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Weed flora dynamics and yield of mustard as influenced by tillage and weed management in pearlmillet-mustard-cowpea cropping system

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ABSTRACT

The effects of tillage and weed management practices were evaluated for four years (2014-15 to 2017-18) in pearlmillet-mustard-cowpea cropping system. The results revealed that conventional tillage during *Kharif* (rainy) and *Rabi* (winter) seasons and zero tillage with previous crop residue application significantly increased the grain yield by 36 and 15% and reduced the total weed biomass by 57 and 26%, respectively compared to zero tillage without residue application. Among different weed flora, conventional tillage during *Kharif* and *Rabi* season *fb* the zero tillage with previous crop residue reduced the population of *P. minor* by 24.6 and 16%, *C. arvensis* and *M. hispida* by 50 and 29% and *C. rotundus* by 42 and 10% with weed control efficiency of 79 and 65%, respectively at 60 DAS over zero tillage without residue application. However, among different weed management practices, the pre-emergence application of oxyfluorfen 0.23 kg/ha with one hand weeding at 30-35 DAS resulted in significant reduction of total weed biomass, highest grain yield, weed control efficiency and net returns. The integrated weed management approach reduced the narrow-leaved weeds by 75%, broad-leaved weeds by 86% and sedges by 90% as compared to the weedy check.

INTRODUCTION

Among oilseeds, mustard occupies second position after soybean in India. It is cultivated in 5.96 mha area with the annual production of 8.32 mt and average productivity of 1.39 t/ha. In Madhya Pradesh, the area occupied under rapeseed and mustard is 0.75 mha with the annual production 0.98 mt and average productivity of 1.30 t/ha (Anonymous 2018). Pearlmillet-mustard is a very popular cropping system in the gird zone of Madhya Pradesh.

Conservation agriculture (CA) practice involves minimum soil disturbance with residue management for achieving higher productivity (Bhan and Behera 2014). CA based crop management technologies are more efficient, improve production and income and address the emerging problems (Gupta and Seth 2007). The presence of crop residue on the soil surface may influence soil temperature and moisture regimes that affect weed seed germination and it helps in reducing weed growth through reduced weed emergence (Sharma *et al.* 2013) and increase the crop yield. Zero tillage (ZT) based crop production can reduce input costs and labour, and conserve the soil (Busari *et al.* 2015). Weed species shifts and losses in crop yield as a result of increased weed density have been cited as major hurdles to the widespread adoption of CA. The presence of crop residue on the soil surface may influence soil temperature and moisture regimes that affect weed emergence patterns over the growing season. Under conventional and conservation tillage practices, crop yields may be similar if crop stands are uniform and weeds are managed under threshold levels. If weeds are not controlled during critical periods of crop-weed competition, the yields of mustard crop may reduce drastically up to 58% (Banga and Yadav 2001). The findings of weed species shifts under CA have however, been largely inconsistent (Chauhan *et al.* 2006). Several studies have been indicated that the density of perennial weeds increased in CA (Malik *et al.* 2002). Meanwhile, the use of different weed control strategies in CA system could influence weed population and density conspicuously over a period of time (Muoni *et al.* 2016).

Research efforts so far indicate that no single practice of weed management is economically effective for a given crop or cropping system. Surface residue retention in ZT suppresses weed emergence to a certain extent and also restricts mechanical or manual weed control (Mhlanga *et al.* 2016). Meanwhile, hand weeding has been a traditional and effective but economically unfeasible method of weed control in mustard. So, it is imperative to find out the alternative methods for reducing the weed density during early growth period of crops to realize maximum yields. Thus, weed management with herbicides by integration of tillage practices may increase the productivity of crops by decreasing the weed density and nutrient removal by the weeds.

MATERIALS AND METHODS

A field experiment was conducted during *Rabi* 2014-15 to 2017-18 to study the weed flora dynamics, growth and yield response of mustard crop as influenced by conservation tillage and weed management practices in pearlmillet–mustard–cowpea cropping system at Research Farm, College of Agriculture, RVSKVV, Gwalior (79° 54' E longitude and 23° 10' N latitude, 412 above MSL), Madhya Pradesh, The average rainfall of gird zone was 750 mm and very little and occasional rains were received during the crop growth period in four years. Humidity ranged from 93% in the morning to 28% in the evening and temperature ranged from 4°C to 32°C. The soil was low in nitrogen content (246 kg/ha), medium in phosphorus (13.0 kg/ha) and potassium (243 kg/ha) with sandy clay loam in texture. The pH of the soil was 7.6 with electrical conductivity 0.34 S/m containing 0.5% organic carbon in the topmost layer up to 15 cm of the soil. The experiment was laid out in a strip plot design, replicated thrice and consisted of 15 treatments. The five treatments of tillage practices were conventional tillage in *Kharif* and *Rabi* both and fallow in summer; conventional tillage in *Kharif fb* zero tillage in *Rabi* and summer both; zero tillage in *Kharif*, *Rabi* and summer, zero tillage in both *Kharif* and summer and with crop residues in *Rabi*, zero tillage with crop residues in *Kharif, Rabi* and summer in combination with three weed management practices, *viz.* pendimethalin 1.0 kg/ha just after sowing as PE, oxyfluorfen 0.23 kg/ha just after sowing as PE *fb* one hand weeding at 25-30 DAS and one kept weedy check for comparison. Two ploughing was done by the cultivator *fb* rotavator, 15 cm deep in the plots where conventional tillage (CT) was done *fb* levelling before sowing of the crop. The soil was not disturbed where ZT was done.

The recommended dose of NPK for mustard (80:40:20 kg/ha) was applied. The variety '*Rohini*' was sown 6 kg/ha in rows 40 cm apart and later thinning was done to maintain plant to plant distance as 10 cm. Before sowing, the seeds were treated with the fungicides dithane M-45 2.0 g/kg seed, for 30 minutes to control soil and seed borne diseases. Crop residues were placed as per the treatments and irrigation was applied as per requirement of crop during the experimentation. Herbicides were applied as per the treatments with the help of knapsack sprayer and flat-fan nozzle of spray volume 500 litres water/ha. Weed observations were recorded with the help of a quadrate 1.0 m^2 placed randomly at two spots in each plot at 30 and 60 DAS. The number of weed species present in the quadrate was recorded, sun dried for a few days then oven dried at 75°C for 48 hours, weighed and expressed in g/m^2. Weed control efficiency was calculated using weed dry weight at 60 DAS and economics of different weed control treatments was worked out by taking the selling price of mustard at existing market prices of the inputs. Statistical analysis of the data was carried out using ANOVA technique as applicable to strip plot design. The data on weed density was subjected to square root transformation *i.e.* $\sqrt{x+0.5}$ before carrying out analysis of variance and comparisons were made on transformed values only.

RESULTS AND DISCUSSION

Soil parameters

After completion of the first phase of long-term experimentation in four years, available nitrogen in the soil was decreased 4% (237 kg/ha) while the available phosphorous and potassium was increased by 46% (19.7 kg/ha) and 14% (277 kg/ha), respectively. However, the organic carbon of the soil was increased from 0.4 to 0.5 and pH from 7.6 to 7.8, but the electrical conductivity was remained same (0.34 dS/m) in the soil.

Weed flora

The major weed flora observed in an experimental site during the four years (2014-15 to 2017-18) at 30 and 60 DAS as influenced by different tillage and weed management practices were presented (**Table 1**). The main weeds were *Phalaris minor* (7%), *Spergula arvensis* (10%), and *Cynodon dactylon* (8%) as grasses and *Chenopodium album* (13%), *Anagallis arvensis* (18%), *Convolvulus arvensis* (8%), and *Medicago hispida* (6%) as major broad-leaved weeds. *Cyperus rotundus* (30%) was most dominating sedges among all the weeds grown in the experimental site. In the beginning of the experimentation, density of *Cynodon dactylon* and *Medicago hispida* was very less (2014-15 and 2015-

16) but the density and weed biomass of other weeds increased with time and thereafter declined.

Among different tillage practices (**Table 1**), density of *C. rotundus* was maximum over *P. minor*, *S. arvensis* and *C. dactylon*, whereas the maximum density of broad-leaved weeds was found in *A. arvensis fb C. album*. The count of *M. hispida* was very less during the entire crop growth period in four years.

Effect on weeds

All the weed control treatments proved effective in reducing the population and dry weight of weeds over weedy check (**Table 1**). Under different conservation tillage practices, conventional tillage during *Kharif* and *Rabi* both resulted significant reduction in weed population and relative weed dry weight with 79% weed control efficiency *fb* ZT practice with residue application during *Kharif* and *Rabi* and without residues in summer with 65% WCE due to fragile seedbed and better aeration which favour the germination and better growth of crop. Similarly, the population of *P. minor* as narrow-leaved weed, *C. arvensis* and *M. hispida* as broad-leaved weeds significantly reduced but the population of *Cyperus rotundus* was much higher under ZT without residue application in all three seasons compared to CT during both *Kharif* and *Rabi* season. Among different weed flora, CT during both *Kharif* and *Rabi* season and ZT with residues application in *Kharif* and *Rabi* and without residue in summer reduced the population of *P. minor* by 85 and 62% and broad-leaved weeds by 23 and 8%, respectively. The influence of tillage treatments was not seen on sedges but the population of *P. minor* and *S. arvensis* continued to be less from 30 to 60 DAS (**Table 1**). Therefore, CA, can contribute to decrease the population of *P. minor* and *S. arvensis* in mustard.

Under different weed management practices, higher weed population and dry weight was recorded in weedy check while the lowest was recorded with integrated weed management practices where pre-emergence oxyfluorfen 0.23 kg/ha with one hand weeding at 25-30 DAS was applied. The weed control efficiency was also 86% which was 12% higher over pre-emergence application of pendimethalin 1.0 kg/ha alone.

Effect on crop

Tillage and weed control practice exerted significant effect on plant height, number of branches/plants, length of siliqua, number of siliquae/ plant and number of seeds/siliqua. The crop stands were uniform in the field under CT practice during *Kharif* and *Rabi* which resulted in significant increase in the yield and growth parameters of mustard crop (**Table 2**). Similar study was done by Yaduraju *et al.* (2002) and Mishra *et al.* (2005). The maximum seed yield was recorded 1.96 t/ha which was 19% higher than ZT without crop residue (**Table 3**).

Table 1. Density of different weeds/m^2, WCE and weed biomass as affected by different tillage and weed management practices in mustard under pearl millet-mustard-cowpea cropping system (pooled 2014-15 to 2017-18)

Treatment	Narrow-leaved weeds/m^2								Broad-leaved weeds/m^2								WCE %	Weed biomass (kg/ha)
	C. rotundus		*P. minor*		*S. arvensis*		*C. dactylon*		*M. hispida*		*C. album*		*A. arvensis*		*C. arvensis*			
	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	60 DAS	at harvest
Tillage practice																		
CT-CT-F	5.76 (40.7)	7.13 (53.2)	1.44 (2.9)	1.34 (1.9)	1.58 (3.9)	1.66 (3.2)	1.97 (4.4)	2.47 (7.3)	1.37 (1.9)	1.42 (2.4)	2.36 (8.9)	3.26 (14.5)	2.93 (17.1)	3.49 (19.8)	1.87 (3.8)	2.17 (5.6)	79.33	235
CT-ZT-ZT	8.11 (88.8)	9.08 (91.6)	1.99 (7.9)	1.59 (2.8)	3.14 (22.3)	2.14 (6.6)	2.77 (10.3)	3.07 (11.7)	1.75 (3.9)	1.99 (5.2)	4.08 (31.4)	4.69 (33.2)	6.10 (60.2)	5.81 (62.6)	2.62 (9.2)	2.64 (9.0)	50.81	288
ZT-ZT-ZT	8.60 (102.5)	9.89 (118.1)	1.81 (3.8)	1.83 (3.9)	2.93 (18.6)	2.55 (9.2)	2.39 (6.9)	3.23 (11.8)	1.86 (4.6)	2.09 (5.2)	4.12 (32.4)	5.29 (42.4)	7.10 (95.7)	6.85 (85.4)	2.81 (10.2)	3.50 (14.0)	27.20	368
ZT-ZT+R–ZT	8.71 (90.4)	9.06 (99.5)	1.97 (7.7)	1.67 (3.5)	2.50 (13.7)	2.48 (8.4)	2.21 (6.4)	2.69 (8.6)	1.60 (3.7)	2.05 (5.4)	4.22 (35.4)	4.23 (25.0)	5.57 (60.5)	5.74 (51.2)	2.47 (8.4)	2.48 (7.3)	43.95	324
ZT+R-ZT+R–ZT	7.40 (74.5)	9.92 (109.4)	1.36 (1.9)	1.76 (3.4)	1.98 (6.7)	2.02 (5.6)	2.13 (5.7)	2.64 (8.1)	1.58 (3.2)	1.52 (2.4)	2.93 (14.4)	3.75 (19.3)	3.15 (18.4)	3.69 (20.2)	2.44 (8.4)	2.68 (9.1)	64.85	292
LSD (p=0.05)	0.79	0.82	0.24	0.32	0.48	0.46	0.38	0.42	0.18	0.40	0.53	0.43	0.74	0.73	0.36	0.39	-	57
Weed management																		
Pendimethalin	7.46 (63.1)	8.16 (72.3)	1.03 (0.8)	1.40 (2.1)	1.50 (2.8)	1.59 (3.1)	2.23 (5.1)	2.53 (6.6)	1.35 (1.8)	1.54 (2.8)	1.92 (4.9)	3.02 (14.3)	2.99 (11.2)	3.33 (13.0)	2.27 (5.3)	2.31 (6.0)	73.57	325
Oxyfluorfen + 1 HW	4.13 (27.6)	6.42 (42.7)	0.77 (0.2)	0.94 (0.6)	0.71 (0.0)	1.33 (2.1)	0.87 (0.4)	1.78 (3.8)	0.71 (0.0)	1.16 (1.3)	0.87 (0.5)	2.31 (7.7)	0.86 (0.6)	1.45 (2.7)	1.05 (0.9)	1.83 (3.8)	86.11	133
Weedy check	11.56 (152.2)	12.47 (168.1)	3.34 (13.6)	2.58 (6.6)	5.07 (36.3)	3.59 (14.6)	3.78 (14.7)	4.15 (18.2)	2.84 (8.6)	2.74 (8.2)	7.83 (68.1)	7.40 (58.6)	11.06 (139.4)	10.56 (127.8)	4.00 (17.8)	3.94 (17.2)	-	445
LSD (p=0.05)	0.67	0.74	0.24	0.32	0.41	0.25	0.28	0.34	0.18	0.29	0.38	0.36	0.51	0.67	0.26	0.43	-	49
Interaction	Sig	Sig	Sig	NS	Sig	Sig	NS	NS	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	-	NS

CA: Conventional tillage, ZT: Zero tillage, F: fallow, R: Residue

Among ZT practices, the highest seed was yielded from the ZT with crop residue in *Kharif* and *Rabi* both and without residue in summer which was 15% higher compared to ZT without residue. ZT with residue as mulch on the soil surface may influence soil temperature and moisture regimes that affect weed seed germination and emergence patterns over the growing season thus help in greater suppression ability of weeds than the without residue treatments that indirectly led to better growth and yield of mustard. The ZT without residue application resulted in the lowest values of growth and yield attributes of mustard. ZT with residue application during *Rabi* only and both *Kharif* and *Rabi* increased the grain yield by 10 and 15%, respectively compared to ZT without residue application. The higher growth and yield of mustard in ZT with residue application may be attributed to better aeration and adequate moisture or differences in soil structure and fertility level.

Integrated weed management application where pre-emergence oxyfluorfen 0.23 kg/ha with one hand weeding at 25-30 DAS was done, resulted in the significantly higher values of growth and yield attributes compared to all other treatments and was *fb* the pre-emergence application of pendimethalin 1.0 kg/ha alone. Application of oxyfluorfen 0.23 kg/ha + one hand weeding at 25-30 DAS established its superiority by recording significantly higher grain yield (**Table 3**) and noted the increment by 34.7 and 19% of seed and stover yield compared to weedy check and 24.6 and 9% higher seed and stover yield in pre-emergence application of pendimethalin 1.0 kg/ha respectively. This increase in yield might be due to effective control of weeds in early stage, which smothered weed growth and gave higher yield attributes of mustard and ultimately resulted to higher yields. The results are in conformity with the findings of Sasode *et al.* (2020) and Radhey Shyam *et al.* (2014).

Economics

Among different tillage practices, CT during both *Kharif* and *Rabi* season and ZT with crop residue during *Kharif* and *Rabi* and without residue in summer season increased the net monetary returns by 58 and 27% and B:C ratio by 24 and 18%, respectively compared to ZT without residue application (**Table 3**). Among different weed management practices, the application of pendimethalin 1.0 kg/ha alone recorded significantly higher B:C ratio (3.21) but net monetary returns were recorded higher (₹ 45747/ha) with the application of oxyflourfen + one hand weeding at 25-30 DAS. However, the net monetary returns (₹ 40709/ha) and benefit cost ratio (2.87) were lowest in weedy check plots.

Based on four years experimentation it is concluded that the population of *P. minor* as narrow and *C. arvensis* and *M. hispida* as broad-leaved weeds continues to be less under CT during *Kharif* and *Rabi* both *fb* the ZT with crop residue application during *Kharif* and *Rabi* and without residue in summer. The application of oxyflourfen 0.23kg/ha with one hand weeding at 25-30 DAS resulted in the maximum control of weeds and provided the maximum grain yield and net returns under conventional tillage during *Kharif* and *Rabi.* Therefore, CT, can contribute to decrease narrow-leaved weeds and higher productivity and profitability of mustard in pearlmillet-mustard-cowpea cropping system.

Table 2. Growth of the mustard crop as affected by different tillage and weed management practices under pearlmillet-mustard-cowpea cropping system at harvest stage (pooled 2014-15 to 2017-18)

Treatment	Plant height (cm)	No. of branches/plant	Length of siliqua (cm)	No. of siliqua /plant	No. of seeds/ siliqua
Tillage practice					
CT-CT-F	162	5.32	4.48	203.4	14.2
CT-ZT-ZT	154	4.69	4.34	190.0	13.5
ZT-ZT-ZT	151	4.52	4.22	175.8	13.2
ZT-ZT+R–ZT	152	4.62	4.33	182.0	13.6
ZT+R-ZT+R–ZT	155	4.87	4.35	190.3	13.7
LSD (p=0.05)	4.6	0.36	0.10	10.6	0.40
Weed management					
Pendimethalin	156	4.85	4.32	190.5	13.8
Oxyfluorfen + 1 HW	163	5.55	4.62	210.4	14.4
Weedy check	145	4.01	4.09	163.9	12.6
LSD (p=0.05)	2.4	0.18	0.08	5.90	0.27
Interaction	NS	Sig	NS	Sig	NS

CA: Conventional tillage, ZT: Zero tillage, F: fallow, R: Residue

Table 3. Yield and economics of the mustard crop as affected by different tillage and weed management practices under pearlmillet-mustard-cowpea cropping system at harvest stage (pooled 2014-15 to 2017-18)

Treatment	Seed yield (t/ha)					Stover yield (t/ha)					Net returns (x10^3 ₹/ha)					B:C ratio
	2014-15	2015-16	2016-17	2017-18	Pooled	2014-15	2015-16	2016-17	2017-18	Pooled	2014-15	2015-16	2016-17	2017-18	Pooled	
Tillage practice																
CT-CT-F	1.98	1.95	1.96	1.97	1.96	7.12	6.54	5.70	7.96	6.83	51.07	49.79	50.34	50.52	50.43	3.45
CT-ZT-ZT	1.64	1.62	1.58	1.68	1.63	6.05	6.49	5.60	6.94	6.27	41.83	37.61	38.26	41.18	39.72	3.24
ZT-ZT-ZT	1.46	1.42	1.35	1.53	1.44	5.81	5.25	4.58	6.48	5.53	32.88	31.01	28.64	35.26	31.95	2.80
ZT-ZT+R–ZT	1.57	1.60	1.47	1.70	1.58	6.46	5.47	5.24	6.69	5.96	39.95	35.68	33.88	41.75	37.82	3.14
ZT+R-ZT+R–ZT	1.69	1.62	1.66	1.65	1.65	6.57	5.56	5.44	6.68	6.06	46.37	34.96	41.39	39.94	40.67	3.30
LSD (p=0.05)	0.08	0.11	0.21	0.10	0.11	0.19	0.51	0.86	0.81	0.54	4.58	4.27	4.32	3.93	4.87	0.15
Weed management																
Pendimethalin	1.70	1.75	1.67	1.78	1.72	5.84	6.38	5.26	6.96	6.11	43.13	40.97	40.39	43.71	42.05	3.21
Oxyfluorfen + 1 HW	1.88	1.85	1.81	1.92	1.86	6.58	6.76	5.98	7.37	6.67	47.25	44.25	44.26	47.23	45.75	3.16
Weedy check	1.40	1.35	1.33	1.42	1.38	5.06	6.16	4.70	6.53	5.61	31.17	30.25	29.04	32.38	30.71	2.87
LSD (p=0.05)	0.04	0.03	0.21	0.07	0.11	0.19	0.37	0.47	1.08	0.46	4.12	4.22	3.96	3.23	4.90	0.15
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CA: Conventional tillage, ZT: Zero tillage, F: fallow, R: Residue

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