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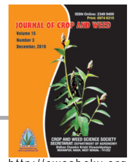

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Effect of tillage and herbicide application on broad-leaf weeds and wheat yield under alluvial zone

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ABSTRACT

Wheat (Triticum aestivum L.) is infested with several broad-leaved weeds which create competitive stress resulting in yield losses varying from 10-70% depending upon their density. Weeds problem becomes very challenging under the era of climate shifting and weed density varies with different cultural or tillage practices. Continuous and improper use of herbicides resulted in the shifting of weed flora in terms of herbicide-resistant weed biotypes. An experiment was conducted to study the effect of herbicide on weeds in wheat grown under different tillage systems. The field experiment was conducted at the District Seed Farm (AB Block), Kalyani under the aegis of Bidhan Chandra Krishi Viswavidyalaya during the winter season of 2017-18 and 2018-19 in an upland situation. The geographical details of the site are 23° N latitude, 89° E longitude and 9.75 meter above mean sea level (MSL). The experiment was carried out in a randomized block design, replicated thrice with ten treatment mainly comprising with zero tillage + weedy, zero tillage + metsulfuron-methyl 4 g ha^{-1}, zero tillage + metsulfuron-methyl @ 4 g ha^{-1}fb 2,4-D @ 0.75 kg ha^{-1}, zero tillage + metsulfuron-methyl @ 4 g ha^{-1} fb carfentrazone @ 20 gha^{-1},conventional tillage + weedy, conventional tillage + metsulfuron-methyl @ 4 gha^{-1}, conventional tillage + metsulfuron-methyl @ 4 gha^{-1} fb 2,4-D @ 0.75 $kgha^{-1}$, conventional tillage + metsulfuron-methyl @ 4 gha^{-1} fb carfentrazone @ 20 gha^{-1}, zero tillage + weed free conventional tillage + weed free were replicated four times in randomized block design. Highest grain yield was obtained with the conventional tillage + weed free (4.30 t ha^{-1}) and showed parity only with conventional tillage + metsulfuron-methyl @ 4 g ha^{-1}fb carfentrazone @ 20 g ha^{-1} (3.91 t ha^{-1}) and was significantly better to other options. This was followed by zero tillage + weed free (3.81 t/ha) and conventional tillage + metsulfuron-methyl@ 4 gha^{-1}fb 2,4-D @ 0.75 kg ha^{-1} (3.62 t ha^{-1}). Conventional tillage + weed free and conventional tillage + metsulfuron-methyl @ 4 g ha^{-1}fb carfentrazone @ 20 g ha^{-1} registered, 137 and 116 % more grain yield over zero tillage + weedy treatments, which recorded the lowest economic yield. From this study, we conclude that, conventional tillage + metsulfuron-methyl @ 4 gha^{-1}fb carfentrazone @ 20 gha^{-1} was supposed to be the most promising option in wheat over other cultural operations.

Keywords : Herbicides, tillage, weed, wheat, yield.

Wheat (*Triticum aestivum* L. emend.Fiori and Paol.) is one of the most important cereal crops, occupying the prime position among food crops in the world and an important constituent of food security. This is an important crop contributing 40 % in the total food grain production and is next only to rice. The importance of wheat crop may be understood from the fact that it covers about one-fifth of the total area under food grains and accounts for about one-third (40%) of the total food grain production in India (Mukherjee, 2017). After the introduction of high yielding varieties, wheat became an important crop in West Bengal. In West Bengal, wheat is grown on a 0.22 million ha area and contributes 0.31 million tons of food grain (Mukherjee, 2016). Sowing of wheat in these areas gets delayed due to late harvesting of medium to long-duration rice, the previous crop in the rotation. Wet soil conditions further enhance delayed the sowing of wheat as it takes another 20-25 days to come in working condition. Delayed sowing resulted in a reduction of yield to the tune of 37.5 $kgha^{-1}day^{-1}$ (Jat *et al.,* 2013). Research has shown that tillage practices could play an important role in weed management in conservation agriculture systems; however, their level of adoption at present is fairly low. Changes in patterns of tillage, planting systems, and other management strategies can alter the soil environment and lead to a major change in weed flora.

Today herbicides constitute integral part of weed management in crops for producing high economic yield. Herbicide use has been an extremely important component of weed management in the conservation system; however, their importance becomes under question. Herbicide rotation and use of herbicide mixture are two major strategies to prevent the selection of resistant biotypes of a weed species. Herbicides with different mode of action when mixed together, bind to different target site in weeds and prevent the probability of target site resistance in susceptible species. Use of low dose herbicide such as carfentrazone, sulfosulfuron, metsulfuron etc. become very effective under various weed ecosystem and also reduced chemical load in the environment. Carfentrazone belongs to aryl triazolinone

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family, which has been found effective to control wide range of weeds under different crop sequence by inhibiting activity of protoporphyrinogen oxidase in chlorophyll biosynthetic pathway. This become effective against few BLW, however its effect under various tillage become a question. In most crop production systems, soil tillage is one of the largest items of expenditure and thus an economically important factor. It influences the physical, chemical and biological processes and also the long term productivity with effective control of weeds (Choudhary *et al.,* 2017). It has been observed that tillage along with efficient weed control options can enhance the yield up to 40 to 60% (Mukherjee, 2008). Change in tillage system affects weed communities by direct killing of weeds or by redistributing weed seeds in varying soil depths, and by changing the soil environment and thereby affecting weed seed germination and emergence (Nichols *et al.,* 2015). As the concept of tillage in wheat and information regarding the proper use of herbicides are scanty under the alluvial zone, the present investigation was carried out to assess the performance of wheat under different tillage and weed control measure under the new alluvial zone of West Bengal, India.

MATERIALS AND METHODS

Present work was conducted at the District Seed Farm (AB Block), Kalyani under the aegis of Bidhan Chandra Krishi Viswavidyalaya during the winter season of 2017-18 and 2018-19 in an upland situation. The geographical details of the site are 23° N latitude, 89° E longitude and 9.75 meter above mean sea level (MSL). The soil of the experimental field was loamy in texture and almost neutral in reaction having pH 7.1, organic carbon 0.47%, available nitrogen 231.6 kg, available phosphorus 21.7 kg and available potassium 256.9 kg/ha.

The experiment was carried out in a randomized block design, replicated thrice with ten treatment mainly comprising with zero tillage + weedy, zero tillage + metsulfuron-methyl@ 4gha^{-1}, zero tillage + metsulfuron-methyl@ 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1}, zero tillage + metsulfuron-methyl @ 4 g ha^{-1}*fb* carfentrazone @ 20 gha^{-1},conventional tillage + weedy, conventional tillage + metsulfuron-methyl @ 4 g ha^{-1}, conventional tillage + metsulfuron-methyl@ 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1}, conventional tillage + metsulfuron-methyl@ 4 gha^{-1}*fb* carfentrazone@ 20 g ha^{-1}, zero tillage + weed free, conventional tillage + weed free were replicated four times in randomized block design. Wheat cv. HD 2967 was sown 5 ×5 m^2 plot size with a row spacing of 20 cm apart on 10th and 15th November 2017 and 2018, respectively at 5-6 cm seeding depth using 100 kg seed ha^{-1}. Under zero tillage, seed drill was used to allow planting of wheat seed into fields after rice harvest without ploughing the field. Conventional tillage was prepared by having four ploughings (harrowing and cultivation) with a depth of 40-50 cm followed by planking. The recommended dose of fertilizer was 150 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}. A dose of nitrogen was applied as per treatments in split form, whereas phosphorus (diammonium phosphate (DAP), 18% N and 46% P_2O_5) and K (muriate of potash, 60% K_2O) were drilled uniformly as basal dose across all the treatment. The basal dose of N was applied through DAP, whereas the remaining N dose was top-dressed as urea (46% N) in two splits at 42 and 66 DAS. Irrigations and plant protection measures were applied as per the crop need. Post-emergence application of metsulfuron-methyl@ 4 g ha^{-1} was given 22 days after sowing (DAS). However, post-emergence application of succeeding herbicides, 2,4-D @ 0.75 kg ha^{-1} and carfentrazone@ 20 g ha^{-1} were made at 30 DAS. The crop was harvested on 01 and 03 April during 2018 and 2019, respectively.

The data on growth and LAI were recorded at 60 DAS. However, data on yield attributing characters were recorded on 10 selected plants at harvest as per the normal procedure. The crop was threshed plot-wise and grain yield thus obtained from the net plot was converted into kg ha^{-1}. Crop and weed samples were analyzed for the uptake of nitrogen, phosphorus, and potash as per standard laboratory procedures (Jackson, 1973). The experimental data were analyzed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of the overall difference among treatments by the F test and conclusions were drawn at a 5 % probability level. Benefit: cost ratio (B: C) was obtained by dividing the gross income with the cost of cultivation. The effect of treatments was evaluated on pooled analysis basis on growth, yield attributes and yields.

RESULTS AND DISCUSSION

Effect of treatments on growth characters

With various treatments, conventional tillage gave maximum plant height and statistically better to other tillage options either in sole or with any chemical treatments. Amongst various herbicidal treatments, more plant height at 60 DAS observed with the conventional tillage + metsulfuron-methyl @ 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1} and was at par only with zero tillage + weed free. Dry matter accumulation at 60 DAS, was highest observed with the zero tillage + weed free and was significantly better to all other treatments (Table 1). LAI was highest observed with the zero tillage + weed free and was statistically similar with all the treatments except conventional tillage + weedy, conventional tillage +

Table 1: Effect of various treatments on growth and yield attributes of wheat (pooled data of two years)

Treatments	Plant height (60 DAS) (cm)	Dry matter (60 DAS) (gm^{-1})	LAI (60 DAS)	Effective tiller m^{-2} (No.)	Ear length (cm)	Grain ear^{-1} (No.)	Grain weight ear^{-1} (g)	Filled grains ear^{-1} (No.)	Test weight (g)
Zero tillage + metsulfuron methyl @ 4g ha^{-1}	61.23	129.23	2.13	217.66	7.79	29.54	1.78	24.53	38.98
Zero tillage + metsulfuron methyl @ 4 g ha *fb* 2,4-D @ 0.75 kg ha^{-1}	71.44	130.51	2.55	261.06	8.03	37.91	2.41	38.11	41.33
Zero tillage + metsulfuroan methyl @ 4 gha^{-1}*fb*carfentrazone @ 20 g ha^{-1}	68.33	122.33	2.98	233.88	8.41	32.55	2.09	29.78	37.51
Zero tillage + weedy	51.38	79.63	3.02	133.33	7.21	18.33	1.29	20.51	37.00
Zero tillage + weed free	73.40	171.46	3.20	287.36	8.87	40.83	2.72	37.23	39.01
Conventional tillage + metsulfuroan methyl @ 4 g ha^{-1}	61.53	136.55	2.09	249.58	8.32	35.11	2.31	31.09	40.54
Conventional tillage + metsulfuron methyl @ 4 g ha *fb* 2,4-D @ 0.75 kg ha^{-1}	74.21	97.45	3.11	278.11	9.09	38.5 1	2.50	36.12	39.74
Conventional tillage + metsulfuroan methyl @ 4 gha^{-1}*fb*carfentrazone @ 20 gha^{-1}	65.59	138.51	3.11	302.54	8.79	39.00	2.65	37.19	40.33
Conventional tillage + weedy	54.39	74.30	2.15	165.54	7.98	24.21	1.38	22.05	38.19
Conventional tillage + weed free	78.03	153.21	3.02	311.66	9.01	43.36	2.88	40.39	40.22
SEm±	**0.57**	**5.61**	**0.21**	**4.21**	**0.47**	**1.17**	**0.24**	**0.97**	**0.74**
LSD (p=0.05)	**1.72**	**16.73**	**0.60**	**12.13**	**1.11**	**3.41**	**0.61**	**2.63**	**2.03**

Table2: Effect of different treatments on different species of broad-leaf weeds, weed population density ($No.m^{-2}$)and weed dry weight (gm^{-2}) (pooled data of two years)

Treatments	*Chenopodium album* ($No.m^{-2}$)		*Melilotus alba* ($No.m^{-2}$)		*Rumex spinosus* ($No.m^{-2}$)		*Lathyrus aphaca* ($No.m^{-2}$)		*Vicia hirsuta* ($No.m^{-2}$)		*Physalis minima* ($No.m^{-2}$)		*Solanum nigrum* ($No.m^{-2}$)		Other minor BLW ($No.m^{-2}$)		Weed density (BLW) ($No.m^{-2}$)		Weed dry weight (BLW) ($g\ m^{-2}$)	
	30 DAS	**60 DAS**	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**
Zero tillage + metsulfuron methyl @ 4g ha^{-1}	3.5* (12)**	4.6 (21)	3.7 (13)	4.6 (21)	1.6 (2)	3.4 (11)	0.7 (0)	3.2 (10)	2.3 (5)	3.2 (10)	4.2 (17)	5.4 (29)	8 (63)	11.3 (128)	3.1 (9)	9 (81)	2.3 (5)	3.4 (11)	3.1 (9)	3.5 (12)
Zero tillage + metsulfuron methyl @ 4 g ha *fb* 2,4-D @ 0.75 kg ha^{-1}	3.2 (10)	4.2 (17)	2.7 (7)	3.9 (15)	3.2 (10)	4.4 (19)	0.7 (0)	2.7 (7)	1.6 (2)	2.7 (7)	2.7 (7)	3.9 (15)	0.7 (0)	1.2 (1)	2.9 (8)	4.4 (19)	6.7 (44)	10.6 (112)	3.4 (11)	7.1 (50)
Zero tillage + metsulfuroan methyl @ 4 g ha^{-1} *fb* carfentrazone @ 20 g ha^{-1}	2.7 (7)	4.3 (18)	3.1 (9)	3.4 (11)	2.3 (5)	4.7 (22)	0.7 (0)	2.5 (6)	2.1 (4)	2.5 (6)	0.7 (0)	2.1 (4)	1.9 (3)	3.1 (9)	3.7 (13)	3.4 (11)	6.4 (41)	9.6 (92)	2.5 (6)	7.6 (57)
Zero tillage + weedy	3.7 (13)	6.3 (39)	3.5 (12)	5.8 (33)	4.1 (16)	6.2 (38)	2.1 (4)	3.5 (12)	4.1 (16)	3.5 (12)	3.2 (10)	5 (25)	2.5 (6)	3.9 (15)	4.7 (22)	8.6 (74)	10 (99)	16.4 (269)	7 (48)	11 (130)
Zero tillage + 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)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)
Conventional tillage + metsulfuroan methyl @ 4 g ha^{-1}	2.5 (6)	2.7 (7)	2.5 (6)	3.4 (11)	2.1 (4)	4.6 (21)	1.9 (3)	3.7 (13)	2.9 (8)	3.7 (13)	2.5 (6)	3.4 (11)	3.5 (12)	4.6 (21)	4.2 (17)	4.8 (23)	7.9 (62)	11.2 (126)	3.4 (11)	7.2 (51)
Conventional tillage + metsulfuron methyl @ 4 g ha *fb* 2,4-D @ 0.75 kg ha^{-1}	0.7 (0)	3.5 (12)	2.7 (7)	4.1 (16)	2.3 (5)	3.2 (10)	0.7 (0)	1.9 (3)	2.3 (5)	1.9 (3)	3.1 (9)	3.7 (13)	1.6 (2)	2.3 (5)	3.4 (11)	4.3 (18)	6.3 (39)	9.5 (90)	4.3 (18)	6.1 (37)
Conventional tillage + metsulfuroan methyl @ 4 g ha^{-1} *fb* carfentrazone @ 20 g ha^{-1}	1.6 (2)	4.1 (16)	1.9 (3)	4.7 (22)	2.9 (8)	3.8 (14)	1.9 (3)	2.1 (4)	3.1 (9)	2.1 (4)	1.2 (1)	(0)	1.9 (3)	2.7 (7)	2.3 (5)	3.1 (9)	5.9 (34)	8.8 (77)	3.2 (10)	5.2 (26)
Conventional tillage + weedy	4.6 (21)	7.5 (56)	4.1 (16)	5.8 (33)	3.5 (12)	5.8 (33)	2.7 (7)	4.7 (22)	4.2 (17)	4.7 (22)	3.4 (11)	5.6 (31)	3.2 (10)	5.4 (29)	5.3 (28)	5.8 (33)	11 (122)	16.4 (268)	5.5 (30)	9.9 (97)
Conventional tillage + 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)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)
SEm±	**0.11**	**0.13**	**0.06**	**0.07**	**0.08**	**0.09**	**0.05**	**0.07**	**0.11**	**0.13**	**0.10**	**0.13**	**0.05**	**0.08**	**0.06**	**0.13**	**0.19**	**0.26**	**0.29**	**0.32**
LSD (p=0.05)	**0.29**	**0.32**	**0.19**	**0.21**	**0.22**	**0.25**	**0.15**	**0.22**	**0.30**	**0.35**	**0.27**	**0.36**	**0.18**	**0.22**	**0.19**	**0.32**	**0.52**	**0.71**	**0.72**	**0.91**

**Data analyzed after square root transformation $\sqrt{(x + 0.5)}$; **Figures in parentheses are original values*

Table 3: Effect of various treatments on yield, harvest index and benefit-cost ratio of wheat production (pooled data of two years)

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)	Economics		
				Cost of cultivation (x10^3 ₹ ha^{-1})	Net return (x10^{3}ha^{-1})	B:C ratio
Zero tillage + metsulfuron methyl @ 4g ha^{-1}	2.14	4.38	32.82	38.19	26.39	1.69
Zero tillage + metsulfuron methyl @ 4 g ha *fb* 2,4-D @ 0.75 kg ha^{-1}	3.42	5.81	37.05	41.93	31.09	1.74
Zero tillage + metsulfuroan methyl @ 4 g ha^{-1} *fb* carfentrazone @ 20 g ha^{-1}	3.29	5.43	37.73	45.18	27.19	1.60
Zero tillage + weedy	1.81	2.15	45.71	41.89	22.06	1.53
Zero tillage + weed free	3.81	4.92	43.64	47.30	38.85	1.82
Conventional tillage + metsulfuroan methyl @ 4 g ha^{-1}	3.30	5.68	36.75	43.93	28.36	1.64
Conventional tillage + metsulfuron methyl @ 4 g ha *fb* 2,4-D @ 0.75 kg ha^{-1}	3.62	5.12	41.42	45.69	36.54	1.79
Conventional tillage + metsulfuroan methyl @ 4 g ha^{-1} *fb*carfentrazone @ 20 g ha^{-1}	3.91	6.99	35.87	47.36	40.21	1.84
Conventional tillage + weedy	2.11	3.16	40.04	39.01	24.50	1.63
Conventional tillage + weed free	4.30	6.11	41.31	52.11	44.13	1.84
SEm±	**0.14**	**0.68**	**0.78**	**3.78**	**1.46**	**0.07**
LSD (p=0.05)	**0.41**	**1.11**	**2.11**	**10.25**	**4.24**	**0.19**

Table 4: Effect of various treatments on nutrient uptake pattern of weeds and wheat (pooled data of two years)

Treatments	Nutrient uptake by weeds at 60 DAS(kgha^{-1})				Nutrient uptake by crop at harvest (kgha^{-1})									
	Nitrogen	Phosphorus	Potassium	Total nutrient uptake	Nitrogen			Phosphorus			Potassium			Total nutrient uptake
					Grain	*Straw*	*Total uptake*	*Grain*	*Straw*	*Total uptake*	*Grain*	*Straw*	*Total uptake*	
Zero tillage + metsulfuron methyl @ 4g ha^{-1}	9.11	3.97	10.12	23.20	60.38	29.39	89.77	10.21	7.15	17.36	27.13	66.33	93.46	200.59
Zero tillage + metsulfuron methyl @ 4 g ha *fb* 2,4-D @ 0.75 kg ha^{-1}	6.74	1.99	6.91	15.64	73.36	32.76	106.12	13.11	9.94	23.05	27.08	74.27	101.35	230.52
Zero tillage + metsulfuroan methyl @ 4 g ha^{-1} *fb*carfentrazone @ 20 g ha^{-1}	8.22	3.66	8.78	20.66	65.34	32.34	97.68	11.15	7.32	18.47	28.67	67.55	96.22	212.37
Zero tillage + weedy	16.31	7.11	17.36	40.78	51.19	18.32	69.51	9.21	4.36	13.57	23.28	51.14	74.42	157.5
Zero tillage + weed free	0.00	0.00	0.00	0.00	76.83	37.21	114.04	15.32	10.43	25.75	31.05	78.12	109.17	248.96
Conventional tillage + metsulfuroan methyl @ 4 g ha^{-1}	7.99	3.41	8.62	20.02	70.17	35.05	105.22	12.04	8.63	20.67	29.21	73.64	102.85	228.74
Conventional tillage + metsulfuron methyl @ 4 g ha *fb* 2,4-D @ 0.75 kg ha^{-1}	5.36	1.53	5.32	12.21	75.66	36.02	111.68	15.07	9.77	24.84	29.91	77.13	107.04	243.56
Conventional tillage + metsulfuroan methyl @ 4 g ha^{-1} *fb*carfentrazone @ 20 g ha^{-1}	2.96	0.90	2.66	6.52	78.15	46.84	125.99	15.65	11.04	26.69	32.93	80.25	113.18	265.86
Conventional tillage + weedy	14.98	5.53	15.98	36.49	59.63	28.11	87.74	10.01	6.36	16.37	25.78	61.34	87.12	191.23
Conventional tillage + weed free	0.00	0.00	0.00	0.00	83.10	49.60	130.7	18.70	12.91	31.61	34.40	83.8	118.20	280.51
SEm±	**1.19**	**0.44**	**1.26**	**1.77**	**2.15**	**1.54**	**5.66**	**1.55**	**1.12**	**3.13**	**1.89**	**2.45**	**3.87**	**4.97**
LSD (p=0.05)	**3.52**	**1.29**	**3.61**	**5.02**	**6.96**	**4.11**	**17.11**	**4.21**	**3.31**	**8.78**	**5.05**	**7.11**	**11.05**	**15.01**

metsulfuron-methyl @ 4 gha^{-1}, zero tillage + metsulfuron-methyl@ 4 gha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1}and zero tillage + metsulfuron-methyl @ 4g ha^{-1}. The higher values of growth parameters under these treatments may lead to the proper development of yield components and yield of the crops.

Effect of treatments on broad-leaf weeds

The wheat field was dominated by naturally occurring highly aggressive broad-leaved weeds along with few grasses and sedges mainly, *Chenopodium album*, *Vicia hirsuta*, *Rumex spinosus, Melilotus alba, Oldenlandia diffusa, Spilanthe spaniculata, Eleusine indica* and *Cyperus difformis.*

All the tillage options along with the weed control measure significantly influenced the total BLW population and it's dry weight at 30 and 60 DAS (Table 2). Observation from table 2 revealed that, density of different BLW varied significantly with various treatments. Amongst various treatments, minimum total BLW population at 30 DAS, registered with the conventional tillage + metsulfuron-methyl 4 gha^{-1}*fb* carfentrazone @ 20 gha^{-1} and was at par with conventional tillage + metsulfuroan methyl @ 4 g ha^{-1} fb carfentrazone @ 20 g ha^{-1} and zero tillage + metsulfuron-methyl @ 4 g ha^{-1}*fb* carfentrazone@ 20 gha^{-1}, and significantly superior to all other treatments except weed free situation under different tillage practices. However, at 60 DAS least weed population was found with the conventional tillage + metsulfuron-methyl @ 4 g ha^{-1} *fb*carfentrazone@ 20 gha^{-1} and was at par only with conventional tillage + metsulfuron-methyl @ 4 gha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1} and statistically superior to other treatments except weed free treatments. Weed dry weight at 30 DAS, amongst various herbicidal treatments under different tillage practices, zero tillage + metsulfuron-methyl @ 4 gha^{-1}*fb*carfentrazone@ 20 gha^{-1} gave least value and showed parity with conventional tillage + metsulfuron-methyl @ 4 gha^{-1}*fb*carfentrazone @ 20 gha^{-1} and zero tillage + metsulfuron-methyl @ 4 gha^{-1}. At 60 DAS, amongst various herbicidal treatments lowest BLW dry weight observed with the Conventional tillage + metsulfuroan methyl @ 4 g ha^{-1} *fb* carfentrazone @ 20 g ha^{-1} and showed parity only with conventional tillage + metsulfuron methyl @ 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1}(Table 2). At 60 DAS, significantly lowest dry weight of total weeds was found with the conventional tillage + metsulfuron-methyl @ 4 g ha^{-1}*fb* carfentrazone@ 20 g ha^{-1} and notably better to all other herbicidal options. These results can be discussed in the light of fact that most of the herbicides when applied individually, control few broad-leaf /or grassy weeds. The dry matter accumulation by weeds envisages that the dry matter accumulation by weeds in different treatments varied in accordance with the weed population recorded under these treatments. The maximum reduction in weed dry weight was observed under the treatment conventional tillage + metsulfuron-methyl @ 4 gha^{-1}*fb* carfentrazone 20 gha^{-1}, conventional tillage + metsulfuron-methyl @ 4 gha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1} and minimum in untreated control. Nichols *et al.* (2015) also reported a significant reduction in weeds dry weight due to a decrease in their population under herbicide treatments with different management practices.

Further observation on nutrients uptake pattern of weeds revealed that, least uptake of major nutrient by weed was found with the conventional tillage + metsulfuron-methyl@ 4 g ha^{-1}*fb* carfentrazone@ 20 g ha^{-1} and was significantly better to all other treatments except weed free situation (Table 4).This might be due to the lesser weed population owing to the high efficacy of the mixture of herbicide application (Walia *et al.*, 2010).

Effect of treatments on yield attributes

Number of effective tiller/m^2 was found higher with the conventional tillage + weed free, and showed parity only with conventional tillage + metsulfuron-methyl@ 4 g ha^{-1} *fb* carfentrazone @ 20 g ha^{-1} and significantly better to all other treatments (Table 1). This increase was primarily due to faster growth, better root development and aeration owing to more free space available for better plant growth. These results are in line with those of Majeed *et al,* (2015) and Mukheree (2008). Ear length was observed highest with the conventional tillage + metsulfuron-methyl@ 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1}and was at par with all the treatments except zero tillage + weedy and zero tillage + metsulfuron-methyl @ 4g ha^{-1}. Grain/ear was maximum observed with the conventional tillage + weed free and significantly better to other methods of treatments except for zero tillage + weed free. Highest grain weight/ear was registered with the conventional tillage + weed free and showed parity with most of the treatments except conventional tillage + weedy, zero tillage + weedy, zero tillage + metsulfuron-methyl @ 4 g ha^{-1} *fb* carfentrazone@ 20 g ha^{-1} and zero tillage + metsulfuron-methyl @ 4g ha^{-1}. The number of filled grains/ear was observed higher with conventional tillage + weed free, and was at par with the zero tillage + metsulfuron-methyl 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1} and statistically better to all other treatments. Dou and Hons (2006) reported similar crop growth under different tillage systems. As test weight is a genetic character it was not so much influenced by tillage methods either alone or with herbicide application. Moreover, notably, more test weight was found with the conventional tillage + weed free and was at par with all the treatment except zero tillage + weedy and zero tillage + metsulfuron-methyl@ 4 g ha^{-1}*fb* carfentrazone@ 20 g ha^{-1}.

Effect of treatments on wheat yield

Highest grain yield was registered with the conventional tillage + weed free (4.30 t/ha) and showed parity only with conventional tillage + metsulfuron-methyl@ 4 gha^{-1}*fb* carfentrazone @ 20 g ha^{-1} (3.91 t ha^{-1}) and was statistically superior to other options on pooled basis(Table 3). These treatments gave higher growth and yield attributes along with higher yield indicating better resource utilization in good weed control measures. This was followed by zero tillage + weed free (3.81 t ha^{-1}) and conventional tillage + metsulfuron-methyl@ 4 g ha^{-1} *fb* 2,4-D @ 0.75 kg ha^{-1} (3.62 t ha^{-1}). Conventional tillage + weed free registered 9.97 % more grain yield over the conventional tillage + metsulfuron-methyl@ 4 gha^{-1}*fb* carfentrazone@ 20 g ha^{-1}. These treatments registered, 137 and 116 % more grain yield over zero tillage + weedy treatments, which recorded lowest economic yield. This increase in yield could be accredited to higher numbers of effective tiller m^{-2}, grain ear^{-1}, grain weight ear^{-1} and 1000 grain weight under conventional tillage system. More straw yield was noticed with the conventional tillage + metsulfuron-methyl @ 4 g ha^{-1}*fb*carfentrazone@ 20 g ha^{-1} (6.99 t/ha) and was statistically at par with the conventional tillage + weed free, conventional tillage + metsulfuron-methyl@ 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1}, conventional tillage + metsulfuron-methyl@ 4 g ha^{-1}, zero tillage + metsulfuron-methyl@ 4 gha^{-1}*fb*carfentrazone @ 20 gha^{-1} and zero tillage + metsulfuron-methyl 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1}. This corroborate with the earlier findings of Bandyopadhyay*et al.* (2017). The modified microclimatic conditions within the field due to the congenial environment to the crop resulted in reduced crop lodging and decreased insect pests incidence owing to reduced canopy humidity which contributed towards enhanced crop straw yield (Fahong*et al.*, 2004). Further Table 3 revealed that, more harvest index was produced with zero tillage + weedy, and was at par only with zero tillage + weed free,and significantly better to other treatments.

Effect of treatments on plant nutrient uptake

Nutrient uptake patterns of crops significantly differed with various treatments (Table 4).Highest nitrogen in grain and straw was observed with the conventional tillage + weed free and notably better than other treatments except conventional tillage + metsulfuron-methyl@ 4 gha^{-1}*fb* carfentrazone @ 20 gha^{-1}. The uptake of nitrogen in wheat was the highest with conventional tillage mainly due to more crop economic and biomass production. Higher dry matter production with increased tissue nitrogen content may attribute to this higher uptake (Soni *et al.,* 2020). Conventional tillage + weed free registered highest uptake of phosphorus and potassium by grain, straw and total uptake and showed parity with zero tillage + weed free, conventional tillage + metsulfuron-methyl@ 4 g ha^{-1}*fb*carfentrazone@ 20 g ha^{-1} and conventional tillage + metsulfuron-methyl @ 4 g ha^{-1}*fb* 2,4-D @ 0.75 kg ha^{-1}.Tillage helped to release soil nutrients needed for crop growth through mineralization and oxidation after exposure of soil organic matter to air. This helps to more crop nutrient absorption and ultimately leads to higher productivity per unit area (Ribeiro, 2003).

Effect of treatments on benefit-cost ratio

With various treatments, conventional tillage + weed free exhibited a higher net return (44.1 x10^{3}ha^{-1})andB-Cratio (1.84) over other treatments (Table 3).This was followed by conventional tillage + metsulfuron-methyl@ 4 g ha^{-1} *fb* carfentrazone@ 20 g ha^{-1}, which gave net return of 40.21 x10^{3} ha^{-1} with B-Cratio of 1.84. It was mainly due to less operational cost as there was no cost incurred towards hand weeding.

From the above study we can conclude that, conventional tillage + metsulfuron-methyl @ 4 gha^{-1}*fb* carfentrazone @ 20 gha^{-1} was supposed to be the most promising option in wheat production under new alluvial zone because of higher growth, yield attributes and more yield indicating better resource utilization with good weed control measures. Moreover, this needs more research work in different location under the era of climate change and weed shifting behavior.

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