Impact of Tillage Practices on Soil Properties and Crop Productivity of Mung Bean: A Review

Abstract

Pulses endowed with unique ability of nitrogen fixation constitute an important component of crop diversification and resource conservation in farming system. Mung bean is one the thirteen food legumes grown in India and the third most important pulse crop after chickpea and pigeon pea.Tillage practices have an important effect on soil microstructure characteristics, water thermal properties and nutrients, but little is known in the newly reclaimed cultivated land. Tillage properties showed positive effects on soil properties and yield of mung bean. Bulk density decreased due to tillage practices. Since tillage fractures the soil disrupts soil structure, accelerating surface runoff and soil erosion. Tillage also reduces crop residue, which help cushion the force or ponding raindrops. Without crop residue, soil particles become more easily dislodged being moved or splashed away.

Keywords: Conventional tillage, conservation tillage, productivity, growth and yield

INTRODUCTION

Mung bean is a major short duration and drought tolerant pulse crop in India. It belongs to the family Leguminosae and sub family Papilionaceae. India is its primarily origin and is mainly cultivated in “East Asia”and “South East Asia” and Indian subcontinent. It is a source of protein for the vegetarian population. It is a short duration crop, tolerant to photoperiod thermal variations, and thus extend over time and area, during the spring and summer season.

Conservation tillage ameliorates these factors and can release the productive potential off lands if forestalled by edaphic constraints, while inappropriate ploughing may bring a range of undesirable consequences including accelerated soil structure degradation erosion loss or organic matter and fertility disturbance of water and plant nutrient cycling[24].Tillage practices of conventional tillage alter soil structure by changing content. In addition, continuous mechanical disturbance by traditional tillage will tend to develop a “fine and fluffy soil structure,” while conservation and no-tillage approaches preserve the integrity of native soils [36]. Tillage alters

soil structures by fracturing the soil, which speeds up surface runoff and soil erosion. High erosion completely overturns the soil and bury crop residues, making the land bigger and more vulnerable to the erosive forces of wind and water [25]. When conventional tillage was used, losses of soil organic carbon and deterioration in other characteristics were overstated [33].

Zero tillage ensures timely sowing [18] of crops, reduces production cost [37] and had a positive effect on physical, biological and chemical properties of soil [36]. Minimum and zero tillage system helps in timely planting and healthy germination using residual moisture in the soil[28]. Use of cover crops, adoption of improved and economically viable farming methods, as well as steps taken to reduce soil compaction through regulated traffic, all are the major components [48].

1.1.Effect of tillage practices on growth parameters

1.1.1 Effect of tillage practices on mung bean growth parameters:

Jan *et al.* (2012) carried out field experiment at the New Developmental Farm of NWFP Agricultural University, Peshawar, with two tillage practices and three different P application methods. They found that the maximum emergence m^{-2}, plant height was recorded in conventional tillage plots while the reduce tillage produce higher no. of branches as compared to other treatment.

Amin *et al.* (2014) conducted a field experiment at the University of Agriculture Peshawar, Pakistan, with different treatments and reported that higher plant height was recorded in a chisel plough + rotavator treatment while the highest weed dry biomass was recorded in tine cultivator twice practice.

Amanullah *et al.* (2015) carried out a field experiment at Agricultural Research Station Ahmadwala, Karak with four varieties and four different tillage systems (Zero tillage, Conventional tillage, Minimum tillage, and Maximum tillage). They reported that a high emergence and taller plants were recorded in maximum tillage treatment as compared to other tillage system.

Abid *et al*. (2018) conducted a field experiment at the Kerala Agricultural University with four tillage system (minimum tillage, minimum tillage fb pendimethalin, minimum tillage fb imazethapyr + imazamox, conventional tillage + 2 hand weeding) with four cultivars. They found that the maximum plant height, number of branches, total leaf area, CGR, LAI and LAD was observed in the minimum tillage fb imazethapyr + imazamox as compared to other treatments.

Hakim *et al.* (2022) conducted a field experiment at the Kenya Agricultural and Livestock Research Organization (KALRO) at Katumani and Mwea research stations with three tillage practices, two mulch levels and two green gram varieties. They reported that greater number of branches and higher plant height was observed in the furrow ridge treatment.

At Punjab Agricultural University, Ludhiana, Kumar *et al.* (2022) carried out field experiment for two years and they reported that T6 treatment (Soybean (PB)-Wheat (PB)-Summer mung (PB)(+Residual)) has resulted in highest values of different root parameters recorded (stem and system width, depth to width length, number of nodal roots, taproot diameter, secondary root length) as compared to other treatment studied.

Patel *et al.* (2022) investigated the performance of green gram varieties under different tillage practices at Chandra Shekhar Azad University of Agriculture and Technology Kanpur for two years with two tillage practices (zero tillage and conventional tillage) with three varieties. They noted that higher crop growth rate, relative growth rate, and net assimilation rate was recorded in the conventional tillage. The result also showed that non-significant in root parameters (root length, root dry matter plant^{-1}, root nodule plant^{-1}) while highest in IPM 99-125 variety.

1.1.2 Effect of tillage practices on mung bean growth parameters of other crops

Khurshid *et al*. (2006) conducted a field experiment at the University of Agriculture, Faisalabad, Pakistan with three different tillage systems (minimum tillage, deep tillage, and conventional tillage) and four mulch levels (control, wheat straw @ 4, 8 & 12 Mg ha^{-1}). They found that maximum plant height was observed in conventional tillage while the highest total dry matter was recorded in deep tillage as compared to other treatments studied.

Aikins and Afuakwa (2010) conducted a field experiment at Kumasi, Ghana, with four different tillage practices (disc ploughing, followed by disc ploughing and disc harrowing, no-tillage, and harrowing). They found that the highest plant height, root length, seedling emergence and stem girth was recorded in plough and harrow treatment as compared to other treatment studied.

In 2009-10, a field experiment was carried out by Bilalis*et al*. (2010) at the Agricultural University of Athens. They compared three tillage systems, including conventional tillage, minimum tillage, and no tillage, along with three mulch levels (compost, vetch, and faba bean as a green manure). The results showed that the no-tillage systems had the highest leaf area index, dry weight, and arbuscular mycorrhizal root colonization.

Zamir *et al.* (2013) carried out a field experiment at the University of Agriculture, Faisalabad, Pakistan with different tillage practices (conventional tillage, zero tillage, bar harrow tillage, subsoiler tillage) and two types of mulch levels (wheat straw mulch and saw dust mulch). They reported that maximum plant height was observed in conventional tillage with wheat while the lowest plant height was found in zero tillage.

Meena *et al*. (2015) studied the tillage and residue management effect on soil properties, crop performance and relation at the research farm, Indian Agricultural Research Institute, New Delhi with the four different tillage and four cropping system and found that the higher root length and dry matter was observed in the maize-chickpea-green gram under the conventional tillage with residue retention.

Sharifi *et al.* (2016) conducted a field experiment at Gargan Agricultural Research Station with four different treatments (conventional tillage, minimum tillage, no-tillage with no planter, and no-tillage grain drill) and they reported that the highest plant height and dry matter of soyabean was observed in the NT-grain drill while the lowest was recorded in the minimum tillage.

Khorami*et al*. (2018) examined the effect of changes in soil properties and productivity under different tillage practices at Zarghan Field Station, Agriculture and Natural Resources

Research and Education Center of Fars Province, Iran, and they found that higher plant height and leaf no. plant^{-1} was observed in reduced tillage. The result showed that not significant.

Sapre *et al*. (2019) conducted a research trial at DWR, Jabalpur (M.P.) for two years to study the effect of five different tillage practices and three weed management treatments on growth productivity and weed dynamics in rice-wheat mung bean cropping system. They found that higher plant height and no. of branches plant^{-1} was observed in conventional tillage in rice + Sesbania-conventional tillage in wheat-zero tillage in mung bean while the highest total dry weight was observed in conventional tillage in transplanted rice-conventional tillage in wheat. Moreover, root nodules plant^{-1} were observed in T_4 as compared to other treatments.

Shilpa *et al*. (2021) conducted a field experiment at research farm, Department of Agronomy, CSK HPKV, Palampur with three tillage systems (minimum tillage, minimum tillage with crop residue, and conventional tillage) and four fertility levels. They reported that higher plant height, dry matter, AGR, CGR and RGR was observed in the minimum tillage with crop residue.

1.2 Effect of tillage practices on yield attributes

1.2.1 Effect of tillage practices mung bean yield and yield attributes

Sekhon *et al*. (2007) carried out field experiment in the Indo-Gangetic Plains of India, Pakistan and they reported that the zero-tillage showed higher grain yield and harvest index of mung bean while the lowest was observed in traditional farmer practice.

Shafiq *et al*. (2008) observed the effect of crop yields and nutrient uptake by rainfed wheat and mung bean as affected by tillage, fertilization, and weeding. They reported that the highest grain yield was observed in the conventional tillage while the lowest was observed in the zero tillage. The total dry matter yield was recorded in deep tillage.

Sharma *et al.* (2009) investigated the influence of tillage and nutrient source on yield sustainability and soil quality at Hayathnagar Research Farm of Central Research Institute for Dryland Agriculture, Hyderabad, with the two-tillage system (conventional tillage and reduced tillage) and five low-cost, farm-based, conjunctive nutrient-use treatments using three replicates.

They discovered that the maximum grain yield was observed in the T_3 (4 Mg compost + 2 Mg gliricidialoppings) while the lowest was observed in the T_1 (40 kg N through urea).

Mohammad *et al.* (2010)conducted a field trial to examine the effect of tillage and crop residue management on mung bean at Livestock Research Station, Surezai, Peshawar, in North West Frontier Province (NWEP) Pakistan with the two tillage treatments (tillage and no-tillage) and two crop residues treatments (wheat crop residues retained and wheat crop residues removed). They found that the maximum mung bean grain and straw yield was obtained in no-tillage (residues) treatment as compared to other treatment.

Meena *et al*. (2015) studied the tillage and residue management effect on soil properties, crop performance and relation at the research farm, Indian Agricultural Research Institute, New Delhi with the four different tillage system and four cropping system and they found that the maximum no. pods plant^{-1}, grains pod^{-1}, yield of seed and stover and biological yield was observed in the conventional tillage with residue retention.

Amanullah *et al.* (2015) investigated the impact of different tillage system on growth and yield of mung bean varieties under dryland condition. They observed that highest number of pods plant $^{-1}$, grains pod^{-1}, biological yield, thousand-grain weight, and grain yield was resulted in the maximum tillage as compared to other treatment.

Abid *et al.* (2018) conducted a field experiment at the Kerala Agricultural University with four tillage system (minimum tillage, minimum tillage fb pendimethalin, minimum fb imazethapyr + imazamox, conventional tillage + 2 hand weeding) with four cultivars. They found that maximum no. of pods plant^{-1}, no. of seed pod^{-1}, seed yield, biological yield, protein content was observed in the T_3 treatment (Minimum tillage fb (Imazethapyr + imazamox) while the highest pod length, 1000 seed weight, no. of nodules was recorded in conventional tillage + 2 hand weeding as compared to other treatment.

Suryavanshi *et al*. (2018) conducted a field experiment at Research Farm, of ICAR-Directorate of Weed Research, Adhartal, Jabalpur with the five main treatments and three sub treatments and they reported that the highest seed yield, pods plant^{-1} and stover yield was

observed in the treatment$_5$ (ZT + GR (M) – ZT + MR (Msr) – ZT + MsR (G) as compared to other treatments.

Sapre *et al.* (2019) conducted a field experiment for two years at Directorate of Wheat Research (DWR), Jabalpur (M.P.) with the five tillage practices and three weed management practices and they found that the maximum no. of pods plant^{-1} and seed yield was observed in treatment $_1$ (conventional tillage in rice + Sesbania-conventional tillage in wheat-zero tillage in mung bean) while the lowest was recorded in zero tillage.

At Punjab Agricultural University, Ludhiana, Kumar *et al*. (2022) carried out field experiment for two years and they found that pod length, number of seeds pod^{-1}, number of pods plant^{-1} and seed yield was recorded highest in Soybean (PB) - Wheat (PB) - Summer mung (PB) (+R).

1.2.2 Effect of tillage practices on other crop's yield and yield attributes

Khurshid *et al*. (2006) conducted an experiment at the University of Agriculture, Faisalabad with three tillage systems (minimum, deep & conventional tillage) and four mulch levels (control, wheat straw @ 4, 8 & 12 Mg ha^{-1}) and found that conventional tillage was recorded higher grain yield, no. of grains cob^{-1}, 1000 grain weight no. of cobs $^{-1}$ while maximum total dry matter and grain yield was observed in deep tillage.

Chakraborty *et al.* (2008) investigated the effect of mulching on soil and plant water status and the growth and yield of wheat in a semi-arid environment and reported that high grain yield was observed in mung bean mulched plots. Furrow-ridge mulched with 3 t ha^{-1} plant residues recorded the highest grain yield, while the lowest yield was recorded in conventional tillage with no mulch.

Bilalis*et al*. (2010) conducted a field trial on response of organic linseed (*Linum usitatissium*) to the combination of tillage system and fertilization practices, seed and oil yield production at the Agricultural University of Athens with the three-tillage system (conventional tillage, minimum tillage and no tillage) and three mulch levels (compost, vetch and faba bean as

a green manure) and they found that the highest seed yield and oil yield was found with minimum tillage as compared to other treatment.

At Central Research Farm Bangladesh Agricultural Institute(BARI) Gazipur Salahin*et al.* (2011) conducted a field experiment for three consecutive years to observe the effect of tillage and integrated nutrient management on soil physical properties and yield under tomato-mungbean- T. aman cropping pattern with the three different tillage practices (tillage up to 8 cm depth, tillage up to 12 cm depth and tillage up to 20 cm depth) and three levels of fertilizers and they reported that the maximum seed yield was observed in the tillage up to 20 cm depth during three years as compared to other treatment.

Alam *et al*. (2014) conducted a field experiment at Bangladesh Agricultural Research Institute (BARI) with nine different treatment combinations (3 tillage systems and 3 cropping patterns) and they found that the maximum grain yield, straw yield, 1000 grain weight, grains spike^{-1} and spike length was recorded in the T_3 treatment (deep tillage) as compared to other treatments.

Prasad *et al*. (2016) carried out field experiment at Research Farm of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi to evaluate the influence of tillage practices and cropping systems on crop productivity in soil health. The result showed that minimum tillage with crop residue retention improved the yield of crops by 5-22% and system productivity by 5.4-7.1%.

Shahzad *et al.* (2016) carried out field experiment at Research Farm, Department of Agronomy, Bahauddin Zakariya University, Multan with different tillage practices (zero tillage, conventional tillage, deep tillage and two types of bed sowing) and different cropping system. The result showed that that maximum grain yield was recorded from both type of bed sowing in mung bean-wheat while the lowest yield was observed in the fallow-wheat during second year.

Sharifi *et al.* (2016) conducted a field experiment at Gargan Agricultural Research Station with four different treatments (conventional tillage, minimum tillage, no-tillage with no till planter (NT-planter), and no-tillage grain drill). They found that in the first year 2012, of NT-grain drill produced higher grain yield, 1000-grain weight, no. of pods plant^{-1} and harvest index.

In the second year 2013, NT-Planter had the highest yield while the CT method had the lowest yield.

Khorami*et al*. (2018) examined the effect of changes in soil properties and productivity under different tillage practices At Zarghan Field Station, Agriculture and Natural Resources Research and Education Centre of Fars Province, Iran, and they produced higher wheat grain yield and maize biomass was observed in the reduced tillage.

Arya *et al.* (2020) studied the effect of different tillage practices and the yield of crops (soybean, black gram, and maize) at Aklera (AU, Kota) with three tillage practices (Summer disc harrowing + Cultivator, Deep summer ploughing + harrowing + cultivator, Summer Cultivator + cultivator) and 3 crops Soybean, Black Gram and Maize. The result showed that the highest yield was observed in T_2 treatment (deep summer ploughing + harrowing + cultivar while higher yield of maize crop was recorded over other crops.

Naeem *et al.* (2020) examined the effect of different barley-based cropping systems on soil physiochemical properties at Agronomy Farm, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan with five different tillage practices and five different cropping systems and they found that highest biomass yield produces in bed sowing method while the lowest biomass was recorded in fallow barley cropping system with zero tillage.

1.3 Effect of tillage practices on soil properties

Anikwe*et al*. (2007) carried out a field experiment at Faculty Research Farm of Faculty of Agriculture and Natural Resources Management, with the two tillage systems (tilled and no-till) and plastic-film mulch (black and clear plastic-film mulch) and noticed that soil bulk density was lower in the tilled plot as compared to that of no-tilled plots.

Bilalis*et al.* (2010) investigated a field experiment at Agricultural University of Athens and they observed that the soil organic matter and total was observed in no tillage system while the lowest was observed in conventional tillage.

Salahin*et al*. (2011) conducted a field experiment for three years to observe the effect of tillage and integrated nutrient management on soil physical properties and yield under tomato-mungbean- T. aman cropping pattern at Bangladesh Agricultural Research Institute (BARI) Gazipur with the three different tillage and three levels of fertilizers and the result showed were not significantly affected by tillage practices but higher bulk density and particle density was noted in treatment$_1$ (tillage up to 8cm depth) while soil moisture significantly influenced by both treatments.

Alam *et al*. (2014) carried out field experiment at Bangladesh Agricultural Research Institute (BARI) for two years with the three-tillage system (zero tillage, conventional tillage and deep tillage) and three cropping patterns (wheat fallow- T. aman, wheat- mung bean – T. aman and wheat- dhaincha- T. aman) and they found that maximum bulk density and particle density was observed in zero tillage while the highest porosity was recorded in deep tillage as compared to other treatments.

Prasad *et al*. (2016) carried out field experiment at Research Farm of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi to evaluate the influence of tillage practices and cropping systems on crop productivity in soil health. They reported that minimum tillage improved soil organic carbon (SOC), available nitrogen, phosphorus and potassium, sulphur, pH, and physical properties as compared to conventional tillage.

At Hunan Province and Nanning, Guangxi Province Huang *et al.* (2016) carried out field experiment and they recorded that the 17- 43 percent lower NPK uptake by rice plants in no-tilled plots while lowest was observed in the conventional tillage.

Shahzad *et al*. (2016) conducted a field experiment for two years at Research Farm, Department of Agronomy, Bahauddin Zakariya University, Multan. They found that the soil bulk density and soil porosity was highest in zero tillage under the fallow-wheat cropping system as compared to other tillage systems during both years of study.

Salahin*et al.* (2017) examined the effect of tillage and residue retention on soil properties and crop yields in cropping system with the three tillage practices and eight levels of residue

management and they observed that the higher bulk density and particle density was observed in the minimum tillage while the lowest was observed in the deep tillage.

Ahmad *et al.* (2017) conducted a field experiment at the Agronomy Research Farm of IGKV, Raipur with the three tillage practices (conventional tillage, minimum tillage, zero tillage) and nine weed management practices and they found that higher microbial activity, nodulation, and nutrient uptake was obtained in conventional tillage as compared to the minimum and zero tillage methods.

Khorami*et al.* (2018) examined the effect of changes in soil properties and productivity under different tillage practices at Zarghan Field Station, Agriculture and Natural Resources Research and Education Center of Fars Province, Iran. The result showed that no tillage had higher soil bulk density and lower cumulative water infiltration.

Abid *et al.* (2018) conducted a field experiment at the Kerala Agricultural University with four tillage systems (minimum tillage, minimum tillage fb pendimethalin, minimum fb imazethapyr + imazamox, conventional tillage + 2 hand weeding) with four different cultivars. The study revealed that the highest level of organic carbon, nitrogen, phosphorus, and potassium was observed in the minimum tillage system as compared to other treatments.

Suryavanshi *et al.* (2018) conducted a field experiment at Research Farm, of ICAR-Directorate of Weed Research, Adhartal, Jabalpur with the five main treatments and three sub treatments and they reported that higher bulk density, nitrogen, phosphorus, potassium and organic carbon was recorded in the treatment 5 (ZT + GR (M) -ZT + MR (Msr)-ZT + MsR (G) as compared to other treatments.

Sapre *et al.* (2019) carried out field experiment for two years at Directorate of Wheat Research (DWR) Jabalpur (M.P.) with five tillage practices and three weed management practices they reported that lower soil pH and higher electrical conductivity, organic carbon, nitrogen phosphorous and potassium content was observed in the treatment 4 (zero tillage in rice + *Sesbania* + mung bean residues-zero tillage in wheat+ rice residue-zero tillage in mung bean + wheat residues, (ZT + S + MR (R) - ZT + RR (W) -ZT + WR (M).

Naeem *et al.* (2020) investigated a 2-year field experiment at Agronomy Farm, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan with the five different tillage practices (zero tillage, minimum tillage, strip tillage, conventional tillage and bed-sowing) and different cropping system. They found that highest soil bulk density and lower total porosity was noted in zero tillage.

1.4 Economics

1.4.1 Effect of tillage practices on the economics of mung bean

Cameron and Trivedi (2009) studied the performance of Micro econometrics Using Stata and reported that the economic analysis was conducted to compare the annual net returns of the zero-tillage system with farmer practice.

Dodwadiya and Sharma (2011) performed a field experiment in New Delhi to analyze the impact of tillage practices (conventional and zero tillage) and methods of sowing (flat and raised bed) on five varieties of green gram. They found that the cost of cultivation was higher in both rainy and summer seasons when using conventional tillage.

Tripathi *et al*. (2013) observed the performance of the Impact of Zero Tillage on the Economics of Wheat Production in Haryana and they reported gross return and benefit cost ratio was higher in zero tillage system while lowest was observed in the conventional tillage system.

Meena *et al*. (2015) studied the tillage and residue management effect on soil properties, crop performance and relation at the research farm, Indian Agricultural Research Institute, New Delhi, and obtained from the maize-chickpea-greengram system under the conventional tillage recorded higher gross returns, cost of production, net returns and B: C ratio.

Kumar *et al.* (2017) conducted a field experiment at Krishi Vigyan Kendra Poonch of SKUAST-Jammu (J & K) and they reported that the B: C ratio in a variety of mung bean SML 818 and SML 668 to be 3.20 to 6.56.

Singh *et al.* (2017) conducted a field experiment on impact analysis of frontline demonstrations on pulses in Punjab. It was observed that the cost of cultivation was lower in the

FLD plots, and the net returns were higher in these plots throughout the years. The benefit-cost ratio (B: C ratio) was calculated for different years.

Parlawar*et al*. (2018) carried out a field experiment at Research Project, Akola, and they found that maximum gross monetary returns, net monetary returns, and B: C ratio was reported in the treatment of broad bed and furrow and proved as the most economic and remunerative tillage practices.

Abid *et al.* (2018) studied the performance of green gram cultivars under different tillage methods at Kerala Agricultural University. They reported that maximum cost of cultivation resulted in conventional tillage + hand weeding while higher gross returns and B: C ratio was observed in T_3 treatment (minimum tillage fb (imazethapyr + imazamox).

Hussain *et al.* (2020) examined the effect of zero tillage on the productivity of the traditional mungbean-wheat cropping system in Punjab Province Pakistan and they found that the highest gross benefit, net returns, and benefit-cost ratio was observed in zero tillage while total cost higher in conventional tillage.

1.4.2 Effect of tillage practices on the economics of other crops:

Erenstein and Laxmi (2008) noted that the impact of zero tillage on the productivity of mung bean in Pakistan. According to their report, the zero-tillage mung production method has reduced production costs and increased net income when compared to the conventional method, which requires intensive tillage and water use.

Raju *et al.* (2012) investigated the performance of economics of zero tillage and conventional methods of rice and wheat production in Haryana and they reported that highest gross returns, net returns, and benefit cost ratio was highest in zero tillage while total operation cost higher in conventional tillage.

Laik *et al.* (2014) examined the performance Integration of conservation agriculture with best management practices for improving system performance of the rice–wheat rotation in the Eastern Indo-Gangetic Plains of Indiaand they showed that the highest net returns was observed

in scenario 4 followed by scenario 3 while the highest benefit–cost ratio was recorded with S3 due to its lower cost of crop cultivation.

At Ambala district of Haryana Mehala *et al.* (2016) carried out field experiment and they reported that higher cost of cultivation and gross returns was observed in the conventional tillage while net returns and benefit cost ratio was higher in zero tillage.

Shahzad *et al.* (2017) studied the performance of economic assessment of conventional and conservation tillage practices in different wheat-based cropping systems of Punjab, Pakistan at Research Farm, Department of Agronomy, Bahauddin Zakariya University, Multan, and reported that the maximum total income, total expenses, gross income, net income, and B: C ratio was observed in the both bed sowing method while lowest was recorded in zero tillage.

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