Biological Forum – An International Journal **14(2): 820-823(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Influence of Conservation Tillage on Growth, Productivity, and Production Economics of Soybean under the Semi-arid Climate of the Vidarbha Region

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(Received 09 March 2022, Accepted 05 May, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: A field experiment was conducted at Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the *Kharif* season of 2018-19, to determine the performance of soybean under conservation tillage. Conservation tillage provides an excellent opportunity to reduce the degradation of soil reserve and increase soil productivity. Five tillage treatments were replicated three times in the main plot under a split-plot design with integrated nutrient management in the subplot. The tillage treatments were constituted of Conservation tillage (1 harrowing by tractor-mounted blade harrow before sowing), Minimum Tillage (1 tyne harrow + 1 blade harrow), Subsoil Tillage (1 Subsoiler + 1 tyne harrow + 1 rotavator), Conventional Tillage (1 ploughing + 2 tyne harrowing + 1 blade harrow), Roto Tillage (1 tyne harrow + 1 rotavator). Results revealed that among different tillage practices, significant improvement in plant growth parameters and soybean seed yield was recorded with the treatment of subsoil tillage (ST) (1 Subsoiler + 1 tyne harrow + 1 rotavator). ST posed a great impact than other treatments in respect of grain yield (2219 Kg ha^{-1}), and straw yield (2265 Kg ha^{-1}) Tillage treatment ST attended the greatest biological yield (4684 Kg ha^{-1}) with the greatest index for harvest (47.37%) ensures higher economic productivity from the tillage system imposed. Therefore conservation tillage could be suggested in lower water availability to improve Soybean production as it was associated with higher economic return for the farmers of the Vidarbha region, Maharashtra.

Keywords: Conservation agriculture, Conventional tillage, Economic productivity, Minimum tillage.

INTRODUCTION

Soybean (*Glycine max* L. Merril) is the most important seed legume on the planet, accounting for 25% of all edible oil and two-thirds of all protein concentrate for livestock feed. Soybean meal is an essential component of formulated poultry and fish meals. It is a good source of protein and oil, and it also has a lot of amino acids like lysine, leucine, lecithin, and a lot of phosphorous. Soybeans are high in vitamins and minerals and contain around 40-45 percent protein and 18-22 percent oil. Soybean is known as the "golden bean" because of its many applications. Soybean is the world's top crop for producing vegetable oil (Khare *et al*., 2016). Soybean yields are falling, raising concerns about the sustainability of soybean-based farming systems. Tillage procedures have a distinctive role in the appropriate recycling of organic waste, depending on the situation. Because tillage affects infiltration, runoff, evaporation, and soil water storage, it can affect soil moisture status. With traditional tillage, weeds that compete with crops for moisture and other growth factors are manually eliminated. On the other side, poor residue cover, higher runoff, and lower water penetration may all contribute to drought stress. Several workers have said that high soybean yields may be attained by lowering tillage costs by using minimal tillage, which entails simply tilling the soil once with a light harrow for ease of seeding. In the Vidharbha area of Maharashtra, India, however, little information on the benefits of conservation tillage has been recorded. This article aims to investigate the impact of conservation tillage methods on Soybean growth, productivity, and production economics in the Vidharbha area of Maharashtra's semi-arid climate. The current experiment was conducted in light of these considerations.

MATERIAL AND METHODS

During the Kharif season of 2018-19, a field experiment was conducted at the All India Co-ordinated Research Project on Weed Management, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola, which is located at 22°42' North, 77°02' East, and 281.12 meters above mean sea level. The experimental site's soil was clayey in texture, low in organic carbon (0.57 percent), slightly alkaline in nature (pH 7.71), normal in electrical conductivity (0.31 dS/m), and analyzed in low available N (180.37 Kg/ha), medium available P (15.22 Kg/ha), and high available K (369.7 Kg/ha) contents. The climate of is semi-arid, with three different seasons from March to May: hot and dry summer, warm and wet monsoon from June to October, and moderate cold winter from November to February. The south-west monsoon brought the most of the rain from June to October, with an average annual normal precipitation of 740 mm falling over 42.8 wet days (Average of 40 years from 1971 to 2000). Five tillage treatments were replicated three times in the main plot in a split-plot design with integrated nutrient management. Conservation tillage (1 harrowing with a tractor-mounted blade harrow before sowing), Minimum Tillage (1 tyne harrow +1 blade harrow), Subsoil Tillage (1 Subsoiler + 1 tyne harrow + 1 rotavator), Conventional Tillage (1 ploughing + 2 tyne harrowing + 1 blade harrow), Roto Tillage (1 tyne harrow + 1 100 percent RDF, 75 percent RDF Plus FYM (2 t/ha), and 50 percent RDF + FYM (4 t/ha) were used in the integrated nutrition management strategies. The net plot was 6.3m × 9.2m in size. In the Kharif season, soybean (var. JS-335) was sown on July 3rd, 2018. Land preparation for this study was done according to the stated treatments of various tillage methods. T_1(CnT) treatment included 1 harrowing with a tractor-mounted blade harrow before sowing, with an 8-10 cm depth of operation. For T_2 (MT), a Tyne cultivator was used once to prepare the soil, followed by a harrowing with a tractor-mounted blade harrow once to prepare the seedbed at a depth of 15 cm. The maximum depth of operation, 55 to 60 cm, was maintained under T_3 (ST) treatment by utilizing a subsoiler first, then a tyne harrow, and finally a rotavator. One ploughing was done in the T_4 (CvT) treatment, followed by two tyne harrowings and one ploughing with a tractor-mounted blade harrow. The procedure took place at a depth of 23-25 cm. In the T_5 (RT) treatment, a tyne cultivator was first used, followed by a tractor-mounted rotavator, to prepare the seedbed to a 12-15 cm depth. FYM was treated at 2 t ha^{-1} and 4 t ha^{-1} according to different integrated nutrient management strategies just 2 days before planting. Intercultural operations were used to keep the crops weed-free and the soil loose and porous. On the 25^{th} day following seeding, hand weeding was completed. The intercultural operation was carried out by a bullock pulled double pass hoe on the 29th day after sowing. At the time of harvesting, observations on growth attributes such as plant population, plant height, branches/plant, leaf area index, and yield attributes such as number of pods/plant, weight of pods/plant, number of seeds/pod, harvest index, and seed test weight were made. The yields of seed and straw were reported. Economic parameters were then determined. The data collected throughout numerous observations were statistically analyzed. For the significance test, the influence of tillage techniques was investigated using a randomized block design. The given data was interpreted for the outcomes after the analysis (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

Growth attributes. The number of plants was uniform among the treatments both at the time of emergence as well as at the time of harvest. Various tillage treatments posed a significant effect on soybean plant height during all the growth stages. At 20 DAS significantly highest plant height (13.85 cm) was recorded with treatment ST. It was followed by treatment CvT with a plant height of 12.64 cm. Similar results were found by Gurumurthy *et al*. (2008). Treatment ST recorded a significantly maximum no. of branches per plant (7.18), which was at par with treatment CvT (6.99) and significantly superior over the rest of the tillage treatments. Tillage practices significantly influenced the leaf area index at all the crop growth stages. Treatment ST recorded a significantly maximum leaf area index per plant(4.89) which was found to be at par with treatment CvT (4.76) and significantly superior to the rest of the tillage treatments. The number of pods/plants was found to be significantly highest with ST. The total pods/ plant with this treatment were 27.76. Treatments CvT, RT, MT, and CnT were followed by ST. The number of pods with soybean plants under CnT treatment was found to be the lowest. The weight of pods also differed significantly due to various tillage treatments. It was weighed highest i.e. up to 6.94 g/ plant with subsoiling treatment. The next better treatment was that of conventional tillage with the respective values of 5.45 g/ plant. As far as the number of grains per pod is concerned, the influence of tillage was less amplified. Significantly highest grains per pod were noted with both, the very deep (ST) and deep (CvT) tillage treatments, *i.e.* around 2.19 and 2.15 grains per pod. Ozpinar and Ozpinar (2015) observed better growth performance of plants under conservation tillage than in conventional tillage. The remaining tillage practices produced slightly lesser grains per pod, being similar with each other. The most important aspect for obtaining higher grain yield per hectare is the weight of grains/ plant, in which treatment with subsoil tillage out-yielded other treatments.

Table 1: Effect of Conservation tillage on growth, yield, and economics attribute of Soybean.

Tillage practices	Plant population/ Net plot At harvest	Plant height (cm) 80 DAS	Branches/ Plant 80 DAS	LAI	No. of pods/ Plant	Pod wt./ Plant (g)	Seeds/ Pod	Test weight	Straw yield	Seed yield	Harvest index	CoC (Rs/ha)	GMR (Rs/ha)	NMR (Rs/ha)	BCR
CnT	2499	46.04	46.04	4.00	18.26	4.31	4.02	10.61	2085	1709	45.04	34203	59713	25510	1.75
MT	2475	48.82	48.82	4.45	18.56	4.55	4.17	10.72	2142	1790	45.53	34895	62458	27563	1.79
ST	2500	57.23	57.23	4.89	27.76	6.94	5.28	11.22	2465	2219	47.37	36504	77048	40543	2.11
RT	2486	52.47	52.47	4.58	19.07	4.92	4.48	10.87	2259	1935	46.14	34732	67406	32673	1.94
CvT	2502	53.11	53.11	4.76	20.57	5.45	4.83	10.93	2348	2106	47.29	38435	73140	34705	1.90
SE(m)±	11.72	1.29	1.29	0.05	2.08	0.48	0.10	0.09	67	61	--	--	1295	1295	--
CD at 5%	NS	3.82	3.82	0.15	6.23	1.44	0.31	0.26	202	184	--	--	3898	3898	--

The extent of grain weight per plant with this treatment was up to 5.28. It was followed with slightly decreased figures by deep tillage considered the conventional tillage practice (CvT), with grain yield per plant of 4.83 g/ plant. Performance of other treatments was in decreasing order of RT> MT>CnT. As far as test weight is concerned Significantly highest test weight was noted with both, the very deep (ST) and deep (CvT) tillage treatments, i.e. around 11.22 and 10.93 g. CnT performed lowest with 10.61 g of test weight. Increased morphological traits and yield were the outcomes of improved physiological growth (Table.1). Our findings align with earlier research on sunflower growth and production (Sher *et al.,* 2018). According to Wang *et al.* (2017), conservation tillage leads to stable microbial colonies and nutrient conditions, which improve soil characteristics and lead to increased growth and production. In the case of bottle gourd, similar outcomes were observed in terms of enhanced growth and yield under a teak-based Agroforestry system (Imnatemsu *et al.* 2020).

Yield attributes. ST posed a significant impact than other treatments in respect of grain yield (2219 Kg ha^{-1}) and straw yield (2265 Kg ha^{-1}). The subsequent best treatment obviously was that of conventional tillage (CvT) with grain and straw yield of 2106 Kg ha^{-1} and 2348 Kg ha^{-1} respectively. Gurminder *et al.* (2006) and Gurumurthy and Singh (2006) also noticed similar results for plant yield while conducting their experiment under different tillage practices. Tillage treatment ST attended the most significant biological yield (4684 Kg ha^{-1}) compared with remaining tillage practices.

It was at par with conventional tillage (CvT), having a biological yield of 4454 Kg ha^{-1}. Treatment ST with the most significant index for harvest (47.37%) ensures higher economic productivity from the tillage system imposed. The inferior harvest index as obtained with CnT (45.04%) designates the plants' inefficient nutrient supply due to substandard soil physical characteristics.

Economic advantage. A numerical increase in cultivation cost was noted with treatment CvT (38435Rs/ha) might be due to the operation of 1 ploughing+1 blade harrowing + 2 tyne harrowing at the lateral depth of 23-25 cm costing about 1200 Rs/ ha. It was followed by treatment ST (36504 Rs/ha).Visalakshi and Sireesha, (2015) also reported similar results in maize.TreatmentCnT showed the minimum cost of cultivation (34203 Rs/ ha). Among various tillage practices, significant improvement in gross monetary return was noted with treatment ST (77048 Rs/ ha). Next best tillage practice was CvT with GMR of 73140 Rs/ha. The greatest NMR was delivered by treatment ST, by extending it up to the significantly superior figure of 40543 Rs ha^{-1}. It was followed by CvT (34705 Rs/ha). Wasaya *et al.* (2017) looked at the impact of different tillage techniques on soil parameters and found that diverse tilling strategies did not influence soil bulk density or moisture content. Under conservation tillage, this might produce maximum output in Sunflower.

CONCLUSION

It is concluded that from different tillage practices, significant improvement in plant growth parameters and soybean seed yield was recorded with the treatment of subsoil tillage (1 Subsoiler + 1 tyne harrow + 1 rotavator). However, this treatment was statistically similar to that of conventional tillage treatment. Significantly highest gross monetary returns (77048 Rs ha^{-1}) and net monetary returns (40543 Rs. ha^{-1}) were recorded with treatment subsoil tillage (1 Subsoiler + 1 tyne harrow + 1 rotavator). Similarly, the highest benefit-cost ratio of 2.11 was also recorded in subsoiling treatment. Conservation tillage may be recommended for semi-arid climate of the Vidharbha region for higher Soybean productivity.

Conflict of Interest. None.

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How to cite this article: Tapanwita Senapati, M.R. Deshmukh, Bidusi Tripathy and Sandeep Rout (2022). Influence of Conservation Tillage on Growth, Productivity, and Production Economics of Soybean under the Semi-arid Climate of the Vidarbha Region. *Biological Forum – An International Journal, 14*(2): 820-823.