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Consequence of various tillage and weed management practices on weed control and soybean productivity

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Abstract
A field investigation entitled "Effect of various tillage practices on weed control and soybean productivity" was conducted at research farm of AICRP on Weed Management, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during the year 2016-17 on medium deep black soil. The experiment was laid out in strip plot design with three replications. There were eighteen treatment combinations consisting six tillage and crop management practices. On the basis of results obtained in the present investigation, the weed management treatment i.e. integrated weed management (HHW) found to be superior in controlling the weed over treatment of recommended herbicide (RH) and weedy check, and in case of plant growth, yield attributes and yield of soybean were significantly increased with tillage treatment of 2 Harrowing by tyne cultivator + 1 Harrowing by blade harrow + planking + Residue (CTR) as compared to other tillage treatments.

Keywords: Tillage, monocot, dicot weed, weed control, soybean, yield, productivity.

Introduction
Tillage is the oldest art associated with development of agriculture. Tillage operations are carried out to prepare a fine seed-bed for sowing crops. Tillage plays an important role in the crop growth and production. A soil tillage practice improves soil physical properties and enables the plant to show their full potential and growth. Soil tillage techniques are used to provide suitable environment to seed growth and development, control weeds, manage crop residues, reduce soil erosion and level the surface for planting, irrigation, drainage and incorporation of organic and inorganic fertilizers in the soil. Continuous use of soil tillage practices strongly influence the soil properties, it is important to apply appropriate tillage practices in the soil to avoid the degradation of soil structure, maintain crop yield as well as flora and fauna stability in the soil. The success of any tillage practices is directly related to the improvement of the soil physical properties which in turn may affect the growth and yield of crops due to the different soil conditions created. The choice of any tillage system is too critical for maintenance of the soil physical properties necessary for crop growth. Rotavator plows are rotational tillage implements that break and mix the soil by using either the tractor's power (rotary tiller, rotary power harrow) or an external power source (small motorized rotary tiller), and the operation typically needs only one pass to let the soil ready for planting.

Soybean *(Glycine max. L.)* is one of the important oilseed as well as a leguminous crop. Soybean as a miracle "Golden bean" of the 21st century. It is an excellent source of protein and oil besides it contains high level of amino acids such as lysine, lucien, lecithin and large amount of phosphorous. Soybean contains approximately 40-45% protein and 18-22% oil and is a rich source of vitamins and minerals. Soybean is a worlds first rank crop as a source of vegetable oil. The area covered under soybean in India was 116.285 lakh ha which produced 86.426 lakh MT with productivity of 781 kg ha^{-1} whereas, in Maharashtra the area under cultivation was 37.739 lakh ha which produced 27.835 lakh MT with productivity of 776 kg ha^{-1}. In Vidarbha, area under soybean was 18.726 lakh ha which produced 18.453 lakh MT with productivity of 973 kg ha^{-1} (SOPA, 2015). It is the cheapest and richest source of high quality protein. It supplies most of the nutritional constituents essential for human health.

Materials and Methods

Field experiment was carried out during *Kharif* season of 2016-17 at the All India co-ordinated research project on weed management Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola, situated at the latitude of 22°42' North and longitude of 77°02' East and 281.12 meter above the mean sea level. The experimental plot topography was fairly uniform and leveled. The result of the initial chemical analysis indicated that, the soils have pH 7.84 with electrical conductivity 0.25 dSm^{-1} and organic carbon content was 5.44 g kg^{-1}. The available nitrogen and phosphorus content of soil was low i.e. 234 and medium 24.42 kg ha^{-1}, respectively. However, soils were sufficiently higher in available potash content (478.52kg ha^{-1}). The experiment was laid out in strip plot design with three replications. The treatments were randomly allotted in each replication. There were eighteen treatment combinations consisting six tillage and crop management practices, viz., T_1- 2 harrowing by tyne cultivator + 1 harrowing by blade harrow + planking; T_2 - 2 harrowing by tyne cultivator + 1 harrowing by blade harrow + planking + Residue; T_3 – 1 Rotavator tillage; T_4 -1 Rotavator tillage + Residue; T_5 – zero tillage;T_6 – zero tillage + Residue and three levels of weed management, i.e.H_1– Diclosulam 30g/ha (PE)*fb*Imazethapyr + Imazamox 100g/ha (POE) 20 DAS; H_2-1 hand weeding 20DAS *fb* Imazethapyr +imazamox 100g/ha (POE) 40 DAS ; H_3–weedy check (unweeded). The net plot size was 6.3 x 5.5 m. Sowing of soybean (var. JS-335) was done on 21st June, 2016. For determination of bulk density the core sampler method was used to collect the undisturbed soil samples.

Note: CT: 2 Harrowing by tyne cultivator+ 1 harrowing by Blade harrow+ planking, CTR: 2 Harrowing by tyne cultivator+ 1 harrowing by Blade harrow+ planking+Residue, ZT: Zero tillage, ZTR: Zero tillage+ Residue MT: Rotavator tillage and MTR: Rotavator tillage+ Residue, RH: Diclosulam 30g/ha (PE), *fb* Imazethapyer + Imazamox 100 g/ha (POE) 20 DAS, HHW: Hand weeding (20 DAS) fb Imazethapyer + Imazamox 100 g/ha (POE) 40DAS, UW: Unweeded.

Results and Discussion

Weed studies

Number of monocot weeds

A glance of data would indicate that mean number of monocot weed was increased with successive stage of crop growth up to harvest.

Effect of tillage management

Data presented in Table1 indicated that the monocot weed population was significantly influenced by various tillage practices at all stages of crop growth. Treatment CTR was found to be most efficient tillage treatment which reduced the number of monocot weeds to a remarkable extent, both statistically and numerically. This treatment recorded total monocot weeds of about 16.56, 19.89, 20.56, 25.78 and 27.11at 20, 40, 60, 80 DAS and at harvest, respectively. However, this treatment was found statistically similar with those of CT, MTR and MT. Conversely treatment ZT recorded significantly highest number of weed count i.e. 26.67, 23.33, 25.00, 29.22 and 33.22 during 20, 40, 60, 80 DAS and at harvest, being at par with that of treatment ZTR.

Effect of weed management

Data pertaining to the effect of various weed management treatment on number of monocot weed found to be differed significantly. At 20 DAS treatment of recommended herbicide (RH) recorded significantly minimum number of monocot weed(7.39), while treatments of integrated weed management (HHW) and un-weeded check (UW) recorded significantly maximum number of monocot weeds(20.76 and 29.94). At 40 DAS treatment UW (40.17) recorded significantly superior number of monocot weed followed by treatment RH (10.76). Conversely, treatment HHW (8.78) recorded significantly minimum number of monocot weeds. The same trend of treatment difference was noticed during subsequent crop growth stages.

Interaction effect

An interaction effect due to various tillage and weed management practices on number of monocot weed was found to be non-significant over all the stages of crop growth.

Number of dicot weeds

A glance of data would indicate that mean number of dicot weed was increased with successive stage of crop growth up to harvest. The mean number of dicot weed at different growth stages ranged from 16.80 at 20 DAS to 27.17 at harvest. The rate of increase in dicot weed was declined subsequently 20 DAS.

Effect of tillage management

Data presented in Table 2 indicated that the dicot weed population was significantly influenced by various tillage practices at all stages of crop growth. The treatment ZT recorded the maximum number of dicot weed at all the growth stages of crop (18.89, 21.00, 22.00, 31.00, and 33.11 at 20, 40, 60, 80 DAS and at harvest, respectively). Treatment CTR recorded significantly least number of dicot weeds (14.11, 15.78, 16.22, 20.78 and 22.22 at 20, 40, 60, 80 DAS and at harvest, respectively) which was statistically similar with treatments MTR, CT and MT from 20 DAS to at harvest.

Effect of weed management

Data pertaining to the effect of various weed management treatment on number of dicot weed found to be significantly superior at all stages of crop growth. Initially at 20 DAS, treatment RH recorded significantly minimum number of dicot weed (4.28), which was followed by treatment HHW (19.83) and UW (26.28) by recording significantly higher number of monocot weeds. At 40 DAS, treatment UW recorded significantly superior number of monocot weed (39.00) which was followed by treatment RH (9.78). However, at this stage the most efficient treatment was that of HHW (6.09) with significantly minimum number of monocot weed.

Interaction effect

An interaction effect due to various tillage practices and weed management practices on number of dicot weed was found to be non-significant over all the stages of crop growth.

Number of total weeds

Effect of tillage management

Data presented in Table 3 indicated that the total weed population gets significantly influenced by various tillage practices at all stages of crop growth. Significant improvement in controlling the total weed completion was noticed with tillage treatment of CTR, where the residues were added as mulch. The total weed count recorded with this treatment was only 29.78 at 20 DAS. Whereas significantly maximum total weed count (45.56) and thus it proved to be most weedy tillage treatment. Treatments MTR, CT and MT being statistically at par were moderately improved the status of weed by recording the total weed number as 32.11,33.56 and 33.67, respectively. The similar phenomena of treatment differences were noticed during the further stages of crop growth in soybean field.

Effect of weed management

As expected, the number of total weed differed significantly at all stages of crop growth. At 20 DAS, significant improvement in checking the weed was noted with herbicide treatment RH, where the weed count was much less (11.67), and conversely the unweeded check recorded significantly highest total number of weeds (56.22). The remaining treatments, i.e. HHW recorded moderate improvement with 40.61weeds per plot. At 40 DAS, however, significantly lowest weed count was noted with treatment of integrated weed management (HWW) with respective number of 14.83. Treatment UW recorded significantly maximum number of total weeds (79.17). The similar trend of treatment differences was noticed during further periodical stages.

Kalpana and Velayutham (2004) [5] reported that application of Imazethapyr at 100 g a.i ha^{-1} as post-emergence plus hand weeding at 30 DAS recorded significantly higher weed control similar result were also recorded by Sasikala *et al*. (2004) [9], Dixit (2006) [4], Kumar *et al.* (2013), Patel *et al*. (2013) [8].

Interaction effect

An interaction effect due to various tillage practices and weed management practices on number of total weed population found to be non-significant over all stages of crop growth.

Seed yield and straw yield (kg ha^{-1}) of soybean

During the period of present investigation, the net plot yield values were converted to per hector yield by using the hector factor. The relevant data in respect of seed and straw yield as obtained during the given year 2015-16 are presented in Table 4 and graphically represented in Fig.2.

Effect of tillage management

Marked effect of tillage practices of varying depth and intensity was observed over seed and straw yield of soybean during given period of study. It is apparent that treatment consisting of CTR posed a great impact along with treatment CT in respect of seed yield. Treatment CTR recorded seed yield to an extent of 2305 kg ha^{-1}, while treatment CT; being non-significant with treatment CTR recorded the corresponding value of 2298kg ha^{-1}. These two treatments in together recorded a yield advantage of about 11.15 % over the zero tillage treatments of ZT and ZTR, where, the soybean seed yield was 2068 and 2071 kg ha^{-1}, respectively. It is noteworthy to mention that medium deep tillage treatments i.e. MT and MTR; being statistically similar with each other, also found superior over no-tillage treatments of ZT and ZTR and recorded the seed yield of soybean in the range of 2171 to 2192 kg ha^{-1}.The similar trend of treatment differences were noticed when the straw yield of soybean was measured after harvest of the crop. Alizadeh and Allameh (2015) [2] reported the highest seed yield in tillage treatment of mouldboard plough plus rotavator. Blecharczyk *et al*. (1999) [3] compared different tillage treatments and observed higher wheat yield with conventional deep tillage than other tillage practices. Similar kind of research results were reported earlier by Varshney *et al* (1990) [10], Ahmad *et al*. (2010) [1] and Meena *et al*. (2011) [7].

Effect of weed management

The seed yield and straw yield (kg ha^{-1}) pertaining to weed management treatment had shown significant effect on seed yield and straw yield at harvest. The treatment HHW (2396 kg ha^{-1}) was found to be significantly superior, followed by the treatment RH (2268 kg ha^{-1}). However treatment UW (1888 kg ha^{-1}) recorded the minimum seed yield compeered with other remaining treatment. The treatment HHW (2400 kg ha^{-1}) was found to be superior, being statistically similar with treatment RH (2388 kg ha^{-1}) with respect to straw yield. However treatment NH (2366 kg ha^{-1}) recorded the minimum straw yield compeered with other remaining treatment. The effect of various weed management practices on biological yield was found to be significant. The treatment HHW (4796 kg ha^{-1}) recorded the significantly superior biological yield, followed by the treatment RH (4656 kg ha^{-1}) and UW (4214 kg ha^{-1}).

Interaction effect

An interaction between tillage and weed management practices was found to be significant at harvest. It is obvious that treatment combination of CT x HHW and CTR x HHW, recorded significantly maximum seed yield (kg ha^{-1}) than rest of the treatment combinations. An interaction between tillage and weed management practices of CTRx RH and CTR x HHW was found to be significantly superior over rest of the treatment combinations by recording highest values of straw yield of soybean (2725 and 2690 kg ha^{-1}, respectively). An interaction CTR X HHW and CT x RH recorded significantly maximum biological yield (5235 and 5133 kg ha^{-1}) and proved to be the best treatment combinations.

Table 1: Number of monocot weeds in soybean field (m^{-2}) as influenced by various tillage practices

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
A) Tillage management					
CT	16.56	19.89	20.56	25.78	27.11
CTR	15.67	17.44	18.11	23.00	24.44
MT	17.00	18.33	21.00	25.67	26.67
MTR	16.11	18.33	18.89	24.22	25.56

ZT	26.67	23.33	25.00	29.22	33.22
ZTR	24.22	22.11	24.33	27.44	30.44
SE (m)+-	1.07	1.04	1.23	1.26	1.16
CD at 5%	3.06	3.00	3.54	3.62	3.35
B) Weed management					
RH	7.39	10.78	12.00	13.72	15.83
HHW	20.78	8.78	5.72	8.50	11.44
UW	29.94	40.17	46.22	55.44	56.44
SE (m)+-	0.75	0.74	0.87	0.89	0.82
CD at 5%	2.16	2.12	2.51	2.56	2.37
Interaction (AxB)					
SE (m)+-	1.85	1.81	2.14	2.18	2.02
CD at 5%	NS	NS	NS	NS	NS
GM	19.37	19.91	21.31	25.89	27.91

Table 2: Number of dicot weeds in soybean field (m^{-2}) as influenced by various tillage practices

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
A) Tillage management					
CT	17.00	18.33	18.67	23.56	25.89
CTR	14.11	15.78	16.22	20.78	22.22
MT	16.67	17.00	18.89	23.11	26.44
MTR	16.00	17.67	17.44	21.11	24.33
ZT	18.89	21.00	22.00	31.00	33.11
ZTR	18.11	19.89	20.33	28.00	31.00
SE (m)+-	1.01	0.92	1.14	1.37	1.42
CD at 5%	2.91	2.66	3.29	3.92	4.08
B) Weed management					
RH	4.28	9.78	9.78	13.33	14.50
HHW	19.83	6.06	5.33	11.33	11.28
UW	26.28	39.00	41.67	49.11	55.72
SE (m)+-	0.72	0.65	0.81	0.97	1.00
CD at 5%	2.06	1.88	2.32	2.77	2.89
Interaction (AxB)					
SE (m)+-	1.75	1.60	1.98	2.36	2.46
CD at 5%	NS	NS	NS	NS	NS
GM	16.80	18.28	18.93	24.59	27.17

Table 3: Number of total weeds in soybean field (m^{-2}) as influenced by various tillage practices

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
A) Tillage management					
CT	33.56	38.22	39.22	49.33	53.00
CTR	29.78	33.22	34.33	43.78	46.67
MT	33.67	35.33	39.89	48.78	53.11
MTR	32.11	36.00	36.33	45.33	49.89
ZT	45.56	44.33	47.00	60.22	66.33
ZTR	42.33	42.00	44.67	55.44	61.44
SE (m)+-	1.53	1.65	1.87	2.11	2.33
CD at 5%	4.41	4.74	5.37	6.06	6.70
B) Weed management					
RH	11.67	20.56	21.78	27.06	30.33
HHW	40.61	14.83	11.06	19.83	22.72
UW	56.22	79.17	87.89	104.56	112.17
SE (m)+-	1.08	1.17	1.32	1.49	1.65
CD at 5%	3.12	3.35	3.80	4.28	4.73
Interaction (AxB)					
SE (m)+-	2.66	2.86	3.24	3.65	4.04
CD at 5%	NS	NS	NS	NS	NS
GM	36.17	38.19	40.24	50.48	55.07

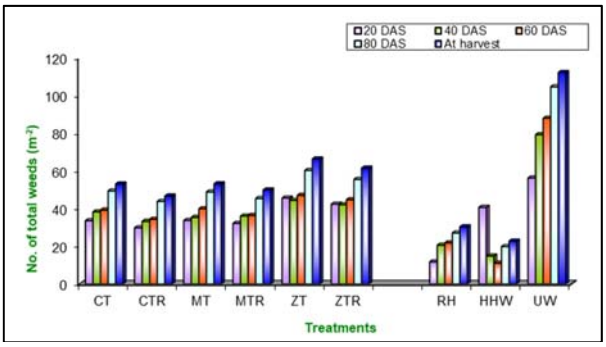

Fig 1: Number of total weeds on soybean field (m^{-2}) as influenced by various tillage practices

Table 4: Seed and straw yield (kg ha^{-1}) of soybean as affected by various tillage and weed management practices

Treatment	yield of soybean (kg ha^{-1})		
	Seed	Straw	Biological
A) Tillage management			
CT	2298	2568	4866
CTR	2305	2696	5001
MT	2171	2298	4469
MTR	2192	2420	4611
ZT	2068	2085	4154
ZTR	2071	2162	4233
SE (m)+-	20.617	19.967	30.314
CD at 5%	59.246	57.378	87.110
B) Weed management			
RH	2268	2388	4657
HHW	2396	2400	4796
UW	1888	2326	4214
SE (m)+-	14.579	14.119	21.435
CD at 5%	41.893	40.572	61.596
Interaction(AxB)			
SE (m)+-	36	35	52.51
CD at 5%	102.62	99.38	150.88
GM	**2184**	**2372**	**4556**

Table 5: Seed yield (kgha^{-1}) of soybean as affected by interaction of various tillage and weed management practices after harvest

Treatment	CT	CTR	MT	MTR	ZT	ZTR
RH	2331	2307	2280	2282	2212	2200
HHW	2503	2510	2397	2410	2263	2292
UW	2060	2098	1835	1883	1730	1720
SE (m)+-	35.710					
CD at 5%	102.617					

An interaction between tillage and weed management practices was found to be significant at harvest. It is obvious that treatment combination of CT x HHW and CTR x HHW, recorded significantly maximum seed yield (kg ha^{-1}) than rest of the treatment combinations.

Table 6: Straw yield (kg ha^{-1}) of soybean as affected by interaction of various tillage and weed management practices after harvest

Treatment	CT	CTR	MT	MTR	ZT	ZTR
RH	2630	2725	2358	2350	2118	2219
HHW	2598	2690	2321	2448	2086	2186
UW	2477	2573	2215	2461	2051	2081
SE (m)+	34.584					
CDat 5%	99.381					

An interaction between tillage and weed management practices of CTRx RH and CTR x HHW was found to be significantly superior over rest of the treatment combinations by recording highest values of straw yield of soybean (2725 and 2690 kg ha^{-1}, respectively).

Table 7: Biological yield (kg ha^{-1}) of soybean as affected by interaction of various tillage and weed management practices after harvest.

Treatment	CT	CTR	MT	MTR	ZT	ZTR
RH	5133	4947	4754	4760	4382	4512
HHW	4929	5235	4601	4730	4298	4386
UW	4537	4772	4050	4344	3781	3801
SE (m)±	52.505					
CD at 5%	150.879					

An interaction CTR X HHW and CT x RH recorded significantly maximum biological yield (5235 and 5133 kg ha^{-1}) and proved to be the best treatment combinations.

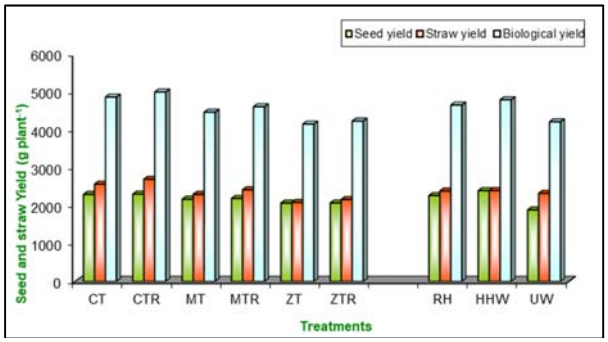

Fig 2: Seed and straw yield (kg ha^{-1}) of soybean as affected by various tillage practices

Conclusion

1. Significantly lowest weed count at 40 DAS was recorded with the combination of tillage treatment of 2 harrowings by tyne cultivator + 1 harrowing by blade harrow + planking with residue addition and weed management treatment of integrated weed management.
2. Significantly highest soybean productivity gross and net monetary returns were observed with combination of 2 harrowings by tyne cultivator + 1 harrowing by blade harrow + planking with or without residue addition and recommended herbicide application treatments.

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