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RESEARCH ARTICLE

Effect of different tillage and weed management treatments on growth and yield of soybean

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ABSTRACT

A field experiment was conducted, during 2019-20 to 2021-22 at Akola, Maharashtra to study the effect of tillage (conventional, reduced, minimum and zero tillage) and herbicides (diclosulam, propaquizafop + imazethapyr, farmers practice and weedy check) on soybean productivity. The total weed biomass and soybean yield were significantly influenced by various tillage practices at all stages of crop growth. Conventional tillage recorded statistically significant minimum weed biomass, higher number of soybean pods/plant, soybean seed weight/m^2, soybean grain yield/ha and economic returns than rest of the tillage treatments. The next best response was recorded with reduced tillage followed by minimum tillage. The zero tillage recorded the highest weed biomass. Amongst herbicidal treatments tested, minimum weed biomass, maximum soybean yield and economic benefit was recorded with pre-emergence application (PE) of diclosulam 0.026 kg/ha followed by (*fb*) post-emergence application of (PoE) propaquizafop + imazethapyr 0.125 kg/ha.

Keywords: Diclosulam, Economics, Propaquizafop + imazethapyr, Soybean, Tillage, Weed management

INTRODUCTION

Soybean (*Glycine max* L.) is one of the important oilseeds as well as a leguminous crop. The area covered under soybean in India during the year 2024 was 13.50 M ha which produced 12.58 MT with productivity of 930 kg/ha. In Maharashtra the area under soybean cultivation was 51.59 lakh ha with a production of 84.38 lakh tonnes of soybean grains and productivity of 1635 kg/ha (www.krishi.maha.gov.in). It is an excellent source of protein and oil besides it contains high level of amino acids such as lysine, lucien, lecithin. Soybean contains approximately 40-45% protein and 18-22% oil and is a rich source of vitamins and minerals. Soybean contain40-45% protein hence called as the “Poor man’s meat”.

Tillage helps to prepare an appropriate seedbed for crop planting, which have several advantages such as loosening soil, regulating the circulation of water and air within the soil, increasing the release of nutrient elements from the soil for crop growth, and controlling weeds by burying weed seeds and emerged seedlings (Reicosky and Allmaras 2003). Conservation tillage techniques save time, energy, money and also help in improving the soil carbon status (Erenstein and Laxmi 2008). Assessing tillage’s impact on soybean yields has been complicated by inconsistent weed control practices, often leading to lower yields in no-till systems compared to conventional tillage due to weed competition. Thus, adequate weed management is equally essential as tillage to realize optimal soybean yield. The tillage experiments are site specific and yield results are often non-repeatable even under the same soil conditions. While tillage changes soil characteristics, the effects are usually not of the magnitude to significantly affect emergence and early plant growth in experimental plots. The practical feasibility of the tillage practice would play a major role when it comes to disseminate the technology to farmer’s field. Hence, identifying appropriate tillage and weed management practices will certainly be beneficial to the stakeholders of this region for sustainable soybean production. Therefore, an experiment was conducted to study the impact of both tillage and weed management practices on weeds and the productivity of soybean.

MATERIALS AND METHODS

The experiment was conducted at All India Coordinated Research Project (AICRP) on Weed Management, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2019-20 to 2021-22. Akola is situated in the Sub-tropical zone at the latitude of 22^{0}42’ North longitude of 77^0 02’ East. The altitude of the place is 307.41 meter above mean sea level. The

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soil of experimental plot was medium deep black with fairly uniform and leveled topography with slightly alkaline in reaction with medium status of organic carbon content, available nitrogen and phosphorous and fairly rich status of available potassium. The climate of Akola is semi-arid and characterized by three distinct season *viz.,* hot and dry summer from March to May, warm and rainy monsoon from June to October. Total rainfall of 774.1 mm was recorded during the crop growing season. Four tillage treatments were in main plots viz., conventional tillage (CT) – ploughing twice with harrowing tyne cultivator + harrowing with blade harrow; reduced tillage (RT) - harrowing with tyne cultivator + rototill; minimum tillage (MT) - rototill (rotavator) and zero tillage. The sub-plot treatments were five weed management practices viz; pre-emergence application (PE) of diclosulam 0.026 kg/ha; post-emergence application (PoE) of propaquizafop + imazethapyr 0.125 kg/ha at 15 days after seeding (DAS); diclosulam 0.026 kg/ha PE followed by (*fb)* propaquizafop + imazethapyr 0.125 kg/ha PoE at 30 DAS; weed free (hoeing twice 15 and 30 DAS + 1 hand weeding (HW) 20 DAS; and weedy check. The gross plot size of the sub plot was 70 m^2, while the gross plot size of the main plot was 3500 m^2. The soybean variety AMS 1001 during *Kharif* (June to October) was sown at row to row spacing of 45 cm and 20 cm. The application of herbicides was done as per the treatments with manually operated knapsack sprayer attached with a flat fan nozzle. The recommended practice of fertilizers application was followed to both the crops. The N, P and K were given in the form of urea, single super phosphate and muriate of potash, respectively in soybean 30:75:30 N, P and K kg/ha. Standard procedures were adopted to collect the data of recorded parameters. The data recorded for different characters in this study were analyzed by following analysis of variance procedure as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Weed flora

The major weed flora during *Kharif* season in soybean in the experimental field composed of *Cyperus rotundus, Commelina benghalensis, Euphorbia geniculate, Boerhavia diffusa, Parthenium hysterophorus, Phyllanthus niruri, Portulaca oleracea, Cynodon dactylon, Dinebra arabica, Digera arvensis, Amaranthus viridis, Euphorbia hirta, Abutilon indicum, Abelmoschus moschatus, Ageratum conyzoides, Alternanthera triandra, Panicum* spp., *Ischaemum pilosum*, *Digitaria sanguinalis, etc.* Both broad- and narrow-leaved weeds were observed.

Weed biomass and weed indices

The weed dry matter (weed biomass) was significantly influenced by various tillage practices. At 20 DAS, significantly lowest weed biomass was recorded with conventional tillage which was followed by reduced tillage and minimum tillage. The zero tillage recorded the highest weed biomass. At 40 DAS, the treatment of conventional tillage registered significantly lowest weed biomass and conversely, zero tillage treatment recorded highest weed biomass. Highest weed control efficiency was recorded in treatment of conventional tillage followed by minimum tillage. In this study, zero tillage showed the lowest weed control efficiency and the highest weed index, while conventional tillage demonstrated the lowest weed index, followed by reduced tillage.

Amongst herbicide treatment, the lowest weed biomass was observed with diclosulam 0.026 kg/ha PE up to 20 DAS, as diclosulam application resulted in better weed control at initial stage by inhibiting weed seed germination and seedling development. The pre-emergence herbicide shows its efficacy up to 20 DAS. However, diclosulam 0.026 kg/ha PE *fb* propaquizafop + imazethapyr 0.125 kg/ha PoE showed its superiority by recording least weed biomass. Maximum weed control efficiency and lowest index were noted with weed free where hoeing and hand weeding practices were carried out and found statistically superior at all the growth stages. The second-best treatment was diclosulam 0.026 kg/ha as PE *fb* propaquizafop + imazethapyr 0.125 kg/ha as PoE.

Soybean yield and yield attributes

Conventional tillage proved significantly superior in number of pods, weight of seed per m^2, test weight and seed yield than all the treatments due to maximum depth of tillage operation which resulted in highest root proliferation and subsequently easy availability of moisture and nutrients. Monsefi (2009) reported that the yield attributes in soybean was significantly influenced by the tillage and crop establishment treatments and maximum for these traits were recorded in conventional tillage than zero tillage. The second-best treatment was reduced tillage which was recorded significantly higher yield than minimum tillage and zero tillage. The lower seed yield with treatments of minimum tillage (consisting only one rototill) and zero tillage (no tillage) where the soil was undisturbed could be attributed to the inferior value of plant growth and yield attributing characters.

It indicates that soybean plants did not respond well to shallow tillage. Soybean grown in a conventional tillage system has yield advantage over soybean grown in a reduced, minimum and no-tillage system. The results are in agreement with Guy and Oplinger, (1989) and Singh *et al.* (1998).

Weed free treatment recorded significantly higher number of pods/plant, weight of seed/m^2, maximum test weight, seed yield over rest of the herbicidal treatments which in turn was found at par with treatment diclosulam 0.026 kg/ha PE *fb* propaquizafop + imazethapyr 0.125 kg/ha PoE. Weedy check showed lowest number of pods/plant. These treatments remain significantly superior over treatments diclosulam 0.026 kg/ha PE and propaquizafop + imazethapyr 0.125 kg/ha PoE. Weed check treatment recorded lowest number of pods/plant, test weight and seed yield than herbicidal treatments. The similar result was recorded with Susmita Panda *et al.* (2015) and Rajkumari *et al.* (2015).

Economics

Conventional tillage treatment, due to its consistency in improving the soil characteristics, provided an ideal ground for prolific crop growth, which ultimately triggered the yield potential of

Table 1. Weed biomass, weed control efficiency and weed index as influenced by various tillage and weed management treatments in soybean (mean of 3 years)

Treatment	Weed biomass (g/m^2)			Weed control efficiency (%)			Weed index (%)
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	
Main plot- tillage							
Conventional tillage (1 Plo + 2 Hr by Tc + 1 Hr by Bd)	16.9(4.17)	27.5(5.30)	34.8(5.94)	64.88	60.28	55.44	5.70
Reduced tillage (1Hr by Tc +1 rototill)	20.7(4.60)	34.2(5.89)	42.2(6.54)	56.92	50.65	45.95	16.37
Minimum tillage (1 rototill)	26.9(5.23)	41.3(6.47)	49.7(7.08)	44.00	40.45	36.41	24.10
Zero tillage (no tillage)	36.2(6.06)	49.8(7.10)	57.8(7.64)	24.59	28.13	25.96	39.31
LSD (p=0.05)	0.24	0.25	0.28	--	--	--	--
Sub plot- weed management							
Diclosulam 0.026 kg/ha PE	20.5(4.58)	46.6(6.86)	59.4(7.74)	57.32	32.80	23.97	28.39
Propaquizafop + imazethapyr 0.125 kg/ha PoE upto 15 DAS	33.9(5.86)	44.3	54.3	29.47	36.19	30.54	21.55
Diclosulam 0.026 kg/ha PE *fb* propaquizafop + imazethapyr 0.125 kg/ha PoE up to 30 DAS	16.6(4.13)	30.3(5.55)	40.0(6.37)	65.53	56.36	48.76	7.96
Weed free (2 hoeing at 15 and 30 DAS + 1 hand weeding at 20 DAS)	4.2(2.18)	5.5(2.45)	5.1(2.36)	91.15	92.08	93.52	0.00
Weedy check	48.0(6.97)	69.4(8.36)	78.1(8.87)	0.00	0.00	0.00	48.20
LSD (p=0.05)	0.12	0.18	0.25	--	--	--	--
Interaction(A×B)							
LSD (p=0.05)	0.05	0.05	0.07	--	--	--	--

Data are subjected to square root transformation ($\sqrt{x + 0.5}$) and original data presented in parentheses; Plo –Ploughing; Hr- Harrow; Tc- Tyne cultivator; Bd- Blade; PE= pre-emergence application; PoE= post-emergence application; DAS= days after seeding

Table 2. Number of pods/ plants, seed weight/m^2, test weight and seed yield of soybean as influenced by various tillage and weed management treatments (mean of 3 years)

Treatment	No. of pods/ plant	Seed weight/m^2 (g)	Test weight (g)	Seed yield (kg/ha)
Main plot- tillage				
Conventional tillage (1 Plo +2 Hr by Tc +1Hr by Bd)	40.48	445	13.36	2414
Reduced tillage (1Hr by Tc +1 rototill)	37.32	406	12.87	2138
Minimum tillage (1 rototill)	35.31	374	11.92	1941
Zero Tillage (no tillage)	30.12	327	10.92	1532
LSD (p=0.05)	2.42	11.51	0.48	186
Sub plot- weed management				
Diclosulam 0.026 kg/ha PE	32.26	403	11.82	1828
Propaquizafop + imazethapyr 0.125 kg/ha 15 DAS	36.76	352	12.13	2007
Diclosulam 0.026 kg/ha PE *fb* propaquizafop + imazethapyr 0.125 kg/ha PoE 30 DAS	42.22	426	12.38	2357
Weed free (2 hoeing 15 and 30 DAS + 1 hand weeding 20 DAS)	44.19	455	12.89	2612
Weedy check	22.59	304	10.38	1287
LSD (p=0.05)	3.05	7.26	0.40	185
Interaction (A× B)				
LSD (p=0.05)	NS	15.62	NS	NS

Plo –Ploughing; Hr- Harrow; Tc- Tyne cultivator; Bd- Blade; PE= pre-emergence application; PoE= post-emergence application; DAS= days after seeding

Table 3. Economics of soybean as influenced by different tillage and weed management treatments (mean of 3 years)

Treatment	Gross monetary returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net monetary returns (Rs/ha)	Benefit Cost ratio
Main plot- tillage management				
Conventional tillage (1 ploughing +2 Hr by Tc +1Hr by Bd)	95353	42820	52533	2.23
Reduced tillage (1Hr by Tc +1 rototill)	84451	39257	45194	2.15
Minimum tillage (1 rototill)	76670	37502	39168	2.04
Zero tillage (no tillage)	60514	34604	25910	1.75
LSD (p=0.05)	2905	--	2905	--
Sub plot- weed management				
Diclosulam 0.026 kg/ha PE	72206	37409	34797	1.93
Propaquizafop + imazethapyr 0.125 kg/ha PoE 15 DAS	79277	37915	41361	2.09
Diclosulam 0.026 kg/ha PE *fb* propaquizafop + imazethapyr 0.125 kg/ha PoE 30 DAS	93102	39960	53141	2.33
Weed free (2 hoeing 15 and 30 DAS + 1 hand weeding 20 DAS)	103174	42814	60360	2.41
Weedy check	50837	34630	16206	1.47
LSD (p=0.05)	2163	--	2163	--
Interaction (AXB)				
LSD (p=0.05)	4586	--	4586	--

Plo –Ploughing; Hr- Harrow; Tc- Tyne cultivator; Bd- Blade; PE= pre-emergence application; PoE= post-emergence application; DAS= days after seeding

soybean, and subsequently offered highest economic return as compared to the input cost incurred towards cultivating this crop; which had reflected in obtaining the highest gross monetory return (GMR) and net monetory return (NMR) both being statistically similar with each other; as a result of its higher productivity owing to better soil and plant characters, as observed throughout the investigational period. It was followed by treatments minimum tillage and significantly lowest GMR and NMR was recorded with zero tillage could be ascribed to its lower productivity as compared to cost of cultivation. Even after undertaking the intensive tillage with expensive operation of deep tillage through tyne harrow, blade harrow and planking, the greater B:C value was observed with reduced and minimum tillage and proved marginally superior over conventional tillage. The zero tillage, recorded lowest B:C (1.96).

Among various weed management treatments, the highest return and maximum B:C was noticed with treatment weed free as a result of more productivity and best weed management through cultural practices as observed throughout the study period, which was closely followed by treatment diclosulam 0.026 kg/ha PE *fb* propaquizafop + imazethapyr 0.125 kg/ha up to 30 DAS where sequential application of PE and PoE herbicides were done and lowest return was recorded with treatment weedy check. Weedy check recorded the minimum B:C. Similarly, Chaudhari *et al.* (2020) also reported the higher net returns with application of imazethapyr + propaquizafop 125 kg/ha PoE in soybean.

It was concluded that in swell and shrink type of soils use of conventional tillage practices i.e. ploughing+ two harrowing by tyne harrows + a blade harrow or reduced tillage *i.e.* 1 harrow by tyne cultivator + 1 rototill in soybean was found optimum. The sequential application of diclosulam 0.026 kg/ha PE *fb* propaquizafop + imazethapyr 0.125 kg/ha PoE at 30 DAS was found effective in managing weeds and increasing yield as well as economic returns in soybean.

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