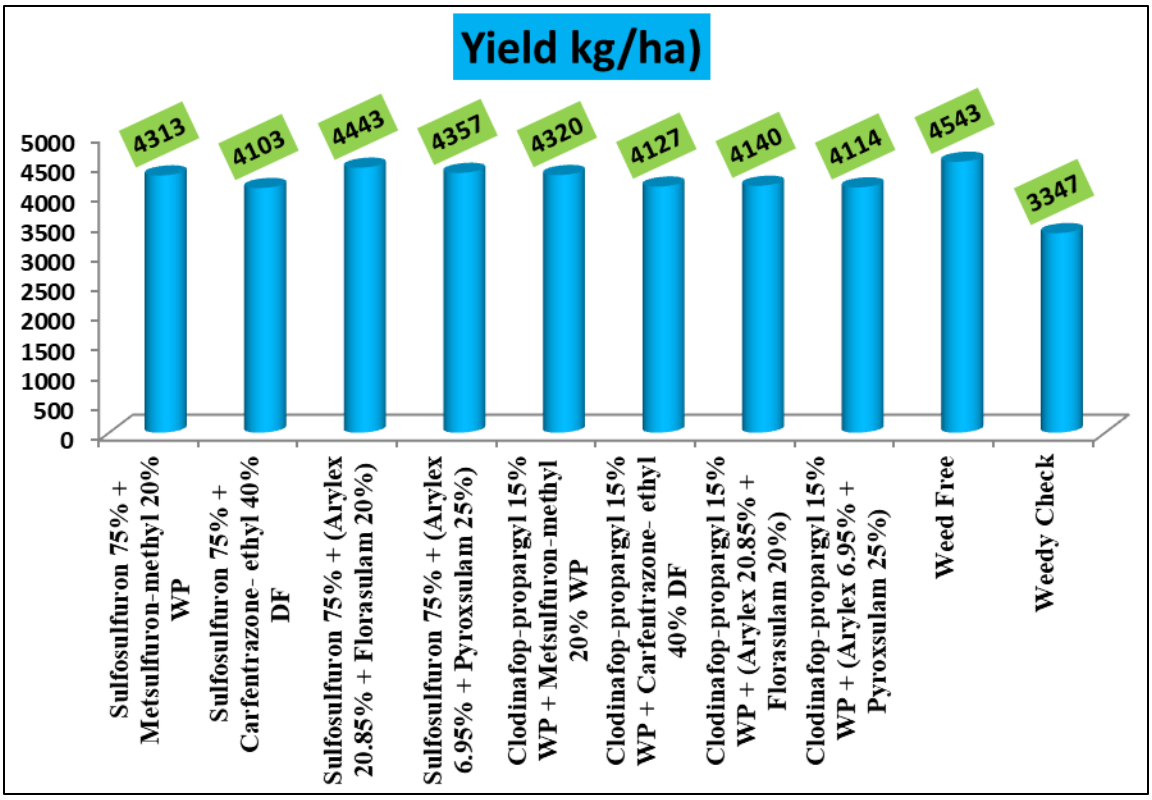

Fig 1: Effect of weed control treatments on yield pooled data of two years

Conclusion

Among herbicidal treatments, tank mix application of Sulfosulfuron 75% + (Arylex 20.85% + Florasulam 20%) 25+12.76 g/ha was found to be superior followed by Sulfosulfuron 75% + (Arylex 6.95% + Pyroxsulam 25%) 25 + 23.96 g/ha, Clodinafop-propargyl 15% WP + Metsulfuron-methyl 20% WP 60+4 g/ha and Sulfosulfuron 75% + Metsulfuron-methyl 20% WP 25+4 g/ha over rest of the weed management practices as it significantly recorded lowest weeds density and dry weight and nutrients uptake by crop, WPI, HEI and maximum WCE. As a result, it could be a viable strategy for increasing wheat productivity and profitability in irrigated ecosystems in the Middle Indo Genetic Plains of Eastern India.

Acknowledgments

This work is a part of the Ph.D thesis research of the author. The author is highly grateful to T.D.P.G. College, Jaunpur. Distt. Jaunpur (Uttar Pradesh) for providing necessary assistance for conducting the trial and recordind the various observations under the research work.

Literature Cited

1. Barman K, Singh V, Dubey R, Singh P, Dixit A, Sharma AR. Challenges and opportunities in weed management under a changing agricultural scenario. In: (Eds Chauhan and Mahajan) Recent Advances in weed Management. Springer, New York, NY, 2014.
2. Bisen PK, Singh RK, Singh RP. Relative composition of weeds and wheat as influenced by different weed control and tillage practices. Indian Journal of Weed Science. 2006;38:9-11.
3. Chhokar RS, Malik RK. Isoproturon resistant Phalaris minor and its response to alternate herbicides. Weed Technology. 2002;16:116-123.
4. Chhokar RS, Sharma RK. Multiple herbicide resistance in Littleseed canary grass (*Phalaris minor*): A threat to wheat production in India. Weed Biology and Management. 2008;8:112-123.
5. Das TK. Weed Science: Basics and Applications. 1st Edition: Jain Brothers Publishers, New Delhi, 2008,901.
6. FAOSTAT D. Food and agriculture organization of the United Nations Statistical data base, 2020.
7. GOI (Government of India). Annual Report. 2019-20. Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India (GOI), Krishi Bhawn, Directorate of Economics and statistics. Third Advance Estimates of Production of Food grains New Delhi-110001, 2021.
8. Gomez KA, Gomez AA. Statistical Procedure for Agricultural Research, 2nd Edn. John Wiley and Sons, New York, 1984,241-271p.
9. Krishnamurthy K, Raju BG, Raghunath G, Jagnath MK, Prasad TVR. Herbicide efficiency index in sorghum. Indian Journal of Weed Science. 1975;7(2):75-79.
10. Kumar NS. Effect of plant density and weed management practices on production potential of groundnut (*Arachis hypogaea* L.). Indian Journal of Agricultural Research. 2009;43:13-17.
11. Mani VS, Malla ML, Gautam KC, Das B. Weed killing chemical in potato cultivation. PANS. 1973;23:17-18.
12. Meena BL, Singh RK. Response of wheat to rice residue and weed management practices. Indian Journal of Agronomy. 2013;58(4):521-524.
13. Misra M, Mishra A. Estimation of IPM index in Jute: a new approach. Indian Journal of Weed Science. 1997;29:39-42.
14. Monsefi A, Sharma AR, Zan NR. Weed management and conservation tillage for improving productivity, nutrient uptake and profitability of wheat in soybeanwheat

cropping system. International Journal of Plant Production. 2016;10(1):1-12.
15. Pandey IB, Sharma SL, Tiwari S, Bharati V. Effect of tillage and weed management on grain yield and nutrient removal by wheat (*Triticum aestivum*) and weeds. Indian Journal of Weed Science. 2001;33:107-111.
16. Rosegrant MW, Agcaoili M. Global food demand, supply and price prospects to 2010. Washington, DC, 2010.
17. Sarita, Singh Ishwar, Mehriya ML, Shukla UN, Kumar Manoj, Parewa HP *et al*. Effect of different fertilizer levels and herbicide treatments on weed and wheat. Indian Journal of Weed Science. 2021;53(4):367-373
18. Singh AK, Kumar R, Singh AK, Kumari A. Bio-efficacy of sulfosulfuron on weed flora and irrigated wheat (*Triticum aestivum* L.) yield. Environment and Ecology. 2011a;29(2A):834- 838.
19. Singh B, Humphreys E, Eberbach PL, Katupitiya A, Singh Y, Kukal SS. Growth, yield and water productivity of zero-till wheat as affected by rice straw mulch and irrigation schedule. Field Crops Research. 2011;121(2):209–225.
20. Singh J, Singh KP. Effect of organic manures on yield and yield attributing characters of wheat. Indian Journal of Agronomy. 2005;50:289-91.
21. Singh Vishal, Vikram Singh, Shrish Kumar, Pratap Tej. Tank mix herbicide combination effect on weed and yield of wheat in North-Eastern plain zone. The Pharma Innovation Journal. 2022;11(1):1359-1362
22. Tesfay A, Sharma JJ, Kassahun Z. Effect of weed control methods on weeds and wheat (*Triticum aestivam* L.) yield. World Journal of agriculture research. 2014;2:124-128.
23. USDA. World agricultural supply and demand estimates, 2020.
24. Verma SK, Singh SB, Prasad SK, Meena RN, Meena RS. Influence of irrigation regimes and weed management practices on water use and nutrient uptake in wheat. Bangladesh Journal of Botany. 2015;44(3):437-442.