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


**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


**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$^{nd}$ advance estimates state that all India chickpea production in 2022-23 was at 13.63 million tonnes (Anonymous, 2023).

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 (Chambers *et al*., 2016). 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

**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 $kg^{-1}$) 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 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 ($T_1$), Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch ($T_2$), Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch ($T_3$), Zero tillage + crop residue mulch ($T_4$), Permanent broad bed furrow + pre-emergence herbicide application + crop residue mulch ($T_5$). The variety Jaki-9218 was sown in the present investigation. The general recommended dose of fertilizers 20:40:30 N, $P_2O_5$, $K_2O$ kg ha$^{-1}$ 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.

## Results and Discussion

### Impact of conservation tillage on chickpea yield

Among the various treatments, the significantly higher chickpea seed yield (1658 kg ha$^{-1}$) 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 conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch ($T_1$). The lowest chickpea seed yield (1330 kg ha$^{-1}$) was observed in treatment zero tillage + crop residue mulch ($T_4$). The increase in chickpea seed yield in $T_3$ 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 ($T_2$) and zero tillage + crop residue ($T_4$) respectively.

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

| **Treatments** | **Chickpea yield (kg ha$^{-1}$)** | |
|---|---|---|
| | **Seed** | **Straw** |

| | | | |
|---|---|---|---|
| $T_1$ | Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch | 1594 | 1773 |
| $T_2$ | Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch | 1504 | 1647 |
| $T_3$ | Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch | 1658 | 1902 |
| $T_4$ | Zero tillage + crop residue mulch | 1330 | 1533 |
| $T_5$ | 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 |

Higher chickpea straw yield (1902 kg $ha^{-1}$) 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 treatment $T_1$ *i.e.* conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch. The lowest chickpea straw yield (1533 kg $ha^{-1}$) was recorded with zero tillage + crop residue mulch ($T_4$). 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 ($T_3$) was 15.4% and 24% higher as compared to conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch ($T_2$) and zero tillage + crop residue mulch ($T_4$) 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 Age *et al.* (2019), Patode *et al*. (2021) and Singh *et al*. (2022).

**Impact of conservation tillage on nutrient uptake by chickpea**

Significantly higher total N(74.76 kg $ha^{-1}$), P(15.24 kg $ha^{-1}$) and K uptake (33.97 kg $ha^{-1}$) by chickpea was recorded in reduced tillage with crop residue mulch ($T_3$) and N and P uptake was on par with conventional tillage with crop residue mulch ($T_1$). The increase in total N, P and K uptake by chickpea was 15%, 19.90% and 18.15% respectively in treatment $T_3$ as compared to conventional tillage without crop residue mulch ($T_2$), whereas the increase in total N, P and K uptake by chickpea was 40%, 75.77% and 44.92% respectively in treatment $T_3$ as compared to treatment zero tillage with crop residue mulch ($T_4$). 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 Dixit *et al.* (2015) and Age *et al.* (2019).

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

| Treatments | | Total nutrient uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|
| | | N | P | K |
| $T_1$ | Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch | 71.23 | 15.24 | 31.84 |
| $T_2$ | Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch | 64.99 | 12.71 | 28.75 |
| $T_3$ | 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 |
| $T_4$ | Zero tillage + crop residue mulch | 53.14 | 8.67 | 23.44 |
| $T_5$ | 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 |

**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$^{-3}$. The significantly lowest (1.40 Mg m$^{-3}$) BD was observed in reduced tillage with crop residue mulch ($T_3$) and was on par with treatments $T_2$ and $T_5$. The treatment $T_4$ *i.e.* zero tillage with crop residue mulch recorded the higher value of bulk density (1.45 Mg m$^{-3}$). The similar findings were obtained by Das *et al.* (2020), Kumawat *et al.* (2020) and Kumari *et al.* (2021). The soil's hydraulic conductivity varied from 0.78 to 0.86 cm hr$^{-1}$. Reduced tillage with crop residue mulch ($T_3$) had the highest hydraulic conductivity (0.86 cm hr$^{-1}$), which was on par with conventional tillage with crop residue mulch ($T_1$). Hydraulic conductivity was found to be lower (0.78 cm hr $^{-1}$) in treatment ($T_4$), *i.e.* zero tillage with crop residue mulch. The findings align with the conclusions stated by Sharma *et al*. (2016).

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

| Treatments | Physical properties | | Chemical properties | | |
|---|---|---|---|---|---|
| | Bulk density (Mg m$^{-3}$) | Hydraulic conductivity (cm hr$^{-1}$) | pH (1:2.5) | EC (dSm$^{-1}$) | Organic carbon (g kg$^{-1}$) |

| | | | | | | |
|---|---|---|---|---|---|---|
| $T_1$ | Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch | 1.41 | 0.83 | 7.62 | 0.26 | 6.09 |
| $T_2$ | 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 |
| $T_3$ | 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 |
| $T_4$ | Zero tillage + crop residue mulch | 1.45 | 0.78 | 7.64 | 0.28 | 5.79 |
| $T_5$ | 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 |

The soil ranged from 7.59 to 7.65 in pH while EC ranged between 0.25 to 0.28 $dSm^{-1}$, 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 $m^{-1}$) was recorded in reduced tillage with crop residue mulch ($T_3$). Further, it was observed that, all the treatments where crop residue was retained except $T_2$, had lower values of soil pH and EC. The results are in conformity with the findings of Kumar *et al.* (2017).

Highest organic carbon content (6.17 g $kg^{-1}$) was observed in reduced tillage with crop residue mulch ($T_3$) and was on par with conventional tillage with crop residue mulch $T_1$ (6.09 g $kg^{-1}$). 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 10.9% higher as compared to conventional tillage with no crop residue mulch ($T_2$). 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 Kushwa *et al.* (2016), Somasundaram *et al.* (2019) and Naderi *et al.* (2021).

**Impact of conservation tillage on soil fertility**

Available nutrient status of soil indicated that significantly highest available nitrogen (187.29 kg $ha^{-1}$), available phosphorus (21.96 kg $ha^{-1}$) and available potassium

(301.49 kg $ha^{-1}$) were observed in treatment $T_3$ (reduced tillage with crop residue mulch) which was on par with conventional tillage with crop residue mulch ($T_1$). 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 ($T_3$) as compared to treatment $T_1$ and $T_2$ respectively. The increase in available nutrients in reduced tillage with crop residue mulch ($T_3$) 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 Das et al. (2020) and Kumar et al. (2017).

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

| Treatments | | Available nutrients (kg $ha^{-1}$) | | |
|---|---|---|---|---|
| | | **N** | **P** | **K** |
| $T_1$ | Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch | 186.06 | 21.13 | 300.20 |
| $T_2$ | Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch | 180.95 | 18.73 | 296.48 |
| $T_3$ | 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 |
| $T_4$ | Zero tillage + crop residue mulch | 182.40 | 19.94 | 297.20 |
| $T_5$ | 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 |

## 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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