



# Impact of Conservation Tillage on Soil Fertility, Productivity and Nutrient Uptake by Chickpea in Soybean-Chickpea Sequence on Vertisols

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

A field study entitled, impact of conservation tillage on soil fertility, yield and nutrient uptake by chickpea in soybean–chickpea sequence on vertisols was conducted at the research farm of Dryland Agriculture unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, during Rabi 2021–22. The Vertisol of the study area was moderately alkaline in reaction, low in available nitrogen, medium in available phosphorus and high in available potassium. A randomized block design with four replications and five treatments consisted of conventional tillage with crop residue mulch and without crop residue mulch, reduced tillage with crop residue mulch, zero tillage with crop residue mulch, permanent BBF with crop residue mulch. The results indicated the improvement in soil fertility, higher nutrient uptake and yield of chickpea grown in Vertisols under rainfed conditions with reduced tillage and broad bed furrow in conjunction with crop residue mulch and application of pre-emergence herbicide.

*Keywords: Conservation tillage; nutrient uptake; reduced tillage; soil fertility.*

## 1. INTRODUCTION

Throughout ancient times, chickpeas have been grown as one of the oldest pulse cash crops. It is mostly cultivated for grain and green vegetables from September to November during the Rabi season, and harvested in February to April. In India Chickpea is popularly known as “Gram” or “Bengal Gram” or “Chana” or “Egyptian pea”, which belonged to Leguminosae family. It contains 21% protein, 2.2% fat and 62% carbohydrates. It is consumed as vegetable as well as fodder for livestock/animals. Chickpeas are a key source of rabi pulses and are high in dietary iron, niacin, vitamin C, and vitamin B that is easily absorbed. Malic acid, which is found in its leaves, is excellent for treating gastrointestinal problems and purifying blood.

Chickpeas are essential for maintaining soil productivity because they can both fix atmospheric nitrogen and contribute a significant amount of nitrogen to the soil. Known as the poor man's meat, it is also a good source of minerals, vitamins, dietary fiber, carbs, and various bioactive components. It enhances nutrition by serving as a good complement to foods made with cereal. Due to its numerous health advantages, including weight loss, anti-cancer activity, type-2 diabetes prevention, cholesterol control, and weight reduction, chickpeas are becoming more and more popular as functional foods. Crop duration range from 90 to 120 days, depending on the on the variety. It works well in regions with warm to cold temperatures and low to moderate annual rainfall of 600–900 mm.

The top producer of chickpeas is India, which is followed by Pakistan, Iran, and Turkey. Approximately 70% of global output is

contributed by India, which produces between 10 and 11 million tons. During Rabi 2022–23, around 112.01 lakh hectares (276.78 lakh acres) of area in India were covered by chickpea, compared to 114.18 lakh ha (282.14 lakh acres) during the same season in 2021–2022. The top four states in India for chickpea production are Madhya Pradesh (22.08 lakh ha), Rajasthan (21.43 lakh ha), Maharashtra (29.16 lakh ha), and Karnataka (11.84 lakh ha). Government 2<sup>nd</sup> advance estimates state that all India chickpea production in 2022-23 was at 13.63 million tonnes [1]. In Maharashtra, area, production and productivity of chickpea during 2021-22 was estimated as 28.3 lakh ha, 32.8 lakh tonnes and 1156 kg ha<sup>-1</sup> respectively [2].

Conservation tillage maintains permanent soil cover and diversification of plant species, promotes minimum soil disturbance which is essential to maintain minerals within the soil, preventing water loss, stopping erosion from occurring within soil.

Tilling the soil would promote soil mineralization, which would raise soil fertility. Soil organic carbon (SOC) sequestration mostly in surface soil due to conservation tillage practices [3]. A variety of residue management techniques as well as no-till or reduced-tillage methods are included in conservation tillage. It leaves enough crop waste to cover the soil's surface by at least 30%, which improves soil C and N levels, water retention, and potential crop productivity.

## 2. MATERIALS AND METHODS

The study was conducted on impact of conservation tillage on soil fertility, yield and nutrient uptake by chickpea in soybean-chickpea

sequence on Vertisols. The field experiment commenced from 2017-18 and the present study was carried out during 2021-22 on the research farm of Dryland Agriculture unit, Dr. PDKV, Akola, Maharashtra. The Vertisols of experimental site was fine, smectitic, hyperthermic family of Typic Haplusterts. After harvest of chickpea crop the representative soil sampling (0-20 cm) was carried out from all the plots. Experimental soil was nearly neutral to slightly alkaline in nature pH (7.69), with organic carbon (5.3 g kg<sup>-1</sup>) and electrical conductivity (0.30 dSm<sup>-1</sup>), available nitrogen (175.4 kg ha<sup>-1</sup>) was low, available phosphorus was low (17.9 kg ha<sup>-1</sup>), available potassium (291.6 kg ha<sup>-1</sup>) was high and soil was sufficient in available micronutrients.

This experiment was laid out in a randomized block design with five treatments and four replications at research farm of Dryland Agriculture unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The different treatments were Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch (T<sub>1</sub>), Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch (T<sub>2</sub>), Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T<sub>3</sub>), Zero tillage + crop residue mulch (T<sub>4</sub>), Permanent broad bed furrow + pre-emergence herbicide application + crop residue mulch (T<sub>5</sub>). The variety Jaki-9218 was sown in the present investigation. The general recommended dose of fertilizers 20:40:30 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> was used. The plant samples of chickpea straw and seed were collected at harvest of crop and analyzed for nutrient uptake and nutrient content, plot wise chickpea yields and straw yields were recorded.

### 3. RESULTS AND DISCUSSION

#### 3.1 Impact of Conservation Tillage on Chickpea Yield

Among the various treatments, the significantly higher chickpea seed yield (1658 kg ha<sup>-1</sup>) was observed in reduced tillage (RT) - pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T<sub>3</sub>) and was on par with conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch (T<sub>1</sub>). The lowest chickpea seed yield (1330 kg ha<sup>-1</sup>) was observed in treatment zero tillage +

crop residue mulch (T<sub>4</sub>). The increase in chickpea seed yield in T<sub>3</sub> was 10.2% and 24.6% higher as compared to conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch (T<sub>2</sub>) and zero tillage + crop residue (T<sub>4</sub>) respectively.

Higher chickpea straw yield (1902 kg ha<sup>-1</sup>) was observed in reduced tillage (RT) - pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T<sub>3</sub>) and was on par with treatment T<sub>1</sub> i.e. conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch. The lowest chickpea straw yield (1533 kg ha<sup>-1</sup>) was recorded with zero tillage + crop residue mulch (T<sub>4</sub>). The increase in chickpea straw yield in reduced tillage (RT) - pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T<sub>3</sub>) was 15.4% and 24% higher as compared to conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch (T<sub>2</sub>) and zero tillage + crop residue mulch (T<sub>4</sub>) respectively. Higher chickpea yield in reduced tillage might be due to crop residue incorporation, during decomposition process series of nutrient transformation takes place, due to increase in microbial activity that helps in more nutrient availability to the crops that result in higher yield due to higher uptake of nutrients. Similar findings were observed by [4], [5] and [6].

#### 3.2 Impact of Conservation Tillage on Nutrient Uptake by Chickpea

Significantly higher total N(74.76 kg ha<sup>-1</sup>), P(15.24 kg ha<sup>-1</sup>) and K uptake (33.97 kg ha<sup>-1</sup>) by chickpea was recorded in reduced tillage with crop residue mulch (T<sub>3</sub>) and N and P uptake was on par with conventional tillage with crop residue mulch (T<sub>1</sub>). The increase in total N, P and K uptake by chickpea was 15%, 19.90% and 18.15% respectively in treatment T<sub>3</sub> as compared to conventional tillage without crop residue mulch (T<sub>2</sub>), whereas the increase in total N, P and K uptake by chickpea was 40%, 75.77% and 44.92% respectively in treatment T<sub>3</sub> as compared to treatment zero tillage with crop residue mulch (T<sub>4</sub>). The highest nutrient uptake in reduced tillage is due to decomposition of crop residue which increases microbial activity which in turn help in mineralization and slow release of nutrients to chickpea crop resulting in higher uptake of nutrients. The similar observations were also recorded by [7] and [4].

**Table 1. Impact of conservation tillage on chickpea yield**

Treatments	Chickpea yield (kg ha <sup>-1</sup> )	
	Seed	Straw
T <sub>1</sub> Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch	1594	1773
T <sub>2</sub> Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch	1504	1647
T <sub>3</sub> Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch	1658	1902
T <sub>4</sub> Zero tillage + crop residue mulch	1330	1533
T <sub>5</sub> Permanent broad bed furrow + pre-emergence herbicide application + crop residue mulch	1386	1570
SE(m±)	24.06	27.95
CD (5%)	74.95	87.08

**Table 2. Impact of conservation tillage on nutrient uptake by chickpea**

Treatments	Total nutrient uptake (kg ha <sup>-1</sup> )		
	N	P	K
T <sub>1</sub> Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch	71.23	15.24	31.84
T <sub>2</sub> Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch	64.99	12.71	28.75
T <sub>3</sub> Reduced tillage (RT)- Pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch	74.76	15.24	33.97
T <sub>4</sub> Zero tillage + crop residue mulch	53.14	8.67	23.44
T <sub>5</sub> Permanent Broad bed furrow + Pre-emergence herbicide application + crop residue mulch	57.01	11.40	27.07
SE(m±)	1.19	0.36	0.67
CD (5%)	3.65	1.10	2.07

**Table 3. Impact of conservation tillage on physical and chemical properties of soil**

Treatments	Physical properties		Chemical properties		
	Bulk density (Mg m <sup>-3</sup> )	Hydraulic Conductivity (cm hr <sup>-1</sup> )	pH (1:2.5)	EC (dSm <sup>-1</sup> )	Organic carbon (g kg <sup>-1</sup> )
T <sub>1</sub> Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch	1.41	0.83	7.62	0.26	6.09
T <sub>2</sub> Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch	1.43	0.82	7.65	0.28	5.56
T <sub>3</sub> Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch	1.40	0.86	7.59	0.25	6.17
T <sub>4</sub> Zero tillage + crop residue mulch	1.45	0.78	7.64	0.28	5.79
T <sub>5</sub> Permanent broad bed furrow + pre-emergence herbicide application + crop residue mulch	1.44	0.82	7.61	0.26	5.78
SE(m±)	0.01	0.01	0.01	0.01	0.07
CD (5%)	0.03	0.03	0.03	0.02	0.20

**Table 4. Impact of conservation tillage on available nutrients in soil**

Treatments	Available nutrients (kg ha <sup>-1</sup> )		
	N	P	K
T <sub>1</sub> Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch	186.06	21.13	300.20
T <sub>2</sub> Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch	180.95	18.73	296.48
T <sub>3</sub> Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch	187.29	21.96	301.49
T <sub>4</sub> Zero tillage + crop residue mulch	182.40	19.94	297.20
T <sub>5</sub> Permanent Broad bed furrow + Pre-emergence herbicide application + crop residue mulch	184.03	20.11	298.61
SE(m±)	0.69	0.38	0.63
CD (5%)	2.14	1.16	1.94

### 3.3 Impact of conservation Tillage on Properties of Soil

The bulk density of soil was influenced by various treatments and it ranged from 1.40 to 1.45 Mg m<sup>-3</sup>. The significantly lowest (1.40 Mg m<sup>-3</sup>) BD was observed in reduced tillage with crop residue mulch (T<sub>3</sub>) and was on par with treatments T<sub>2</sub> and T<sub>5</sub>. The treatment T<sub>4</sub> i.e. zero tillage with crop residue mulch recorded the higher value of bulk density (1.45 Mg m<sup>-3</sup>). The similar findings were obtained by [8], [9] and [10]. The soil's hydraulic conductivity varied from 0.78 to 0.86 cm hr<sup>-1</sup>. Reduced tillage with crop residue mulch (T<sub>3</sub>) had the highest hydraulic conductivity (0.86 cm hr<sup>-1</sup>), which was on par with conventional tillage with crop residue mulch (T<sub>1</sub>). Hydraulic conductivity was found to be lower (0.78 cm hr<sup>-1</sup>) in treatment (T<sub>4</sub>), i.e. zero tillage with crop residue mulch. The findings align with the conclusions stated by [11].

The soil ranged from 7.59 to 7.65 in pH while EC ranged between 0.25 to 0.28 dSm<sup>-1</sup>, that means soil was slightly alkaline in reaction and EC limits were safer for the crop growth and development. Lower pH (7.59) and electrical conductivity (0.25 dS m<sup>-1</sup>) was recorded in reduced tillage with crop residue mulch (T<sub>3</sub>). Further, it was observed that, all the treatments where crop residue was retained except T<sub>2</sub>, had lower values of soil pH and EC. The results are in conformity with the findings of [12].

Highest organic carbon content (6.17 g kg<sup>-1</sup>) was observed in reduced tillage with crop residue mulch (T<sub>3</sub>) and was on par with conventional tillage with crop residue mulch T<sub>1</sub> (6.09 g kg<sup>-1</sup>). Lowest organic carbon content in soil was observed in conventional tillage with no crop residue mulch (T<sub>2</sub>). The increase in organic carbon content in T<sub>3</sub> was 10.9% higher as compared to conventional tillage with no crop residue mulch (T<sub>2</sub>). The higher values of organic carbon content is 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 [13], [14] and [15].

### 3.4 Impact of Conservation Tillage on Soil Fertility

Available nutrient status of soil indicated that significantly highest available nitrogen (187.29 kg ha<sup>-1</sup>), available phosphorus (21.96 kg ha<sup>-1</sup>) and available potassium (301.49 kg ha<sup>-1</sup>) were

observed in treatment T<sub>3</sub> (reduced tillage with crop residue mulch) which was on par with conventional tillage with crop residue mulch (T<sub>1</sub>). The increase in available N content (0.66% and 3.50%), available P content (3.9% and 17.2%) and available K content (0.42% and 1.6%) were recorded in reduced tillage with crop residue mulch (T<sub>3</sub>) as compared to treatment T<sub>1</sub> and T<sub>2</sub> respectively. The increase in available nutrients in reduced tillage with crop residue mulch (T<sub>3</sub>) might be due to addition of soybean crop residue. Crop residue addition have improved the soil physical conditions and microbial activity in the soil. The findings agree with the conclusions drawn by [8] and [12].

## 4. CONCLUSION

The findings of study showed that reduced tillage combined with annual broad bed and furrow construction, pre-emergence herbicide treatment, crop residue mulching, and pre-sowing harrowing increased soil fertility, nutrient uptake, and chickpea productivity in Vertisols growing in semiarid environments. Therefore, farmers may benefit from these conservation agriculture techniques to maintain crop output and enhance soil health.

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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