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Effects of weed control treatments on wheat crop and associated weeds

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ABSTRACT : A field experiment was conducted in wheat during *Rabi* season 2011-12 on sandy loam soil at Crop Research Centre, Chirodi of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.).The experiment was conducted in R.B.D. with three replications comprising ten treatments of weed management, clodinafop 60 g a.i ha^{-1}, sulfosulfuron 25 g a.i ha^{-1}, metribuzin at 105 g a.i ha^{-1}, carfentrazone 40 g ai ha^{-1}, clodi.+ metri 60 + 122.5 g a.i ha^{-1}, clodi. + metri 60 + 105 g a.i ha^{-1}, sulfo. + metri 25 + 105 g a.i ha^{-1}, sulfo. + carfen. 25 + 40 g a.i ha^{-1} as post emergence and weed free and weedy. The results indicated that plant population, plants height, maximum number of tillers/meter row length, dry matter accumulation, highest grain yield (55.13 q/ha^{-1}), straw yield (78.08 q/ha^{-1}) significantly reduced the weed population, dry weight of weed, highest weed control efficiency and minimum loss of nutrient were recorded with the application of sulfosulfuron .+ metribuzin 25 + 105 g a.i ha^{-1} as post emergence established its superiority over rest of the herbicides. Similarly application of sulfosulfuron .+ metribuzin 25 + 105 g a.i ha^{-1} as post emergence resulted into higher gross return (Rs. 90362.05), net return (Rs. 63453.59 ha^{-1}) and B: C ratio (2.48).

KEY WORDS : Post herbicides, Wheat, Weather parameters, Weed control

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Wheat (*Triticum* spp.) is the most important grain crop both in regard to its antiquity and its use as a source of human food. Wheat serves as a staple food for about one billion people in as many as 43 countries of the world. It provides about 20 per cent of total food calories for the human race. Wheat is grown in approximately 220 million ha. worldwide, about half of which is in developing countries. The main wheat growing countries include China, India, U.S.A., Russia, France, Canada, Germany, Turkey, Australia and Ukrain. Today, among the cereal crops grown in India, wheat comes next only to rice in terms of area and production. Wheat is a member of *Poaceae* family and believed to be originated from the Middle-East region of Asia.

Three main species commonly grown in the world including India are the bread wheat (*Triticum aestivum* L.), the macaroni wheat (*Triticum durum* Desf.) and emmer wheat (*Triticum dicoccum* Schubl.) covering 86, 12 and 2 per cent of total wheat area, respectively. Bread wheat is cultivated in all the wheat growing area of the country. So far ploidy level is concerned, bread wheat comes under the hexaploid wheat with 2n=42 chromosomes and the basic chromosome number of x=7.

Wheat grain contains starch (60-68%), protein (6-21%), fat (1.5-2.0%), cellulose (2.0-2.5%), minerals (1.8%) and vitamins. The uniqueness of wheat in contrast to other cereals is that wheat contains gluten protein which enables leavened dough to rise by forming minute gas cells and this property enables bakers to produce light breads. In India, the whole meal wheat (*atta*) is chiefly used for making *chapatis*, *parathas* and *poories*. It is also used in many kind of breads, cakes, cookies, crackers, pancakes, noodles, piecrust, ice-cream cones, pizza, bulgur and other baby foods.

The area under wheat increased since the start of green revolution in 1967 and the production and productivity were also increased. The area under wheat is increased from12.8 m.ha in 1966-67 to 29.25m.ha in 2011-12. In this period production has also increased from 11.4 to 93.90 mt and the productivity increased from 887 to 3057 kg ha^{-1} (Anonymous, 2012).

The major wheat producing states of India are Uttar Pradesh, Punjab, Haryana with the production of 28.55, 15.73, and 10.81 mt, respectively, the U.P. ranked first in percentage share of wheat production (35.39%) with the second of Punjab (19.50%) and third of Haryana (13.40%). But Punjab has highest productivity followed by Haryana and U.P with 4462 kg/ha, 4390 kg/ha and 4351 kg/ha, respectively (Anonymous, 2011).

Phalaris minor is one of the very serious in wheat in this cropping system and some time almost 100 per cent crop losses have been reported Singh and Singh (2004). However, some broad leaf weeds are also causing a threat but their control is comparatively easier and effectively but control of *Phalaris minor* has become a serious challenge. Since 1977, isoproturon was being used to control *Phalaris minor* very effectively. But may be due to continuous use, some resistant biotypes have come up especially in Punjab, Haryana, Uttaranchal and some pockets in western U.P., consequently isoproturon is not giving the proper response Dixit and Bhan (1998). Considering the facts in view, some new herbicide molecules individually and in combination are to be tested to study their bio-efficiency in control *Phalaris minor* and other weeds in wheat

Weed problem is one of the major barriers responsible for low productivity of wheat because, weed competes with the crop for moisture, nutrients, space, light etc. Moreover they increase production cost, decrease yield of the crop, harbours insects and plant diseases, decrease quality of farm produce and reduce values of the land. The weed in India are causing substantial losses to agriculture production and the annual losses in terms of money come to the Rs. 1650 crores (Joshi, 2002). In agriculture weed causes more damage compared to insects, pests and diseases but due to hidden loss by weed in crop production, it has not drawn much attention of agriculturists (Rao, 2001).

Weeding at an early stage of crop growth in wheat is a very important practice because heavy infestation of weeds hampers the crop growth as well as greater reduction in wheat yield. Slow growth of wheat plants during early growth stage provide specific conditions for the growth of various weed flora at the time of germination and also subsequent growth periods.

The prominent weeds noted in wheat field are *Phalaris minor, Cyperus rotundus, Cynodon dactylon, Chenopodium album, Anagallis arvensis, Avena fatua, Convolvulus arvensis* and *Lathyrus* spp etc., which alone causes 33 per cent reduction in wheat yield. Rice-wheat is one of the most important cropping system in northern part of country stretches from Jammu plains to lower Assam having an area about 10.8 m ha..

The cultivators are not aware of proper dose of herbicides, time of application, economics and their persistence in the soil. Several selective herbicides are available in the market, which are treated to be effective for particular crop. The farmers have to make decisions about the selection of right type of herbicides.

RESEARCH PROCEDURE

The experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, in *Rabi* season of 2011-2012. Meerut is located on the Delhi-Dehradun highway. Geographically it is located at 29^0 40'N latitude and 77^0 42' E longitude at an altitude of 237 meters above the mean sea level. The area lies in the Western Uttar Pradesh. The climate of this region is subtropical and semi-arid the mean maximum temperature of this region is about 43^0C to 45^0C during summer in April, while very low temperature (3^0C) accompanied by frost may be experienced in December-January. The winters are cool, frost generally occurs towards the end of December and may continue till the end of January. The monsoon generally begins during the third week of June and continues up to end of September. The total precipitation 800 mm and its distribution in this region varies largely, about 80 to 90 per cent of it's received during July to September and few showers are also a common feature during the month of December to January and in late spring season. Total precipitation of 43.4 mm was received during the experimentation period. The maximum temperature being 35.6^{0}C was recorded in 14th standard week, while the minimum temperature was 2.6^{0}C in 52th standard week and the relative humidity ranged from 29.7 to 88.2 per cent recorded in 21th and 42th week, respectively. The soil of experimental field was sandy loam in texture for soil analysis, soil samples were taken from different places at site the experimental field from 0-15 cm depth before application of fertilizers. Composite sample was prepared by mixing all soil samples. Wheat variety DBW-16 was used as seed, recommended dose of fertilizer NPK as 150:75:60 kg h^{-1} through source of urea (46% N), DAP (18% N and 46% P_2O_5) and MOP (60% K_2O) were used as experimental material during the experiment.

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under following heads :

Crop growth and development :

Plant height :

In wheat plant height was increased rapidly with advanced age and reached highest up to 90 DAS (Table 1). At 30 days stage data indicate that non-significant response was observed with respect weed control treatment as the herbicide were applied 30 day stages. At 60 days stage, highest plant height (87.33cm) was obtained under weed free (T_9) treatment being at par with rest of treatment except weedy (T_{10}), treatment. Lowest plant height (78.86 cm) was obtained under weedy (T_{10}), treatment. At 90 DAS highest height of plant was obtained under T_9 (108.88 cm), followed by sulfo.+ metri.25+105 g a.i ha^{-1} (T_7) statistically at par, lowest height of plant was observed (96.66 cm) in weedy (T_{10}) treatment. Remaining treatments were observed with significantly highest plant height than weedy (T_{10}) treatment. At harvest stage similar type of trend was observed with respect to above different treatment, lowest and highest plant height in weedy (T_{10}) and weed free (T_9), respectively.

Plant population and number of tillers per meter row length :

Effect of different weed management treatments was found non-significant on initial plant population as the herbicide were applied 30 day stages. It can be seen from the Table 2 that variations in number of tillers due to treatments effects were statistically highest at all the stages. Numbers of tillers were counted at different crop growth stages and it was observed that the more tillers were observed at 60 DAS and started decline thereafter. At 60, 90 DAS and at harvest the highest numbers of tillers (135.22, 118.14, and 110.18, respectively) were recorded in the treatment sulfo.+ metri.25+105 g a.i ha^{-1} (T_7) while the lowest number of tillers (105.70, 97.0 and 90.29) were recorded with weedy treatment (T_{10}) at 60, 90 DAS and at harvest, respectively.

Dry matter of wheat crop (G accumulation meter^{-1} row length) :

Total dry matter accumulation (Table 3) was very

Table 1 : Plant height as influenced by different treatments at different growth stages

Treatments		Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	Clodinafop 60 g a.i ha^{-1}	28.25	83.16	99.32	101.16
T_2	Sulfosulfuron 25 g a.i ha^{-1}	30.07	85.21	101.19	103.31
T_3	Metribuzin 175 g a.i ha^{-1}	31.11	84.10	100.21	102.14
T_4	Carfentrazone 50 g a.i ha^{-1}	31.29	85.51	102.77	105.12
T_5	Clodi.+metri.60+122.5g a.i ha^{-1}	28.53	85.99	104.15	107.26
T_6	Clodi.+ metri. 60+105 g a.i ha^{-1}	31.93	85.26	102.25	104.25
T_7	Sulfo.+ metri.25+105 g a.i ha^{-1}	29.42	87.12	107.15	110.22
T_8	Sulfo.+carfen.25+40 g a.i ha^{-1}	30.25	86.50	104.98	107.20
T_9	Weed free	28.52	87.33	108.88	112.10
T_{10}	Weedy	29.23	78.86	96.66	97.85
S.E.(±)		0.88	1.44	0.76	2.45
C.D. (P=0.05)		NS	4.33	2.36	7.35

NS=Non-significant

slow up to 30 DAS followed by a high rate of dry matter accumulation upto 90 DAS. The dry matter accumulation was increased at higher rate from 60 DAS to 90 DAS. At 30 days stage indicates that non-significant response was observed with respect to weed control treatment as the herbicide was applied 30 day stage. The mean dry matter accumulation was highest under weed free (T_9), and lowest under weedy (T_{10}), treatment at 60, and 90 DAS observation, respectively. At 60 DAS and 90 DAS stage highest dry matter accumulation was found 126.21 and 148.17, respectively, under herbicidal treatment sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), followed by sulfo. + carfen. 25 + 40 g a.i ha^{-1} (T_8) and clodi.+metri.60+122.5 g a.i ha^{-1} (T_8) being statistically at par. Remaining treatments were significantly highest than weedy (T_{10}).

Yield attributes:

The highest spike length (11.48cm) was recorded sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), which was at par with clodi.+metri.60+122.5g a.i ha^{-1} (T_5), sulfo. + carfen. 25+40 g a.i ha^{-1} (T_8), clodi.+ metri. 60+105 g a.i ha^{-1} (T_6), and sulfosulfuron 25 g a.i ha^{-1} (T_2). Lowest spike length (9.15) was observed with weedy (T_{10}), remaining treatments recorded highest spike length than weedy (T_{10}), treatment.

The significantly highest number of spikelet $spike^{-1}$ produced (15.35) was recorded under sulfo.+metri. 25+105 g a.i ha^{-1} (T_7), followed by sulfo. + carfen.25+40 g a.i ha^{-1} (T_8), clodi.+ metri. 60+122.5g a.i ha^{-1} (T_5), clodi.+ metri. 60+105 g a.i ha^{-1} (T_6), sulfosulfuron 25 g a.i ha^{-1} (T_2), metribuzin 175 g a.i ha^{-1} (T_3), carfentrazone 50 g a.i ha^{-1} (T_4) and clodinafop 60 g a.i ha^{-1} (T_1). The lowest number of spikelet $spike^{-1}$ was produced (11.31) under weedy (T_{10}).

In general, grains per spike were highest recorded (46.16) in treatments sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), followed by clodi.+ metri. 60+122.5g a.i ha^{-1} (T_5), sulfo. + carfen.25+40 g a.i ha^{-1} (T_8), and clodi.+ metri. 60+105 g a.i ha^{-1} (T_6). Remaining treatments recorded highest grains per spike than weedy (T_{10}), the lowest grains per spike (34.25) was recorded under weedy (T_{10}), treatment.

The highest 1000 grains weight was recorded (48.17) with sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), which was at par with remaining all treatments except weedy (T_{10}), treatment, the lowest test weight was observed (38.11) under weedy (T_{10}).

Increased values in these yield attributes might have been due to negligible weed crop-competition and increased nutrients and water uptake by the crop leading to increased rate of photosynthesis, supply of photosynthates to various metabolic sinks might have favoured yield attributes and overall improvement in vegetative growth which favorably influenced the tillering, flowering, fruiting and ultimately resulted into increased grain weight and test weight. These findings are in close conformity with those reported by Singh and Saha (2001); Yadav *et al*. (2001); Sardana *et al* (2001) and Jat*et al*. (2004) in respect to number of tillers.

Effect on weeds :

The weed flora in the experimental field were identified and counted in weedy check plot at different stages of crop growth. Out of which *Phalaris minor, Avena fatua* and *Cynodon dactylon* among grasses and

Table 2 : Number of tillers m^{-1} row length as influenced by different treatments at various stages

Treatments		Number of tillers m^{-1} row length			
		Plant population 20 DAS	60 DAS	90 DAS	AT harvest
T_1	Clodinafop 60 g a.i ha^{-1}	58.48	119.18	107.29	98.65
T_2	Sulfosulfuron 25 g a.i ha^{-1}	62.14	124.81	109.15	102.25
T_3	Metribuzin 175 g a.i ha^{-1}	64.22	115.15	105.15	95.88
T_4	Carfentrazone 50 g a.i ha^{-1}	64.59	107.78	99.22	92.29
T_5	Clodi.+metri.60+122.5g a.i ha^{-1}	59.80	130.81	115.18	107.14
T_6	Clodi.+ metri. 60+105 g a.i ha^{-1}	65.19	124.29	112.18	101.26
T_7	Sulfo.+ metri.25+105 g a.i ha^{-1}	60.18	135.22	118.14	110.18
T_8	Sulfo.+carfen.25+40 g a.i ha^{-1}	62.51	127.08	111.29	104.14
T_9	Weed free	59.70	141.85	120.15	115.96
T_{10}	Weedy	60.51	105.70	97.0	90.29
S.E.(±)		1.89	2.95	1.41	1.23
C.D.(P=0.05)		NS	8.84	4.24	3.70

NS=Non-significant

Chenopodium album L., *Anagallis arvensis* L., *Melilotus alba*, *Fumaria parviflora* and *Vicia* spp among the non grassy weeds and *Cyperus rotundus* in sedges were the dominant weed species in the experiment (Table 4).

The species wise density of weeds recorded at various stage of crop growth revealed that the wheat crop was infested with grassy as well as non-grassy weeds. *Phalaris minor,* was the important monocot weeds, which remained throughout growing season. At the time of 30 DAS stage the weed density in weedy plot increased upto 90 DAS stage and decreased at harvest, while concerning the species wise weeds, all the weed species increased up to 90 DAS stage, except of *Phalaris minor,* which was found decreasing in order at harvest. Among narrow leaves, *Phalaris minor,* was the most dominant weed in the weedy while in broad leaved weeds; *Chenopodium album* L.,was one of the most dominant weed species during crop growing period. However, some other broad leaves weeds *i.e. Melilotus alba,* and *Anagallis arvensis* L. were also present. All the weed control treatment decreased the weed density per unit area over weedy at various growth stages. At 60, 90DAS and at harvest stage all the weed control treatment reduced the weed density significantly treatment sulfo.+ metri 25 + 105 g a.i ha^{-1} (T_7), sulfo.+ carfen. 25 + 40 g a.i ha^{-1} (T_8), and clodi.+ metri 60 + 122.5 g a.i ha^{-1} (T_5), were more effective in reducing density of weeds compared to other treatment The fact was that sulfosulfuron 25 g a.i ha^{-1} and clodinafop at 60 g a.i ha^{-1} controlled *Phalaris minor* and metribuzin at 105 g a.i ha^{-1} and carfentrazone 40 g a.i ha^{-1} took care to control the *Phalaris minor* as well as the broad leaves weeds.

Table 3 : Total dry matter accumulation of wheat (g m^{-1} row length) as influenced by different treatments at various stages

Treatments		Total dry matter accumulation		
		30 DAS	60 DAS	90 DAS
T_1	Clodinafop 60 g a.i ha^{-1}	29.25	105.11	121.25
T_2	Sulfosulfuron 25 g a.i ha^{-1}	31.07	110.51	129.20
T_3	Metribuzin 175 g a.i ha^{-1}	32.11	108.28	126.18
T_4	Carfentrazone 50 g a.i ha^{-1}	32.29	117.14	137.22
T_5	Clodi.+metri.60+122.5g a.i ha^{-1}	29.53	122.29	141.25
T_6	Clodi.+ metri. 60+105 g a.i ha^{-1}	32.93	112.81	134.18
T_7	Sulfo.+ metri.25+105 g a.i ha^{-1}	30.09	126.21	148.17
T_8	Sulfo.+carfen.25+40 g a.i ha^{-1}	31.25	123.82	146.21
T_9	Weed free	29.52	128.23	151.19
T_{10}	Weedy	30.23	101.29	116.33
S.E.(±)		0.93	1.73	1.69
C.D.(P=0.05)		NS	5.20	5.06

NS=Non-significant

Table 4 : Effect of various weed control treatment on weed population (No. m^{-2}) at harvest of wheat

Treatments		*P. minor*	*C. album*	*M. alba*	other	Total
T_1	Clodinafop 60 g a.i ha^{-1}	8.5	13.5	8.5	11.2	41.7
T_2	Sulfosulfuron 25 g a.i ha^{-1}	6.1	7.8	5.1	6.2	25.2
T_3	Metribuzin 175 g a.i ha^{-1}	2.5	3.1	2.6	2.1	10.3
T_4	Carfentrazone 50 g a.i ha^{-1}	5.3	4.4	7.9	14.2	31.8
T_5	Clodi.+metri.60+122.5g a.i ha^{-1}	1.0	1.9	3.1	1.5	7.5
T_6	Clodi.+ metri. 60+105 g a.i ha^{-1}	2.1	2.0	2.2	1.1	7.4
T_7	Sulfo.+ metri.25+105 g a.i ha^{-1}	0.9	1.0	1.0	1.2	4.1
T_8	Sulfo.+carfen.25+40 g a.i ha^{-1}	1.3	2.0	1.2	1.6	6.1
T_9	Weed free	0.0	0.0	0.0	0.0	0.0
T_{10}	Weedy	15.2	26.2	13.9	32	87.3
S.E.(±)		0.51	0.98	0.50	1.44	1.84
C.D. (P=0.05)		1.54	2.93	1.50	4.31	5.52

Dry matter of weeds (g/m^2) :

Among different treatments, proved superior to reduce dry weed weight. However, rest of the treatments sulfo.+ metri 25 + 105 g ha^{-1}(T_7), was also found equally effective to restrict dry weight of weeds. Significantly the highest dry weight of weeds was observed under weedy treatment. Reduction in dry weight of weeds under sulfo.+ metri 25 + 105 g a.i ha^{-1}(T_7), sulfo.+ carfen. 25 + 40 g a.i ha^{-1} (T_8), clodi.+ metri 60 + 122.5 g a.i ha^{-1} (T_5), carfentrazone 50 g a.i ha^{-1} (T_4) and clodi.+ metri 60 + 105 g a.i ha^{-1} (T_6), over weedy treatment were 17.14, 70.00, 99.00, and 90.60 g m^{-2}, at 30, 60, 90 DAS and at harvest, respectively (Table 5). Reduction in weed biomass was due to lower weed population recorded under these treatments could be attributed to the effective weed control. The weedy treatment (T_{10}) recorded significantly the highest dry weight of weeds, might be due to uncontrolled condition favoured luxurious weed growth leading to increased dry matter accumulation. The findings corroborate with those of Sukhadia *et al.* (2000); Chopra *et al.* (2001); Poonia *et al.* (2001) and Sardana *et al.* (2001).

Weed control efficiency (%):

The highest weed control efficiency (100 %) was registered under weed free (T_9) treatment and closely followed by treatment sulfo.+ metri.25+105 g a.i ha^{-1} (T_7) with 89.89 per cent and sulfo.+carfen.25+40 g a.i ha^{-1} (T_8) with 86.36 per cent. The lowest weed control efficiency was observed under weedy (T_{10}) treatment (Table 5).

Yield:

In herbicidal weed control treatments highest biological yield was observed (133.21q/ha) under sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), followed by clodi.+ metri.

Table 5 : Total dry matter weeds (g M^{-2}) as affected by weed management practice in wheat

Treatments		Dry matter accumulation of weeds 30 DAS	60 DAS	90 DAS	At harvest	W.C.E (%)
T_1	Clodinafop 60 g a.i ha^{-1}	17.45	27.50	44.60	39.20	54.94
T_2	Sulfosulfuron 25 g a.i ha^{-1}	14.93	24.20	31.20	28.40	68.48
T_3	Metribuzin 175 g a.i ha^{-1}	16.29	9.00	18.40	16.30	81.41
T_4	Carfentrazone 50 g a.i ha^{-1}	13.94	19.00	27.10	23.20	72.62
T_5	Clodi.+metri.60+122.5g a.i ha^{-1}	15.45	6.60	15.00	12.10	84.84
T_6	Clodi.+ metri. 60+105 g a.i ha^{-1}	14.77	9.00	17.60	14.70	82.22
T_7	Sulfo.+ metri.25+105 g a.i ha^{-1}	15.95	6.00	10.00	9.20	89.89
T_8	Sulfo.+carfen.25+40 g a.i ha^{-1}	12.91	7.00	13.50	11.50	86.36
T_9	Weed free	0.0	0.0	0.0	0.0	100
T_{10}	Weedy	17.14	70.00	99.00	90.60	0
S.E.(±)		0.03	1.96	1.37	1.11	
C.D. (P=0.05)		0.11	5.82	4.10	4.10	

Table 6 : Yield (q ha^{1}) and harvest index as influenced by different treatments

Treatments		Biological yield	Grain yield	Straw yield	Harvest Index
T_1	Clodinafop 60 g a.i ha^{-1}	110.98	44.53	66.45	40.12
T_2	Sulfosulfuron 25 g a.i ha^{-1}	117.89	48.06	69.83	40.76
T_3	Metribuzin 175 g a.i ha^{-1}	111.85	46.33	65.52	41.42
T_4	Carfentrazone 50 g a.i ha^{-1}	104.35	42.00	62.35	40.24
T_5	Clodi.+metri.60+122.5g a.i ha^{-1}	130.55	54.60	75.95	41.82
T_6	Clodi.+ metri. 60+105 g a.i ha^{-1}	125.45	52.33	73.12	41.71
T_7	Sulfo.+ metri.25+105 g a.i ha^{-1}	133.21	55.13	78.08	41.38
T_8	Sulfo.+carfen.25+40 g a.i ha^{-1}	125.8	51.73	74.07	41.12
T_9	Weed free	134.45	56.13	78.32	41.74
T_{10}	Weedy	97.25	38.60	58.65	39.69
S.E.(±)		1.42	1.04	1.66	0.33
C.D. (P=0.05)		4.25	3.16	4.99	1.01

60 + 122.5g a.i ha^{-1} (T_5), which were statistically at par. The lowest (97.25 q/ha^{-1}) and highest (134.45) biological yield was observed under weedy (T_{10}), and weed free (T_9), treatment, respectively (Table 6). Highest grain yield (55.13q/ha^{-1}) was recorded in herbicidal weed control treatment under sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), followed by clodi. + metri.60+122.5g a.i ha^{-1} (T_5), and sulfo.+carfen.25+40 g a.i ha^{-1} (T_8), being statistically at par. Remaining treatments were observed significantly with higher grain yield than weedy (T_{10}), treatment. The highest and lowest grain yield was recorded (56.13 q/ha^{-1}), and (38.60 q/ha^{-1}) was recorded under weed free (T_9), and weedy (T_{10}). Treatment sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), was recorded 42.82 per cent higher grain yield than weedy (T_{10}) treatment. In herbicidal weed control treatment highest straw yield was observed (78.08 q/ha^{-1}) under sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), followed by sulfo.+carfen.25+40 g a.i ha^{-1}(T_8), clodi.+metri.60+122.5g a.i ha^{-1} (T_5), and clodi.+ metri. 60+105 g a.i ha^{-1}(T_6), which were statistically at par. The lowest and highest straw yield was observed (78.32 q/ha^{-1}) and (58.65 q/ha^{-1}) under weedy (T_{10}), and weed free (T_9), treatment, respectively, remaining treatments recorded significantly higher straw yield than weedy (T_{10}). Treatment sulfo.+ metri. 25 +105 g a.i ha^{-1} (T_7), recorded 33.12 per cent increased straw yield than weedy (T_{10}), treatment. No different trend with respect to the effect of weed management on harvest index obtained. However, the highest harvest index was obtained (41.82 %) under treatment clodi.+metri.60 + 122.5 g a.i ha^{-1} (T_5), followed by clodi.+metri.60+122.5g a.i ha^{-1} (T_6), sulfo. + metri.25+105 g a.i ha^{-1} (T_7), sulfo.+ carfen.25+40 g a.i ha^{-1} (T_8) and metribuzin 175 g a.i ha^{-1} (T_3). Remaining treatments recorded higher harvest index than weedy (T_{10}), treatment. Lowest harvest index was observed (39.69%) under weedy (T_{10}), treatment.

The higher yields under these treatments could be ascribed to better control of weeds might have favoured higher uptake of nutrients and water, which helped the plant to put optimum growth characters *viz.*, plant height, effective tillers and enhanced photosynthetic activity and partitioning of assimilates, resulting in improved yield attributes like spikelets per spike, grain weight per plant and test weight by virtue of less weed count and dry weight of weeds. These growth and yield attributes evidently reflected in higher grain and straw yields under these treatments. These findings are in close conformity with those reported by Singh *et al.* (1997) and Nayak *et al*. (2003) who obtained the maximum grain yield with 2 hand weeding. Sukhadia *et al.* (2000) and Singh and Singh (2004) also reported similar results.

Economics:

It is one of the very important concepts of any research work which indicates the profitability of a particular treatment. In this experiment, a common cost of cultivation for growing a wheat crop was calculated and its value came out to Rs. 25568.46/ha^{-1} (Table 7). Then the highest cost of cultivation was recorded in weed free (Rs. 31568.46 /ha^{-1}) treatment, followed by sulfo + carfen 25 + 40 g a.i ha^{-1} (T_8), sulfo + metri 25 + 105 g a.i ha^{-1} (T_7), clodi.+ metri 60 + 122.5 g a.i ha^{-1} (T_5), carfentrazone 50 g a.i ha^{-1} (T_4) and clodi + metri 60 + 105 g a.i ha^{-1} (T_6), and lowest cost of cultivation was calculated in weedy treatment (25568.46/ ha^{-1}). Highest gross return (Rs. 90362.05) ha^{-1} was obtained under the sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), treatment followed by clodi.+metri.60+122.5g a.i ha^{-1} (T_5) (Rs. 89148.5), clodi.+metri.60+105 g a.i ha^{1} (T_6) (Rs. 85524.05). The

Table 7 : Economics as influenced by different treatments

	Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net Return (Rs. ha^{-1})	B:C Ratio
T_1	Clodinafop 60 g a.i ha^{-1}	26252.46	73833.55	47581.09	1.86
T_2	Sulfosulfuron 25 g a.i ha^{-1}	26843.46	79214.6	52371.14	2.04
T_3	Metribuzin 175 g a.i ha^{-1}	26517.46	75914.05	49396.59	1.93
T_4	Carfentrazone 50 g a.i ha^{-1}	26106.46	69557.5	43451.04	1.69
T_5	Clodi.+metri.60+122.5g a.i ha^{-1}	26328.46	89148.5	62820.04	2.45
T_6	Clodi.+ metri. 60+105 g a.i ha^{-1}	26317.46	85524.05	59206.59	2.31
T_7	Sulfo.+ metri.25+105 g a.i ha^{-1}	26908.46	90362.05	63453.59	2.48
T_8	Sulfo.+carfen.25+40 g a.i ha^{-1}	27081.46	84990.55	57909.09	2.26
T_9	Weed free	31568.46	91707.05	60138.59	2.35
T_{10}	Weedy	25568.46	64263.5	38695.04	1.51

lowest return (Rs. 64263.5) was observed with weedy treatment. This is because of less weed-crop competition for light, nutrients, space and moisture in weed control treatment plot as compared to weedy treatment plot, which produced higher grain and straw yield from given area. Lowest gross returns of (Rs. 64263.5/ha^{-1}) accrued under weedy (T_{10}) treatment due to more weed crop competition and the production of weak stature of a crop plant.

Remarkably the highest net return (Rs. 63453.59 ha^{-1}) was recorded under the treatment (T_7), followed by Rs. 62820.04 with the treatment clodi.+metri.60+ 122.5 g a.i ha^{-1} (T_5), because higher crop yield with minimum cost of cultivation. The net returns from weed free treatment was somewhat lowest due their high weed control cost. Significantly the lowest net return (Rs. 38695.04 ha^{-1}) was recorded with weedy treatment (T_{10}), because of reduction in overall yield of grains as well as straw because of weed-crop competition and unavailability of healthy surrounding for normal growth or their potential crop production. Among the highest benefit cost ratio (2.48) was calculated under the treatment sulfo.+ metri.25+105 g a.i ha^{-1} (T_7), followed by (2.45) with the treatment clodi.+metri.60+122.5g a.i ha^{-1} (T_5). However, lowest benefit cost ratio (1.51) was calculated under weedy (T_{10}), treatment. This is because of less weed-crop competition for light, nutrients, space and moisture in weed control treatment plot as compared to weedy treatment plot, which produced higher grain and straw yield from given area.

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