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Effect of various tillage and weed management practices on weed control and yield of soybean (*Glycine max*)

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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, dry matter, weed control efficiency, 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. Mulching is a recent and important non-chemical weed control method. Mulch is a material that covers the soil surface to protect and to improve the covered area. Mulch is of two types i.e. organic mulch (living) and inorganic mulch (non-living). Organic mulch includes leaves, barks, woodchips, grass clipping etc., it retains the nutrients found in these organic matters. Inorganic material includes polyethylene sheaths, pebbles, gravels etc. Mulching is the best way used to control weeds, Mulching possessed a positive effect on growth of soybean and soil physical condition. Different Organic mulches lowered increased soil moisture, soil temperature, decreased weed density and increased the crop yield It is necessary to cover the soil surface with different materials to obtain high biological activity, retain soil moisture and to achieve a good control of weed. Intense weed competition is one of the major constraints in productivity of crops. Weeds constitute a major component among the bottlenecks for successful crop production. Tillage helps in controlling weeds by burying the weed seeds and emerged weed seedlings leaving a rough surface to hinder weed seed germination and expose underground parts of perennial weeds leading to desiccation. Adoption of conservation tillage practices can lead to shifts in weed communities. Weed management techniques like manual and herbicidal methods are found to be effective in controlling different groups of weeds in cropped fields.

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 coordinated 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

Dry matter production by weed

Data on dry matter production by weed (g) at different growth stages of crop as influenced by various tillage treatment are presented in following table

Effect of tillage management

The dry matter production of dicot and monocot weed was significantly influenced by various tillage practices. At 20 DAS, significantly lowest biomass production was recorded with treatment CTR (37.73 g) m^{-2} which was statistically similar with treatment CT ant MT (37.98 and 40.95 g). However treatment ZT (43.89 g) recorded the highest dry matter being at par with treatment ZTR (42.21g) and MTR (41.16 g). At 40 DAS, treatment CTR registered significantly lowest weed dry matter of value (34.72 g), and conversely, treatment ZT recorded significantly highest weed dray matter of value (43.47 g) being statistically similar with treatment ZTR (43.47 g). Similar treatment differences were noticed at 60, 80 DAS and at harvest.

Effect of weed management

Data pertaining to the effect of various weed management treatment on weed dry matter found to be significantly influenced at all stages of crop growth. At 20 DAS, herbicide treatment of RH recorded significantly lowest weed dry matter (10.55 g) over all treatments. It was followed by treatment HHW (50.34g). Treatment UW with weed dry matter production of 60.87g, remained most inferior. At 40 DAS, treatment HHW registered the lowest weed dry matter (19.33g), which was followed by treatment RH. However, treatment UW recorded significantly highest weed dray matter (79.08g) and thus recorded the potential weed infestation at the experimental site. Similar was trend of treatment differences during the remaining crop growth stages.

Kushwah and Vyas (2005) reported that application of Imazethapyr 10 % SL @ 75 g ha^{-1} was found most effective in reducing weed biomass and resulting higher weed control efficiency, these result are in accordance with the results reported by Patel *et al*. (2013) [7], Singh *et al.* (2014) [11] Sharma *et al*. (2015) [10].

Interaction effect

An interaction effect of various tillage practices and weed management practices on found statistically significant on weed dry matter at 40,60,80 DAS and at harvest.

From Table 5, it is obvious that interaction of all the tillage treatments with weedy check (UW) recorded significantly highest weed dry matter suggesting the importance of controlling weeds in all the tillage practices including deep tillage. While, the weed control through integrated weed management practices and by using herbicides along with deep to moderate deep tillage proved to be the most promising practice.

An interaction between tillage practices and weed management practices was found to be significant at 60 DAS. Treatment combination of CTR x HHW recorded significantly lowest weed dry matter (20 g) than all the other treatment combinations at 60 DAS. An interaction between treatments CTR x HHW recorded significantly lowest weed dry matter (24 g) and thus proved as significant treatment combination to control the weeds, when compared with other interactions at 80DAS. At harvest stage of soybean significant improvement in controlling the weeds was observed when tillage treatment CTR was tested against the weed management practice of HHW, where significantly lowest weed dry matter (36.70 g) was recorded, when compared with remaining treatment combinations.

Weed control efficiency (WCE)

Weed control efficiency indicate the ratio of total number of weeds present in a plot to the potential weed population as observed in the weedy check, which is expressed in percentage. Data of WCE at different growth stages of crop as influenced by various tillage treatments are presented in Table 6

Effect of tillage management

It is evident from the values presented in Table 2 that treatment CT (35.09 %) recorded the significantly highest WCE at 20 DAS,

followed by treatment CTR (33.89%) and MT (33.45%). Whereas, treatment ZT (32.18%) recorded the lowest WCE, being numerically close to the values observed with treatment ZTR (32.43%) and MTR (32.79). At 40 DAS, treatment CTR (52.75%) recorded the highest weed control efficiency, followed by treatment ZT (49.43%) and ZTR (49.43%). Treatment MTR (45.86%) Recorded the lowest weed control efficiency at par with treatment CT (47.99%). Remaining treatment recorded the intermediate trend.

Effect of weed management

Data pertaining to the effect of various weed management treatment on weed control efficiency are represented in Table 6. The treatment RH (82.78%) recorded the significantly highest WCE over treatment HHW (17.14%). It is due to the effect of pre emergence herbicide at 20 DAS. At 40 DAS Treatment HHW (74.94%) recorded the highest WCE over remaining treatment RH (72.02%). These results are conformity with the finding of Patra and Nayak (2001) [8], Sasikala *et al*. (2004) [9], Kumar *et al*. (2013) [4].

Table 1: Weed dry matter (g) m^{-2} in soybean field as influenced by various tillage practices

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
A) Tillage management					
CT	37.98	36.29	74.07	99.20	119.20
CTR	37.73	34.72	67.60	82.91	102.91
MT	40.55	47.63	91.71	92.11	123.12
MTR	41.16	34.48	72.57	84.92	104.92
ZT	43.89	43.47	92.91	122.54	142.54
ZTR	42.21	43.47	79.23	109.30	129.30
SE (m)+-	1.32	1.41	1.89	2.68	2.69
CD at 5%	3.79	4.04	5.43	7.70	7.72
B) Weed management					
RH	10.55	21.64	44.79	55.27	75.27
HHW	50.34	19.31	32.23	41.07	61.07
UW	60.87	79.08	162.02	199.16	224.66
SE (m)+-	0.93	0.99	1.34	1.89	1.90
CD at 5%	2.68	2.86	3.84	5.44	5.46
Interaction (AxB)					
SE (m)+-	2.28	2.44	3.27	4.64	4.65
CD at 5%	NS	7.00	9.41	13.33	13.37
GM	40.59	40.01	79.68	98.50	120.33

Table 2: Weed dry matter (g) m^{-2} as affected by interaction of various tillage and weed management practices at 40 DAS

Treatment	CT	CTR	MT	MTR	ZT	ZTR
RH	20	19	22	21	68	65
HHW	19	17	20	18	37	35
UW	70	67	101	64	86	86
SE (m)+			2.436			
CD at 5%			7.001			

Table 3: Weed dry matter (g) m^{-2} as affected by interaction of various tillage and weed management practices at 60 DAS

Treatment	CT	CTR	MT	MTR	ZT	ZTR
RH	40	33	50	39	61	45
HHW	30	20	35	33	41	34
UW	152	149	190	146	177	158
SE (m)+-			3.275			
CD at 5%			9.411			

Table 4: Weed dry matter (g) m^{-2} as affected by interaction of various tillage and weed management practices at 80 DAS

Treatment	CT	CTR	MT	MTR	ZT	ZTR
RH	50	49	63	57	60	53
HHW	38	24	45	36	56	45
UW	210	173	168	162	252	230
SE (m)+-			4.640			
CD at 5%			13.334			

Table 5: Weed dry matter (g) m^{-2} as affected by interaction of various tillage and weed management practices at harvest

Treatment	CT	CTR	MT	MTR	ZT	ZTR
RH	69.53	69.30	83.33	76.93	79.57	72.97
HHW	59.17	36.70	64.67	56.00	75.73	65.13
UW	229.90	192.73	221.37	181.83	272.33	249.80
SE (m)+-			4.653			
CD at 5%			13.372			

Table 6: Weed control efficiency (%) as influenced by various tillage practices

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
A) Tillage management					
CT	35.09	47.99	51.31	51.98	47.56
CTR	33.89	52.74	54.75	52.65	48.07
MT	33.45	48.47	51.70	45.28	44.34
MTR	32.79	45.86	50.26	47.54	42.30
ZT	32.18	49.43	47.34	51.42	47.64
ZTR	32.43	49.43	49.84	52.43	48.23
B) Weed management					
RH	82.78	72.02	72.49	71.37	65.84
HHW	17.14	74.94	80.11	79.28	72.74
UW	0.00	0.00	0.00	0.00	0.00
GM	33.31	48.99	50.87	50.22	46.19

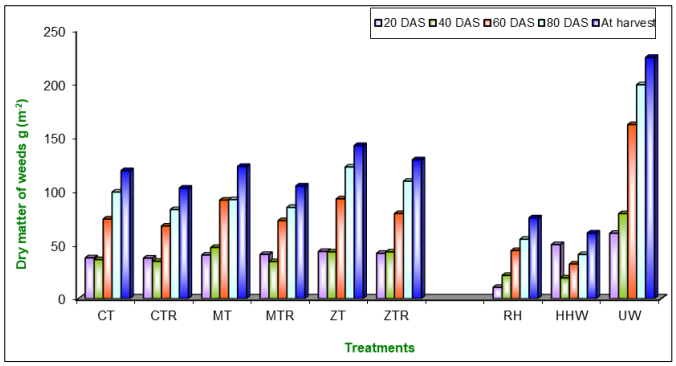

Fig 1: Dry matter of weeds (g) m^{-2} on soybean field as influenced by various tillage practices

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 7 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) reported the highest seed yield in tillage treatment of mouldboard plough plus rotavator. Blecharczyk *et al*. (1999) 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) [12], Ahmad *et al*. (2010) [1] and Meena *et al*. (2011) [6].

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 7: 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 8: 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 9: 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 10: 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.

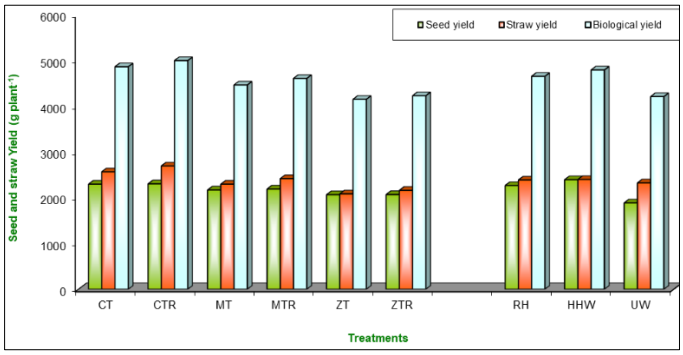

Fig 2: Seed and straw yield (kg ha^{-1}) of soybean as affected by various tillage practices

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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