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Tillage and weed management effect on productivity of wheat in North-West Rajasthan

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ABSTRACT

A field experiment was carried out at SKRAU, Bikaner, Rajasthan, during *Rabi* seasons of 2016-17 and 2017-18 to investigate the effect of tillage and weed management practices on productivity of wheat (*Triticum aestivum*) in North-West Rajasthan. Amongst the tillage treatments, adoption of stale seedbed (SSB) using glyphosate at 2.0 kg/ha resulted in higher dry matter at harvest, effective tillers (101.77 per m.r.l.) and grain yield (4.06 t/ha), and significantly lowered the density and dry matter of weeds. Among various weed management treatments, metsulfuron 4.0 g/ha + one hand weeding (HW) at 45 DAS significantly lowered the density and dry matter of all the broad-leaf weeds, but not effective against *Cyperus rotundus* and *Cynodon dactylon*. Being at par with weed free check and also 2,4-D E + one HW, it was significantly superior to all other treatments and resulted 4.40 t/ha grain yield of wheat.

INTRODUCTION

Wheat is an important winter season cereal crops of North-West India not only in terms of providing calories but also in terms of versatile adoption under wide range of agro climatic conditions. In India, wheat is grown in 30 million ha area with total production of 107 mt and an average productivity of 3400 kg/ha (IASRI 2019). Its success largely depends on adaptability to environmental conditions and agronomic practices. Weeds substantially reduce the productivity and production of wheat. It competes with crops for water, soil, nutrients, light, and space and thus reduces crop yields (Das 2008). Stale seedbed technique involves rains or irrigation applied to invoke germination of weeds and then the soil preparation of a seedbed or application of non-selective pre-seeding herbicide to kill the germinated weeds, a weeks before the actual planting of the crop, thus depleting the seed bank in the surface layer of soil and reducing subsequent emergence of weeds. Looking to the scenario of stale seedbed technique with tillage and herbicides and its impact on weeds, and productivity of wheat, there is a need to test this current practice in wheat. Deep tillage may also bury the weed seed deeper in the soil layer and minimize the weed seed bank in upper layer of soil. Supplementing these mentioned practices, herbicides play an important role for weed control in close spaced crops like wheat, where manual or mechanical weeding is difficult (Yaduraju and Das 2002). Also the mimicry weeds are arduous to be weeded out by hand weeding or other mechanical methods. Only chemical weed control is most suitable option to overcome this problem; and in this backdrop the present study was undertaken.

MATERIALS AND METHODS

A field experiment was conducted in wheat at College of Agriculture, Bikaner (28.01^{0}N latitude and 73.22^{0}E longitude at an altitude of 234.7 M above mean sea level). The soil was loamy sand, low in organic carbon (0.08%) and available N (78 kg/ha) and medium in available phosphorus (22 kg P/ha) and available K (210 kg/ha) with pH 8.3. The experiment was laid down in strip-plot design with four replications. The treatments comprising of 28 combinations having four tillage methods, *viz.* stale seedbed (SSB) using shallow tillage, SSB using glyphosate 2.0 kg/ha, deep tillage) and conventional tillage as main plots; and seven weed management practices, *viz.* weedy check, weed free, one hand weeding (1 HW) at 30 DAS, 2,4-D at 0.5 kg/ha 30 DAS, metsulfuron at 4.0 g/ha 30 DAS, 2,4-D at 0.5 kg/ha 30 DAS + 1 HW 45 DAS and metsulfuron 4.0 g/ha + 1 HW 45 DAS as sub-plots. Wheat cultivar '*Raj- 3077*' was sown using seed rate of 100 kg/ha

with a row spacing of 22.5 cm on 25 November and 28 November during 2016-17 and 2017-18, respectively. The crop was supplied with (100 kg N, 60 kg P and 40 K kg/ha). In stale seedbed (SSB) technique, after seedbed preparation or without it, the field was irrigated and left unsown to allow weeds to germinate and then these were killed by spraying of glyphosate 2.0 kg/ha or by carrying out shallow tillage prior to the sowing. Whereas in deep tillage, disc plough and in conventional tillage one harrow along with cultivator was used. Metsulfuron (4 g/ha) and 2,4-D ester (0.5 kg/ha) were applied as post-emergence with 500 liters of water with the help of knapsack sprayer, fitted with flat-fan nozzle. Weed density was recorded (at 30, 60 DAS and crop maturity) from 0.25 m^2 by placing a quadrate of 0.5 × 0.5 m randomly at three places in each plot. The weeds were dried in an oven till a constant weight was observed and then transformed into g/m^2 by using the appropriate formula. The data on total weed count and weed dry matter were subjected to square root transformation to normalize their distribution (Gomez and Gomez 1984). In order to test the significance of variance in experiments, the data obtained for various treatment effects were pooled and statistically analysed as per procedure described by Panse and Sukhatme (1985). The critical differences were calculated to assess the significance of treatment means wherever, the "F" test was found significant at 5 per cent level of significance.

RESULTS AND DISCUSSION

Tillage

Stale seedbed (SSB) using glyphosate at 2.0 kg/ha significantly decreased the density and dry matter of *Chenopodium album, Rumex dentatus, Cyperus rotundus* and *Cynodon dactylon* at 30, 60 DAS and crop maturity followed by SSB using shallow tillage and it was significantly superior to deep and conventional tillage (**Table 1** and **2**). It might be due to the removal of most of germinated sprout seeds, which were active in upper top soil layer, as compared to deep and conventional tillage. The perennial weeds *i.e. C. rotundus* and *C. dactylon* were difficult to control because of their re-germination capacity but with the adoption of stale seed bed technique particularly using glyphosate at 2.0 kg/ha, these were significantly controlled. This might be due to fact that glyphosate destroys reserve food material in its rhizome by its systemic action (Safdar *et al*. 2011).

Table 1. Effect of tillage and weed management on weed density (no./m^2) in wheat on pooled basis

Treatment	*Chenopodium album*			*Rumex dentatus*			*Cyperus rotundus*			*Cynodon dactylon*
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS
Tillage										
SSB using shallow tillage	3.21 (10.9)	1.65 (3.1)	1.99 (4.1)	2.76 (8.0)	1.63 (2.9)	1.87 (3.5)	1.99 (3.8)	1.80 (3.7)	2.01 (4.3)	2.01 (3.8)
SSB using glyphosate at 2.0 kg/ha	2.91 (8.9)	1.54 (2.5)	1.85 (3.4)	2.54 (6.5)	1.54 (2.5)	1.83 (3.3)	1.67 (2.5)	1.50 (2.3)	1.60 (2.3)	1.42 (1.6)
Deep tillage	3.79 (15.5)	1.87 (4.3)	2.08 (4.6)	3.21 (11.0)	1.76 (3.5)	2.01 (4.2)	2.99 (9.5)	1.85 (4.1)	1.94 (3.9)	2.38 (5.7)
Conventional tillage	4.00 (17.4)	1.94 (4.7)	2.19 (5.2)	4.00 (17.4)	1.88 (4.3)	2.11 (4.7)	3.19 (10.9)	1.96 (4.7)	2.08 (4.6)	2.57 (6.7)
LSD(p=0.05)	0.10	0.04	0.07	0.11	0.06	0.07	0.08	0.04	0.04	0.08
Weed management										
2,4-D at 0.5 kg/ha 30 DAS	4.07 (16.4)	2.32 (5.1)	2.51 (5.9)	3.51 (12.4)	2.57 (6.2)	2.47 (5.7)	2.81 (8.1)	2.80 (7.5)	2.66 (6.8)	2.34 (5.3)
Metsulfuron at 4.0 g/ha 30 DAS	3.88 (14.9)	2.18 (4.4)	2.18 (4.3)	3.53 (12.5)	2.15 (4.2)	2.02 (3.6)	2.74 (7.6)	2.76 (7.3)	2.63 (6.6)	2.34 (5.3)
2,4-D at 0.5 kg/ha 30 DAS + 1 HW at 45 DAS	3.99 (15.8)	0.71 (0.0)	1.55 (1.9)	3.44 (11.7)	0.71 (0.0)	1.54 (1.9)	2.74 (7.6)	0.71 (0.0)	1.38 (1.4)	2.32 (5.1)
Metsulfuron at 4.0 g/ha 30 DAS + 1 HW at 45 DAS	3.86 (14.7)	0.71 (0.0)	1.43 (1.6)	3.55 (11.7)	0.71 (0.0)	1.47 (1.7)	2.78 (7.9)	0.71 (0.0)	1.45 (1.7)	2.33 (5.2)
One hand weeding (HW) at 30 DAS	3.96 (15.6)	2.16 (4.2)	2.42 (5.4)	3.62 (13.2)	2.05 (3.7)	2.36 (5.1)	2.73 (7.6)	1.93 (3.4)	1.82 (2.9)	2.29 (5.0)
Weed free	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
Weedy check	3.88 (15.0)	3.47 (11.8)	3.40 (11.3)	3.54 (12.7)	3.01 (8.8)	3.11 (9.3)	2.73 (7.6)	2.83 (7.7)	2.70 (7.0)	2.31 (5.2)
LSD (p=0.05)	0.16	0.10	0.11	0.15	0.06	0.10	0.13	0.09	0.10	0.10

SSB- Stale Seedbed technique, DAS- Days after sowing

Stale seedbed using glyphosate 2.0 kg/ha accumulated maximum dry matter of wheat over all other treatments at 90 DAS and crop maturity **(Table 3)**. This might be due to adequate weed control by reducing the broad-leaved as well as perennial weeds. These results are in agreement with the findings of Khatun *et al*. (2016). Data showed that spike length, grain/spike and test weight of wheat was not influenced due to crop establishment methods. SSB using glyphosate 2.0 kg/ha recorded significantly higher effective tillers, grain and biological yield than deep and conventional tillage but remained at par with SSB using shallow tillage. The increase of grain yield due to adoption of SSB using glyphosate at 2.0 kg/ha was to the tune of 9.9 and 7.7 per cent than deep and conventional tillage, respectively. This might be due to significant improvement in dry matter accumulation and higher number of effective tillers that could be due to less competition by weeds to wheat. These results are in agreement with the findings of Kumar *et al*. (2003) and Khatun *et al*. (2016).

Weed management

At crop maturity, significantly the lowest density and dry matter of weeds was found in metsulfuron at 4.0 g/ha + 1 HW followed by 2,4-D at 0.5 kg/ha + 1 HW and metsulfuron 4.0 g/ha. Dry matter of *R. dentatus* and *C. album* at harvest was decreased by metsulfuron at 4.0 g/ha + 1 HW over weedy check to the tune of 98.8 and 99.1%, respectively **(Table 1** and **2)**. Regeneration of *R. dentatus* was noticed in 2,4-D at 0.5 kg/ha applied plots and thus increased the dry matter of the weed as compared to metsulfuron treated plots. These findings were in conformity with those reported by Singh and Ali (2004) and Pisal *et al*. (2013). The extent of weed control achieved with these herbicides, *i.e.* metsulfuron-methyl and 2,4-D seems to be due to their phytotoxic action on weeds. Metsulfuron-methyl is generally absorbed by leaves and translocated to growing points of the plant where it stops cell division and inhibiting the photosynthesis resulting into yellowing of plants. 2,4-D herbicide kills the target weed by mimicking the plant growth hormone auxin (indole acetic acid), and when administered at effective doses, causes uncontrolled and disorganized plant growth that leads to plant death (Tu *et al*. 2001).

Application of metsulfuron 4.0 g/ha + one hand hoeing significantly increased the grain, straw and biological yield over 1 HW 30 DAS and 2,4-D at 0.5 kg/ha, but was statistically at par with 2,4-D at 0.5 kg/ha + 1 HW as well as weed free check **(Table 3)**. Increase in grain yield due to applied weed control

Table 2. Effect of tillage and weed management on weed dry matter (g/m^2) in wheat on pooled basis

Treatment	*Chenopodium album*			*Rumex dentatus*			*Cyperus rotundus*			*Cynodon dactylon*		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Tillage												
SSB using shallow tillage	1.45 (1.7)	3.36 (22.0)	7.08 (94.0)	2.02 (3.9)	3.20 (21.1)	8.60 (131.4)	1.51 (1.9)	2.66 (9.9)	2.51 (8.3)	1.53 (2.0)	3.25 (12.2)	7.27 (89.5)
SSB using glyphosate at 2.0 kg/ha	1.37 (1.5)	3.03 (17.3)	6.48 (78.9)	1.84 (3.1)	2.85 (15.5)	8.19 (122.3)	1.24 (1.1)	2.10 (5.7)	2.01 (4.8)	1.07 (0.7)	2.47 (6.5)	6.03 (59.2)
Deep tillage	1.62 (2.3)	3.84 (20.5)	7.62 (108.5)	2.28 (5.2)	3.55 (25.8)	9.50 (156.6)	1.74 (2.7)	2.88 (11.7)	2.71 (9.7)	1.61 (2.2)	3.32 (12.8)	7.99 (106.6)
Conventional tillage	1.70 (2.5)	4.05 (32.2)	8.22 (122.5)	2.72 (7.6)	3.84 (32.1)	9.88 (169.5)	1.82 (3.0)	2.89 (11.8)	2.81 (10.6)	1.69 (2.5)	3.57 (14.9)	8.65 (126.8)
LSD (p=0.05)	0.03	0.14	0.25	0.06	0.17	0.15	0.04	0.09	0.06	0.03	0.09	0.32
Weed management												
2,4-D at 0.5 kg/ha 30 DAS	1.67 (2.3)	4.04 (16.2)	11.31 (129)	2.41 (5.5)	6.47 (42.7)	14.51 (212.9)	1.73 (2.5)	4.53 (20.4)	4.14 (17.0)	1.60 (2.2)	4.54 (20.7)	14.05 (202.4)
Metsulfuron at 4.0 g/ha 30 DAS	1.66 (2.3)	2.98 (8.6)	4.99 (25.2)	2.46 (5.7)	3.03 (8.8)	7.27 (53.8)	1.71 (2.5)	4.48 (19.9)	4.13 (16.9)	1.60 (2.2)	4.50 (20.3)	13.91 (196.8)
2,4-D at 0.5 kg/ha 30 DAS + 1 HW at 45 DAS	1.67 (2.3)	0.71 (0.0)	2.47 (5.7)	2.44 (5.6)	0.71 (0.0)	2.98 (8.5)	1.72 (2.5)	0.71 (0.0)	0.89 (0.3)	1.60 (2.1)	2.50 (5.8)	1.49 (1.8)
Metsulfuron at 4.0 g/ha 30 DAS + 1 HW at 45 DAS	1.68 (2.3)	0.71 (0.0)	2.17 (4.3)	2.50 (6.0)	0.71 (0.0)	2.75 (7.2)	1.72 (2.6)	0.71 (0.0)	0.94 (0.4)	1.61 (2.2)	2.35 (5.0)	1.42 (1.6)
One hand weeding (HW) at 30 DAS	1.69 (2.4)	4.47 (19.9)	8.12 (66.4)	2.49 (5.9)	1.45 (1.6)	10.24 (107.6)	1.72 (2.5)	2.75 (7.5)	2.61 (6.7)	1.59 (2.1)	2.92 (8.2)	5.71 (32.8)
Weed free	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
Weedy check	1.67 (2.3)	11.37 (131.9)	21.70 (476.5)	2.51 (6.0)	10.47 (112.3)	24.83 (623.8)	1.72 (2.5)	4.56 (20.7)	4.17 (17.2)	1.61 (2.2)	4.57 (21.0)	15.09 (233.4)
LSD (p=0.05)	0.04	0.26	0.24	0.08	0.24	0.17	0.04	0.10	0.08	0.04	0.16	0.33

SSB- Stale Seedbed Technique, DAS- Days after sowing

Table 3. Effect of tillage and weed management on growth, net return and B:C on pooled basis

Treatment	Plant height	Dry matter (g)			Effective tillers (mrl)	Spike length (cm)	Grain /spike	Test weight (g)	Net return (x10^3 ₹/ha)	BC ratio
		60 DAS	90 DAS	At harvest						
Tillage										
SSB using shallow tillage	37.9	60.9	108.4	148.9	98.2	6.16	35.13	41.11	32.17	1.89
SSB using glyphosate at 2.0 kg/ha	37.8	61.4	114.5	153.1	101.8	6.20	35.68	41.41	36.41	2.03
Deep tillage	37.6	60.1	102.9	144.6	93.6	6.13	33.54	41.11	30.59	1.87
Conventional tillage	37.2	59.6	100.4	140.8	91.4	6.10	33.73	40.63	29.24	1.83
LSD (p=0.05)	NS	NS	3.4	2.4	3.6	NS	NS	NS	1.47	
Weed management										
2,4-D at 0.5 kg/ha 30 DAS	37.4	57.4	104.2	145.5	89.0	6.12	31.91	40.53	25.43	1.73
Metsulfuron at 4.0 g/ha 30 DAS	37.9	61.1	109.2	152.6	100.7	6.20	35.00	41.16	37.44	2.10
2,4-D at 0.5 kg/ha 30 DAS + 1 HW at 45 DAS	37.9	63.2	113.3	156.7	104.2	6.23	36.94	41.38	39.57	2.11
Metsulfuron at 4.0 g/ha 30 DAS + 1 HW at 45 DAS	37.8	63.4	114.9	158.0	105.7	6.26	38.53	40.84	43.03	2.27
One hand weeding (HW) at 30 DAS	37.4	61.5	113.1	151.8	98.2	6.05	32.28	40.91	33.74	1.96
Weed free	37.8	66.2	121.3	161.7	107.4	6.29	39.81	41.78	40.29	2.03
Weedy check	37.2	50.7	69.7	101.5	68.5	5.90	27.16	40.84	5.23	1.16
LSD (p=0.05)	NS	2.3	3.9	5.1	6.5	0.10	3.04	NS	2.06	

SSB:-Stale Seedbed technique, MRL: - Meter row length, DAS- Days after sowing

Table 4. Effect of tillage and weed management on yields and harvest index of wheat during both the years

Treatment	Grain yield (t/ha)			Straw yield (t/ha)			Biological yield (t/ha)			Harvest index (%)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Tillage												
SSB using shallow tillage	3.11	2.83	2.97	4.07	3.75	3.91	7.17	6.57	6.87	43.45	43.17	43.31
SSB using glyphosate at 2.0 kg/ha	3.27	2.99	3.13	4.18	3.94	4.06	7.45	6.93	7.19	43.96	43.34	43.65
Deep tillage	3.01	2.75	2.88	3.75	3.71	3.73	6.76	6.46	6.61	44.73	42.60	43.67
Conventional tillage	2.92	2.70	2.81	3.69	3.55	3.62	6.61	6.25	6.43	43.96	43.30	43.63
LSD (p=0.05)	0.21	0.19	0.13	0.23	0.26	0.16	0.40	0.23	0.21	NS	NS	NS
Weed management												
2,4-D at 0.5 kg/ha 30 DAS	2.79	2.50	2.64	3.50	3.27	3.39	6.29	5.77	6.03	44.43	43.30	43.87
MSM at 4.0 g/ha 30 DAS	3.29	3.08	3.19	4.18	3.87	4.02	7.47	6.94	7.21	44.16	44.48	44.32
2,4-D at 0.5 kg/ha 30 DAS+ 1 HW at 45 DAS	3.44	3.16	3.30	4.35	4.29	4.32	7.79	7.45	7.62	44.33	42.50	43.42
MSM at 4.0 g/ha 30 DAS+ 1 HW at 45 DAS	3.48	3.23	3.35	4.48	4.33	4.40	7.95	7.56	7.76	43.72	42.91	43.31
One hand weeding (HW) at 30 DAS	3.07	2.87	2.97	4.03	3.87	3.95	7.10	6.74	6.92	43.16	42.64	42.90
Weed free	3.68	3.29	3.49	4.65	4.54	4.60	8.33	7.83	8.08	44.38	42.10	43.24
Weedy check	1.78	1.57	1.68	2.26	2.01	2.14	4.04	3.59	3.81	44.00	43.78	43.89
LSD(p=0.05)	0.21	0.13	0.12	0.39	0.37	0.26	0.49	0.42	0.31	NS	NS	NS

*SSB-Stale Seedbed Technique, DAS- Days after sowing, MSM- Metsulfuron

measures like metsulfuron 4.0 g/ha + 1 HW, 2,4-D at 0.5 kg/ha + 1 HW and metsulfuron 4.0 g/ha alone was to the extent of 102, 99 and 92% than the weedy check. These results were in close conformity with the finding of Das (2008) and Singh *et al*. (2018). The lowest value of yield attributes and yield in weedy check might be due to severe competition by weeds for resources, which made the crop plant incompetent to take up more moisture and nutrients, consequently growth was adversely affected. Poor growth and less uptake of nutrients in weedy check might be due to less photosynthates, then less assimilates to numerous metabolic sink and ultimately poor development of yield components.

Economics

Maximum net returns were recorded under SSB using glyphosate 2.0 kg/ha than deep and conventional tillage (**Table 4**). These results were in corroborate the findings of Kumar *et al*. (2018). Application of metsulfuron 4.0 g/ha + one hand hoeing recorded significantly higher net return over all the weed control treatments. This might be due to lower cost to control of weed. (Jat *et al*. 2003) based on present investigation, it was concluded that SSB (with glyphosate or shallow tillage) and post-emergence application of either metsulfuron 4.0 g/ha + 1 HW, 2,4-D 0.5 kg/ha + 1 HW provided effective

weed control and consequently higher productivity but only metsulfuron 4.0 g/ha + 1 HW could increase yield similar to weed free check.

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