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RESEARCH PAPER

# Effect of Tillage and Weed Management Practices on Yield And Economics of Soybean-Chickpea Cropping System

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## ABSTRACT

The field experiment was conducted at Department of Agronomy, V.N.M.K.V. Parbhani (MS) India during 2017-18 to study the effect of tillage and weed management practices of soybean-chickpea cropping system in vertisol". The experiment was laid out in split plot design with fifteen treatment combinations replicated threes. The result of the study revealed that CT-CT recorded significantly highest seed yield, straw yield and economic yield of soybean-chickpea cropping system compared to other treatments. But at par with CT-ROT practices. Among the weed management practices weed free recorded significantly highest GMR, NMR and B:C ratio but it was at par with adoption pre and post emergence herbicide.

## HIGHLIGHTS

- The excessive tillage not only deteriorates soil structure but also exploits intake amount of farm power energy.
- In semiarid region of India, expensive and energy consuming tillage operations, declining soil fertility and soil moisture limitation are major constraint for agricultural crop production.
- Use of resources conservation tillage techniques, like zero tillage and rotary tillage (RT) is right step in this direction as there technologies save time, energy, money and also help in improving the soil carbon status.

**Keywords:** Soybean, Chickpea, Tillage, Economic, Herbicides, Weed and Yield

Soybean (*Glycine max* (L.) Merrill.), designed as "Golden bean" rich in protein (40%) and moderate in cholesterol free oil (20%) has established its tremendous potential as an industrial vital and useful oilseed crop in India and soybean is a leguminous crop and belongs to family Leguminosae with sub family Papilionideae. It is primarily a pulse crop but gaining importance as an oilseed crop.

Chickpea (*Cicer arietinum* L.) is an annual legume of the family Fabaceae, subfamily Faboideae. Its different types are variously known as Bengal gram or gram, Egyptian pea and Garbanzo bean. It is one of the earliest cultivated legumes and 7500-year-old remains have been found in the Middle East. It is one of the most important *rabi* season pulse crop of Maharashtra. India is largest producer of chickpea in the world, sharing 65 and 70 per cent of total global area and production, respectively.

In semiarid region of India, expensive and energy consuming tillage operations, declining soil fertility and soil moisture limitation are major constraint for agricultural crop production, in *kharif* season crops are dependent of rainwater while *rabi* season crops are dependent on conserved soil moisture (Shiva Dhar *et al.* 2006). Chickpea is important *rabi* season pulse crop of India with drought condition as single most important abiotic constraints of higher

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productivity (Sunil Kumar *et al*. 2006). Tillage is needed to make proper seed-bed, which varies with crop to grow and largely depends upon soil types, nature of previous crop and residue management systems. It includes all operations that are followed for modifying physical properties of soil so as to provide favourable condition. It is estimated that about 30 percent of the total cost of crop production is towards tillage operations.

The excessive tillage not only deteriorates soil structure but also exploits intake amount of farm power energy (fuel and animal draft) and also declining air, water and soil quality, reducing soil disturbance by implementing conservation tillage may improve this situation. Research on zero tillage and minimum tillage has illustrated the greater opportunity to increase soil organic carbon, microbial activity, nutrients and extractable phosphorus due to accumulation of crop residues at the soil surface compared with conventional tillage (CT) (Vu *et al.* 2009). In India, more than 60 percent of total energy utilized for agricultural sector alone. Therefore, energy conservation in agricultural sector is the most important factor. Use of resources conservation tillage techniques, like zero tillage and rotary tillage (RT) is right step in this direction as there technologies save time, energy, money and also help in improving the soil carbon status (Erenstein & Olaf 2008). Altering tillage practices changes weed population dynamics, including weed seed distribution and abundance in the soil seed bank and affects the efficacy of control practices. In the past weeds were the most culprits to reduce the yields in zero tillage (ZT), but availability of pre and post emergence herbicides made it possible to control weeds in zero tillage (ZT) condition.

A sound weed management system is therefore vital for avert losses caused by weeds, amplify input use efficiency and increasing the productivity of the crop. The efficiently and economical weed management in soybean-chickpea crop on large scale is not possible through manual operations and use of mechanical means. Traditional methods of weed control cannot be performed in time due to uncertainty of rains, unworkable soil conditions and higher cost. Non availability of labour further make more noticeable the weed problem. Under these situations, use of herbicides in this crop can be a feasible and effective method of weed control. Poor efficiency of these herbicides in controlling weeds, particularly *Chenopodium album* and other grassy weeds emerging at later stages of crop growth emphasized the need for evaluation of some other new herbicides for effective weed management in soybean-chickpea against complex graminacious and broad-leaved weeds. Of late, the increase emphasis has also been witnessed on the use of the low-dose high-efficacy herbicides capable of controlling mixed flora of weeds. The different tillage practices combined with effective herbicides is needed to identify effective and feasible weed management. Pre and post herbicide weed management method is becoming popular and regarded potentially as one of the most labour saving innovation in modern agriculture.

The integrated use of tillage combined with herbicide can check the loss of these vital inputs to great extent and saving of energy also. The present investigation entitled "Production potential of soybean-chickpea cropping system as influenced by tillage and weed management practices in vertisol"

## MATERIALS AND METHODS

The field experiment was conducted during *kharif,* 2017-18 at Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani(MS). Parbhani located at 190 16' N latitude and 960 41' East longitudes and has sub-tropical climatic conditions. Parbhani is grouped under assured rainfall zone. The normal rainfall of this region is around 954.9 mm, precipitating mostly between mid June-mid Novembers. Parbhani is grouped under assured rainfall zone. The average maximum and minimum temperature recorded 31.2$^{o}$C and 22.6$^{o}$C, respectively. The soil was medium deep black and well drained. The topography of the experimental field was fairly uniform and levelled. The experiment was comprised of a total of fifteen treatment combinations comprising five tillage practices ($T_1$: {CT-CT} Conventional-Conventional tillage, $T_2$ : {CT-RT} Conventional-Reduced tillage, $T_3$: {CT-MT} Conventional-Minimum tillage, $T_4$: {CT-ZT} Conventional-Zero tillage and $T_5$: {CT-ROT} Conventional-Rotary tillage) and three weed management practices ($W_1$: weed free, $W_2$: pre and post emergence herbicide and $W_3$: weedy check) to soybean-chickpea cropping system were assigned in a Split plot Design with three replication. A common dose of 30 kg N $ha^{-1}$, 60 kg $P_2O_5$ $ha^{-1}$ and 30 kg $K_2O$ $ha^{-1}$ through DAP and Urea were applied as basal dose and FYM was also spread uniformly and mixed immediately in the soil before sowing to the all treatment plots.

The soybean-chickpea crop was sown at a spacing of 45 × 5 and 45 × 10 cm on 26 June 2017 and 11 Nov. 2017 harvested on 13 Oct. 2017 and 09 March 2018. The various biometric observations were recorded on five randomly selected plants from net plots, which were tied tags for their easy identification.

## RESULTS AND DISCUSSION

### Soybean

### Tillage practices

Tillage practices recorded non-significant influence on the growth, yield and yield attributes of soybean as well as exerted non-significant effects on evaluation during both the year of study.

### Weed management practices

Among various factors, weed is one of the most important factors responsible for reduction in yield because weeds are silent, malignant, more competitive, self-sown and naturally hardy. Several herbicides have been found effective in controlling weeds therefore, versatility of modern weed control through integration of effective herbicides and traditional methods could be the best option which might be exploited fully so that maximum yield of soybean can be obtained.

### Effect on yield and yield attributes

Improvement in various growth parameters thereby increased photosynthetic efficiency of soybean which led to higher assimilate production and their efficient partitioning to the economic sink. The number of pods increased continuously till maturity. However, increase in number of pods was fast during 60 to 75 days after sowing and slowed down thereafter. At all the stages of crop growth, weed free ($W_1$) recorded the maximum number of pods $plant^{-1}$ than weedy check ($W_3$) and however it was at par with pre and post emergence herbicide ($W_2$). Increase in number of pods $plant^{-1}$ due to proper growth of crop, which might have resulted in greater translocation of food material to the reproductive part, which also reflected towards superiority in yield attributing characters. The increased number of branches and more reproductive growth and conversion of flowers in pods with the support of more conserved soil moisture and nutrients, least competition offered by weeds at peak period of pod initiation might have resulted in increased number of pods $plant^{-1}$ of soybean. The findings are in agreement with the results of Halvankar *et al.* (2005). Similar results also observed by Kurchania *et al*. (2001).

Weight of pods, number and weight of seeds $plant^{-1}$ and seed yield $plant^{-1}$ were closely related with each other and positively correlated with total number of pods per plant. Weight of pods $plant^{-1}$, number and weight of seeds $plant^{-1}$ and seed yield $plant^{-1}$ were the highest when the soybean crop was adopted with weed free treatment ($W_1$) than other weed management i.e. pre and post emergence herbicide and weedy check. The higher growth attributes followed by more synthesis and translocation of food material to the source might have resulted in bold seed size and thus more weight of pods $plant^{-1}$ of soybean. Similar, results were also reported by Singh *and* Jolly (2004).

Weed free ($W_1$) method of weed management had profound effect on seed, straw and biological yield (kg $ha^{-1}$) than weedy check ($W_3$). The increase in seed yield kg $ha^{-1}$ was attributed to increased growth parameters and yield attributes of soybean. This might be owing to better availability of the resources of the soil and soil moisture and also weed free environment after completion of vegetative growth, which contributed for more photosynthesis and translocation of photosynthates towards reproductive organs i.e. from source to sink, which resulted in higher yield of soybean. More favoured overall growth and yield attributing characters may be due to favourable seed bed, better aeration, scope for more space, light interception, benefit of more conserved moisture in weed free environment and its support at critical growth stages like flowering, pod initiation and development of soybean crop. This resulted in higher values of yield attributing characters and which in turn resulted in higher yields of soybean crop. This results correlate with the work of Kamble *et al.* (2017).

**Table 1:** Yield and yield attributes of soybean as influenced by tillage and weed management practices during 2017-18

| Treatments | Weight of pods plant$^{-1}$ (g) | Weight of seed plant$^{-1}$ (g) | Number of seeds plant$^{-1}$ | Number of seed pod$^{-1}$ | Seed index (g) | Seed yield (kg ha$^{-1}$) | Straw yield (kg ha$^{-1}$) | Biological yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| Tillage Practices | | | | | | | | |
| **$T_1$**- CT-CT | 6.19 | 5.68 | 62.77 | 2.67 | 8.31 | 2008 | 2977 | 4985 |
| **$T_2$**- CT-RT | 6.06 | 5.98 | 62.98 | 2.66 | 8.30 | 2021 | 2910 | 4931 |
| **$T_3$**- CT-MT | 6.25 | 5.98 | 62.97 | 2.67 | 8.32 | 2021 | 2902 | 4923 |
| **$T_4$**- CT-ZT | 6.48 | 5.79 | 62.95 | 2.68 | 8.34 | 2017 | 2917 | 4935 |
| **$T_5$**- CT-ROT | 6.14 | 5.76 | 62.99 | 2.64 | 8.36 | 2014 | 2940 | 4954 |
| S.E. ± | 0.11 | 0.13 | 0.87 | 0.17 | 0.48 | 210 | 148 | 348 |
| C.D. at 5% | NS | NS | NS | NS | NS | NS | NS | NS |
| **Weed Management** | | | | | | | | |
| **$W_1$**- Weed free | 7.64 | 7.36 | 73.33 | 2.98 | 8.50 | 2500 | 3419 | 5919 |
| **$W_2$**- Pre & Post emergence herbicides | 7.09 | 6.65 | 70.95 | 2.79 | 8.20 | 2284 | 3213 | 5497 |
| **$W_3$**- Weedy check | 3.93 | 3.50 | 44.51 | 2.21 | 7.80 | 1265 | 2156 | 3421 |
| S.E. ± | 0.32 | 0.33 | 0.81 | 0.23 | 0.23 | 89 | 75 | 157 |
| C.D. at 5% | 0.95 | 0.98 | 2.40 | NS | NS | **264** | **209** | 464 |
| **Interaction** | | | | | | | | |
| T × W | | | | | | | | |
| S.E. ± | 0.65 | 0.74 | 1.82 | 0.53 | 0.53 | 179 | 150 | 315 |
| C.D. at 5% | NS | NS | NS | NS | NS | NS | NS | NS |
| G. M. | 6.22 | 5.84 | 62.93 | 2.66 | 8.33 | 2016 | 2929 | 4945 |

Biological yield was influenced significantly by the weed management. Weed free ($W_1$) treatment recorded significantly higher biological yield of soybean and was remained at par with pre and post emergence herbicide ($W_2$) treatment. Significantly lowest biological yield was observed under weedy check ($W_3$). Similar trend was observed in case of straw yield ha$^{-1}$. The findings are in agreement with results of Renjith and Sharma (2014).

## Economics

Data pertaining to economic studies revealed that weed free treatment recorded higher gross monetary returns than weedy check ($W_3$) in both the years Next best was observed with application of pre and post emergence herbicide which was on par with weed free ($W_1$). The higher gross and net returns were mainly attributed by higher seed yield, obtained due to higher weed control efficiency. The lowest gross and net monetary returns were observed with weedy check which was mainly owing to less seed yield, obtained uncontrolled weeds throughout crop growing period. Dhane *et al.* (2009) also reported similar results with respect to economic studies.

Data perusal regarding B:C ratio, showed that higher B:C ratio, was observed with the application pre and post emergence herbicide than weed free treatment. This might be due to lower cost of cultivation and higher production which resulted higher benefit cost ratio. Manjith Kumar and Angadi (2016) reported the similar kind of results.

## Chickpea

### Yield and yield attributes

### Tillage practices

Improvement in various growth parameters (plant height, leaf area, number of branches and dry matter accumulation plant$^{-1}$) thereby increased photosynthetic efficiency of chickpea which led to higher assimilate production (source) and their efficient partioning to the economic sink i.e. pods and ultimately resulted into more number of pods plant$^{-1}$, weight of seed plant$^{-1}$ (g), weight of pods (g),

**Table 2:** Yield and yield attributes of chickpea as influenced by tillage and weed management practices during 2017- 18

| Treatments | Number of pods plant$^{-1}$ | Weight of pods plant$^{-1}$ (g) | Weight of seed plant$^{-1}$ (g) | Number of seeds pod$^{-1}$ | Test wt. (g) | Seed yield (kg ha$^{-1}$) | Straw yield (kg ha$^{-1}$) | Biological yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **Tillage Practices** | | | | | | | | |
| **$T_1$**- CT-CT | 62.54 | 19.31 | 14.90 | 1.68 | 16.80 | 2304 | 2933 | 5237 |
| **$T_2$**- CT-RT | 59.15 | 17.51 | 13.60 | 1.52 | 16.40 | 1929 | 2695 | 4624 |
| **$T_3$**- CT-MT | 57.16 | 16.89 | 13.11 | 1.48 | 16.31 | 1625 | 2483 | 4108 |
| **$T_4$**- CT-ZT | 56.61 | 16.35 | 12.61 | 1.41 | 16.05 | 1420 | 2280 | 3700 |
| **$T_5$**- CT-ROT | 60.10 | 18.17 | 14.18 | 1.58 | 16.65 | 2168 | 2850 | 5018 |
| S.E. ± | 0.74 | 0.35 | 0.22 | 0.14 | 0.29 | 48 | 37 | 76 |
| C.D. at 5% | 2.44 | 1.14 | 0.72 | **NS** | **NS** | **140** | **110** | 225 |
| Weed Management | | | | | | | | |
| **$W_1$**- Weed free | 71.95 | 21.09 | 17.16 | 1.74 | 16.86 | 2308 | 3054 | 5362 |
| **$W_2$**- Pre & Post emergence herbicides | 67.51 | 19.01 | 16.38 | 1.63 | 16.67 | 2153 | 2895 | 5048 |
| **$W_3$**- Weedy check | 37.86 | 13.99 | 7.49 | 1.23 | 15.79 | 1206 | 1996 | 3202 |
| S.E. ± | 1.55 | 0.35 | 0.27 | 0.67 | 0.41 | 55 | 56 | 109 |
| C.D. at 5% | 4.44 | 1.0 | 0.78 | **NS** | **NS** | **160** | **165** | 321 |
| **Interaction** | | | | | | | | |
| **T × W** | | | | | | | | |
| S.E. ± | 3.48 | 0.78 | 0.61 | 0.14 | 0.92 | 106 | 83 | 170 |
| C.D. at 5% | NS | NS | NS | NS | NS | NS | NS | NS |
| G. M. | 59.11 | 17.68 | 13.68 | 1.53 | 16.44 | 1889 | 2648 | 4537 |

number of seed plant$^{-1}$ and hundred grain weight (g) of chickpea.

Practice of conventional tillage (CT-CT) at 75 DAS recorded more number of pods plant$^{-1}$, than the other treatments but it was at par rotary tillage (CT-ROT) in both year of investigation. Conventional tillage (CT-CT) at 75 DAS recorded higher plant height, number of leaves, leaf area and dry matter ultimately resulted in to better pods exertion and recorded maximum of pods plant$^{-1}$ amongst all tillage practices. This might be due to more number of leaves and leaf area (source) contributed in translocation of assimilates towards developing pods (sink). The results are in agreement with those reported by Dixit *et al.* (2015) and Amanullah *et al.* (2010).

Weight of seeds plant$^{-1}$ and weight of pods plant$^{-1}$ were closely related with each other. Conventional tillage (CT-CT) recorded more seeds and pods weight plant$^{-1}$ followed by rotary tillage (CT-ROT) during both the years. The increase in weight of seeds and pods plant$^{-1}$ was the result of the associated increase in various growth contributing characters *viz*. dry matter accumulation, plant height, number of leaves and leaf area due to increased availability of nutrients in soil, better soil structure, interception of more light and reduction of weed which favoured luxuriant growth and development of crop. Results analogous to this have been reported by Colin and Mustafa (2015). During both the year seeds pod$^{-1}$ and hundred grains weight did not differ significantly due to various tillage practices.

As growth and yield components of chickpea were influenced by both tillage practices in chickpea, improvement in grain and straw yield was observed during both the years and in pooled analysis. The enhancement in grain and straw yield of chickpea could be attributed to cumulative effect of better growth that resulted in better partioning of photosynthates in yield attributes and eventually produced more number of pods plant$^{-1}$, weight of seeds plant$^{-1}$, weight of pods plant$^{-1}$ and hundred grain weights that ultimately increased the yield. Conventional tillage (CT-CT) recorded significantly higher yield due to better seed bed *viz*., better

**Plate 1:** General view of experimental field of chickpea during 2017-18

**Table 3:** Economics of soybean-chickpea as influenced by tillage and weed management practices during 2017-18

| Treatments | Soybean | | | Chickpea | | |
|---|---|---|---|---|---|---|
| | GMR (₹ $ha^{-1}$) | NMR (₹ $ha^{-1}$) | Benefit cost ratio | GMR (₹ $ha^{-1}$) | NMR (₹ $ha^{-1}$) | Benefit cost ratio |
| **Tillage Practices** | | | | | | |
| **$T_1$**- CT-CT | 67333 | 35388 | 2.06 | 76910 | 46693 | 2.51 |
| **$T_2$**- CT-RT | 67715 | 35770 | 2.08 | 64451 | 35980 | 2.23 |
| **$T_3$**- CT-MT | 67700 | 35755 | 2.08 | 54358 | 27631 | 2.01 |
| **$T_4$**- CT-ZT | 67606 | 35661 | 2.08 | 47536 | 22554 | 1.85 |
| **$T_5$**- CT-ROT | 67507 | 35562 | 2.08 | 72403 | 44422 | 2.54 |
| S.E. ± | 6879 | 6441 | 0.19 | 1560 | 1561 | 0.01 |
| C.D. at 5% | **NS** | **NS** | NS | 4510 | 4510 | 0.05 |
| **Weed Management** | | | | | | |
| **$W_1$**- Weed free | 83632 | 47137 | 2.29 | 77090 | 45671 | 2.44 |
| **$W_2$**- Pre & Post emergence herbicides | 76477 | 44182 | 2.37 | 71915 | 43536 | 2.52 |
| **$W_3$**- Weedy check | 42607 | 15562 | 1.58 | 40391 | 17162 | 1.72 |
| S.E. ± | 2813 | 2815 | 0.09 | 1797 | 1798 | 0.04 |
| C.D. at 5% | 8299 | 8299 | 0.28 | 5195 | 5195 | 0.12 |
| **Interaction** | | | | | | |
| **T × W** | | | | | | |
| S.E. ± | 5627 | 4950 | 0.19 | 3294 | 1785 | 0. 05 |
| C.D. at 5% | NS | NS | NS | NS | NS | NS |
| G. M. | 67572 | 35627 | 2.08 | 63132 | 35456 | 2.23 |

physical environment in terms of lower bulk density, penetration resistance in turn with the result an enhanced growth and productivity of chickpea. Increase in yield due to conventional tillage (CT-CT) has also been attributed to the significant improvement in yield parameters like number of pods $plant^{-1}$ number of seeds $pod^{-1}$, seed weight $plant^{-1}$ and hundred seed weight. The results are in agreement with those reported by Arya *et al.*, (2005) and Mante (2019).

As a result of cumulative effect of better growth, more dry matter accumulation and improvement in yield components due to practices of conventional tillage (CT-CT), the biological yield was enhanced.

It was because of better availability of nutrients and favorable soil conditions on growth of plant, which ultimately resulted in profuse branching, vigorous growth and superior yield attributes i.e. higher leaf area in this source and translocated more photosynthates to the sink, which ultimately resulted in higher biological yield of chickpea. Similar view was also expressed by Manjith and Angadi (2016) and Gul *et al.* (2003). The harvest index of chickpea was also higher in conventional tillage (CT-CT) practices during both the years

**Weed management practices**

Almost all the yield attributing characters *viz.*, number of pods plant$^{-1}$, weight of pods plant$^{-1}$, weight of seeds plant$^{-1}$, seed yield (kg ha$^{-1}$), straw yield (kg ha$^{-1}$), biological yield (kg ha$^{-1}$) and harvest index (%) were significantly influenced by various weed management treatments.

Treatment of weed free ($W_1$) recorded significantly higher, number of pods plant$^{-1}$, weight of pods plant$^{-1}$, weight of seeds plant$^{-1}$, number of seeds pod$^{-1}$, test weight, indicating least competition offered by weeds for nutrients and moisture at crucial growth stages under this treatment ultimately improved all yield attributes besides increased rate of N, P and K absorption cumulatively helped the crop plants to produce more surface area for high photosynthetic rate as well as maximum translocation of photosynthesis from source to sink, subsequently resulted in improvement of all yield attributes of chickpea. Because of synergic effect among the yield attributes and benefited to each other in chickpea crop. These findings are in accordance with those of Patel *et al*. (2006).

Seed yield was a function of yield attributes. Similarly, biological yield of crop plant has a close relationship with its economical yield. Data presented in (Table 2) reported that per hectare seed yield and straw yield (Table 2) of chickpea were appreciably higher in all weed control treatments as compared to weedy check ($W_3$). Weed free treatment recorded significantly higher seed yield but statistically at par with application of pre and post emergence herbicide. This may be due to higher seed yield plant$^{-1}$ which occurred from increased pod number, pod weight plant$^{-1}$ and number of seeds plant$^{-1}$. While the lowest number of pods plant$^{-1}$, weight of pods plant$^{-1}$, weight of seeds plant$^{-1}$, number of seeds pod$^{-1}$, seed yield (kg ha$^{-1}$), straw yield (kg ha$^{-1}$) and harvest index (%) were recorded in weedy check ($W_3$) in pooled results due to higher weed density (Khope *et al*. 2011). Harvest index was recorded minimum in weedy check ($W_3$) because of poor partitioning of photosynthesis source to sink (Yousefi *et al*. (2006)).

The yield is a cumulative effect of different growth and yield attributing characters. Whereas, straw yield was an augmenting effect of increased vegetative growth through plant height, number of branches and number of leaves plant$^{-1}$. Profound effect on seed and straw yield ha$^{-1}$ was noted due to different weed management practices. The yield reflected in these treatments which showed the effectiveness to control the weeds at critical growth stages as well as higher uptake of nutrients.

Different herbicides with divergent chemical composition along with conventional practices were found to control weeds in chickpea to a varying degree. This can be seen not only from the effect of herbicides on weeds but also from the crop yields of chickpea. Many research workers reviewed the comparative performance of herbicides in respect to higher chickpea production *viz.* Bhalla *et al.* (1998), Choudhary *et al*. (2005) and Khan *et al*. (2004).

**Economics**

Tillage practices had profound effect on gross monetary returns, net monetary returns and benefit: cost ratio of chickpea. Treatment (CT-CT) conventional tillage recorded significantly higher gross monetary returns and net monetary returns than (CT-ZT) zero tillage. It was at par with rotary tillage (CT-ROT). This might be due to the higher conservation of moisture in Conventional tillage method over tillage methods of rotary tillage, reduced tillage and zero tillage which resulted in higher yield attributes and higher yield observed in given treatment and thus ultimately gave higher GMR and NMR and Also reported Benefit-cost ratio was higher in (CT-ROT) than (CT-CT) due to the higher GMR and lower cost of cultivation during both the years of experimentation. Singh *et al.* (2008) reported that conventional tillage for all soybean chickpea cropping sequence was found to be a better option for increasing the gross and net return compared to the reduced tillage, minimum tillage and zero tillage. Similar finding reported by

Manjith and Angadi (2016), Chitale *et al.* (2007) and Anjum *et al*. (2019).

### Interaction

The interaction effects between tillage practices and weed management were found non significant in respect of different economic evaluation.

## CONCLUSION

The present investigation was conducted to study the, "production potential of soybean-chickpea cropping system as influenced by tillage and weed management practices in vertisol" and after through review of results, it can be concluded that –

1. Among tillage practices, CT-CT recorded significantly higher growth attributes, yield and yield contributing characters than other treatments, but was at par with CT-ROT in soybean-chickpea cropping system.
2. Among weed management practices, higher GMR and NMR were recorded by weed free treatment and followed by pre and post emergence herbicides. The maximum B:C was recorded by application of pre and post emergence herbicides.

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