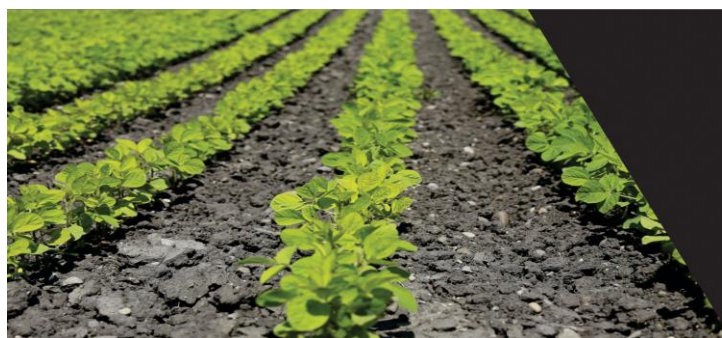




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Impact of conservation tillage on soil fertility and yield of soybean in soybean-chickpea sequence in vertisols

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Abstract

A field experiment was conducted to study the impact of conservation tillage on soil fertility and yield of soybean in soybean-chickpea sequence in Vertisols during *kharif* 2025-26 on an ongoing experiment initiated during 2017-18 at AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The soil of the experimental site was Vertisol, which was moderately alkaline in reaction, low in available nitrogen, medium in available phosphorus, and high in available potassium. The five treatments were replicated four times in a randomized block design comprising conventional tillage with crop residue mulch, conventional tillage without crop residue mulch, reduced tillage with crop residue mulch, zero tillage with crop residue mulch, and permanent BBF with crop residue mulch. The outcome of the study indicated that conservation tillage involving reduced tillage (RT) i.e., broad bed and furrows every year + pre and post emergence herbicide application + crop residue mulch resulted in higher improvement in soil fertility and yield of soybean grown in Vertisols under rainfed conditions.

Keywords: Soybean, conservation tillage, reduced tillage, soil fertility

Introduction

Soybean (*Glycine max* L.) is an important oilseed and food-feed crop cultivated worldwide. It occupies more than 140 million ha globally, with production exceeding 390 million tonnes. Brazil, the USA, Argentina, China, and India are the major soybean-producing countries (FAOSTAT, 2024). In India, soybean is predominantly grown during the *Kharif* season under rainfed conditions. During 2024-25, soybean was cultivated on 126.90 lakh ha, with Maharashtra accounting for 50.72 lakh ha, of which 19.21 lakh ha was under the Vidarbha region. The average soybean productivity in Maharashtra was 1170.13 kg ha⁻¹ (Anonymous, 2025). However, productivity remains affected by variable weather conditions and inadequate agronomic practices, emphasizing the need for improved management strategies.

Conservation agriculture (CA) is a sustainable production approach based on minimum soil disturbance, permanent soil cover, and crop diversification. Reduced and zero tillage, along with crop-residue retention, can improve soil physical, chemical, and biological properties, enhance water and nutrient-use efficiency, reduce erosion and production costs, and sustain crop productivity (Lal, 2015; FAO, 2016). Long-term intensive cultivation and excessive soil disturbance can degrade soil quality by accelerating organic matter decomposition and reducing soil health. In contrast, conservation tillage helps maintain soil organic matter, improve soil structure and biological activity, and enhance long-term soil fertility and productivity [7, 8, 15]. Therefore, evaluating suitable conservation tillage practices under soybean-chickpea cropping systems on Vertisols is essential for improving soil fertility, nutrient uptake, and soybean productivity. The present study was undertaken to assess the effect of conservation tillage on soil fertility, soil biological properties, yield, and nutrient uptake of soybean in a soybean-chickpea sequence on Vertisols, and to examine the relationship between soil properties and soybean yield.

2. Materials and methods

The study was conducted to assess the impact of conservation tillage on soil fertility and yield of soybean in a soybean-chickpea sequence in Vertisols. The field experiment commenced in

2017-18, and the present study was carried out during 2025-26 on the research farm of the Dryland Agriculture Unit, Dr. PDKV, Akola, Maharashtra. The Vertisols of the experimental site were fine, smectitic, hyperthermic family of Typic Haplusterts. Experimental soil was nearly neutral to slightly alkaline in nature pH 7.69, with organic carbon (0.53 g kg^{-1}) and electrical conductivity (0.30 dSm^{-1}); available nitrogen (175.4 kg ha^{-1}) was low, available phosphorus was low (17.9 kg ha^{-1}), available potassium (291.6 kg ha^{-1}) was high, and the soil was sufficient in available micronutrients.

This experiment was laid out in a randomized block design with five treatments and four replications at the research farm of the Dryland Agriculture Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The different treatments were Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowings + One hand weeding + Opening of furrow with hoe in each row at 30-35 DAS + Crop residue mulch (T_1), Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowings + One hand weeding + Opening of furrow with hoe in each row at 30-35 DAS without crop residue mulch (T_2), Reduced tillage (RT) - Broad bed and furrow every year + Pre and post emergence herbicide application + crop residue mulch (T_3), Zero tillage + crop residue mulch (T_4), Permanent BBF with furrow after every 4 rows + crop residue mulch (T_5). The soybean variety JS-9305 was sown in the present investigation. The recommended dose of fertilizers 30: 60: 30 N:P₂O₅:K₂O kg ha^{-1} was used. After harvest of the crop, representative soil samples (0-20 cm) was collected from all the plots. Plot-wise seed and straw yield of soybean was recorded.

3. Results and discussion

3.1 Impact of conservation tillage on chemical properties of soil

The soil pH and EC were significantly differed due to the different tillage treatments (Table 1). The soil pH ranged from 7.63 to 7.69,

indicating that the soil was slightly alkaline in reaction. The lower soil pH (7.63) recorded in the crop residue-incorporated treatments may be attributed to the addition of a substantial amount of organic matter through crop residues. During microbial decomposition, organic acids are released, which contribute to a reduction in soil pH. Furthermore, the added organic matter acts as a pH buffer by releasing H^+ ions, thereby reducing soil alkalinity. The present findings are in agreement with those reported by Kumar *et al.* (2017).

The electrical conductivity varied from 0.24 to 0.29 dS m^{-1} . The lower EC was observed in (T_3) reduced tillage (RT) - broad-bed and furrow every year + pre- and post-emergence herbicide application + crop residue mulch at par with (T_1) Conventional tillage (CT) - ploughing once in 3 years + 2 pre-sowing harrowings + one hand weeding + opening of furrow with hoe in each row at 30-35 DAS + crop residue mulch and the highest EC was observed in (T_4) Zero tillage + crop residue mulch. The present findings are in agreement with those reported by Kumar *et al.* (2017) [12, 14].

The significantly highest organic carbon content (6.68 g kg^{-1}) was observed in reduced tillage (RT) - pre-sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T_3) and was on par with (T_1) conventional tillage with crop residue mulch (6.47 g kg^{-1}). The lowest organic carbon content in soil was observed in conventional tillage with no crop residue mulch (T_2). The increase in organic carbon content in T_3 was 12.83% higher as compared to conventional tillage with no crop residue mulch (T_2). The improvement in organic carbon was due to the direct incorporation of crop residues, which encourages microbial activity in soil and create favorable environment for them which might have resulted in the increased organic carbon content. The findings are in line with the research findings of Moreno *et al.* (2006), Bhattacharya *et al.* (2013), Yadav *et al.* (2014), Hok *et al.* (2015), Ghosh *et al.* (2016), Parihar *et al.* [19, 9, 18, 19, 24].

Table 1: Impact of conservation tillage on chemical properties of soil

Treatment	OC (g kg^{-1})	pH (1:2.5)	EC (ds m^{-1})
T1 Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowing + One hand weeding + Opening of furrow with hoe in each row at 30-35 DAS + Crop residue mulch	6.47	7.66	0.25
T2 Conventional tillage (CT) - ploughing once in 3 years + 2 pre-sowing harrowing + one hand weeding + opening of furrow with hoe in each row at 30-35 DAS + without crop residue mulch	5.92	7.69	0.28
T3 Reduced tillage (RT) - Broad bed and furrow every year + pre- and post-emergence herbicide application + crop residue mulch	6.68	7.63	0.24
T4 Zero tillage + crop residue mulch	6.23	7.68	0.29
T5 Permanent BBF with furrow after every 4 rows + crop residue mulch	6.12	7.65	0.27
SE ($m \pm$)	0.07	0.01	0.01
CD (5%)	0.23	0.04	0.02

3.2 Impact of conservation tillage on soybean yield

The effect of different conservation tillage treatments was significant on seed and straw yield of soybean (Table 2).

The highest seed yield (1807 kg ha^{-1}) was recorded under reduced tillage (RT) with broad bed and furrow (BBF) every year + pre- and post-emergence herbicide application and crop residue mulch (T_3) and was on par with (T_1) Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowing + one hand weeding + Opening of furrow with hoe in each row at 30-35 DAS + without crop residue mulch (1784 kg ha^{-1}). The lowest

soybean seed yield (1380 kg ha^{-1}) was observed in treatment zero tillage + crop residue mulch (T_4). The increase in soybean seed yield in T_3 was 4.57% and 30.90% higher than in conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + no crop residue mulch (T_2) and zero tillage + crop residue (T_4), respectively. The improved yield under reduced tillage with residue mulch may be attributed to better soil moisture conservation, enhanced nutrient availability, improved soil physical conditions and increased microbial activity, which collectively promoted better crop growth and productivity.

Table 2: Impact of conservation tillage on soybean yield

Tr.	Treatment	Seed	Straw
T1	Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowing + one hand weeding + Opening of furrow with hoe in each row at 30-35 DAS + Crop residue mulch	1784.25	1896.25
T2	Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowing + one hand weeding + Opening of furrow	1728.25	1840.25

	with hoe in each row at 30-35 DAS + without crop residue mulch		
T3	Reduced tillage (RT) - Broad bed and furrow every year + pre- and post-emergence herbicide application + crop residue mulch	1806.75	1975.00
T4	Zero tillage + crop residue mulch	1380.25	1492.50
T5	Permanent BBF with furrow after every 4 rows + crop residue mulch	1447.50	1548.50
	SE(m±)	57.3	36.3
	CD (5%)	176.4	111.9

Significantly higher soybean straw yield (1975 kg ha^{-1}) was observed in reduced tillage (RT) - broad-bed and furrow every year + pre- and post-emergence herbicide application + crop residue mulch (T₃) and was on par with treatment T₁, conventional tillage (CT) - Ploughing once in 3 years +2 pre-sowing harrowing + one hand weeding + Opening of furrow with hoe in each row at 30-35 DAS +Crop residue mulch(1896 kg ha^{-1}).The lowest soybean straw yield (1493 kg ha^{-1}) was recorded under zero tillage + crop residue mulch (T₄). The increase in soybean straw yield in reduced tillage (RT) - pre-sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T₃) was 7.33% and 32.28% higher as compared to conventional tillage (CT) - pre-

sowing harrowing + one hoeing + one hand weeding + no crop residue mulch (T₂) and zero tillage + crop residue mulch (T₄),respectively. Higher soybean straw yield in reduced tillage might be due to crop residue incorporation; during the decomposition process, a series of nutrient transformations takes place due to increased microbial activity, which helps in greater nutrient availability to the crops,resulting in higher yield due to higher uptake of nutrients.Blaise *et al.* (2003), Aulakh *et al.* (2012), Singh *et al.* (2014a), Zheng *et al.* (2014), Dixit *et al.* (2015), Sharif *et al.* (2016), Kumar and Paslawar (2017), Basha *et al.* (2018), Age *et al.* (2019),Pooniyaet *et al.* (2021), and Sonuneet *et al.*(2025) [1, 2, 3, 5, 6, 12, 14, 21, 23, 25].

Table 3: Impact of conservation tillage on soil fertility

Treatment	Avai. N (kg ha ⁻¹)	Avai.P (kg ha ⁻¹)	Avai.K (kg ha ⁻¹)
T1Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowing + One hand weeding + Opening of furrow with hoe in each row at 30-35 DAS + Crop residue mulch	191.08	23.05	304.09
T2 Conventional tillage (CT)-ploughing once in 3 years + 2 pre-sowing harrowing + one hand weeding + opening of furrow with hoe in each row at 30-35 DAS + without crop residue mulch	184.38	20.73	299.53
T3 Reduced tillage (RT)-Broad bed and furrow every year + pre- and post-emergence herbicide application +crop residue mulch	194.14	24.26	306.11
T4 Zero tillage + crop residue mulch	186.09	21.79	299.96
T5 PermanentBBF with furrow after every 4 rows + crop residue mulch	188.77	21.59	302.09
SE(m±)	1.16	0.45	0.82
CD (5%)	3.56	1.40	2.54

3.3 Impact of conservation tillage on soil fertility

The available N, P and K was significantly influenced due to the various tillage treatments (Table.3) The significantly highest available N ($194.14 \text{ kg ha}^{-1}$), available P (24.26 kg ha^{-1}) and available K ($306.11 \text{ kg ha}^{-1}$) were observed in treatment T₃reduced tillage (RT) - pre-sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch, which was on par with conventional tillage with crop residue mulch (T₁). The increase in available N content (1.60% and 5.29%), available P content (5.24% and 17.02%), and available K content (0.66% and 2.19%) was recorded in reduced tillage with crop residue mulch (T₃) as compared to treatments T₁ and T₂, respectively. The improvement in available nutrients in reduced tillage with crop residue mulch (T₃) might be due to addition of chickpea crop residue. Crop residue addition has improved the soil physical conditions and microbial activity in the soil. The findings agree with the conclusions drawn byKumar *et al.* (2017), Das *et al.* (2020),Lemanowicz (2011), Kushwa *et al.* (2016), Margenot *et al.* (2017) Hati *et al.*(2014), Kumar *et al.*(2018), Patra *et al.* (2019) [10, 12, 14, 13, 16, 17, 20].

4. Conclusion

From the results of the presentinvestigation, it can be concluded that reduced tillage (RT) - broad-bed and furrow every year + pre- and post-emergence herbicide application + crop residue mulch enhanced nutrient availability and yield of soybean in Vertisols

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