Improving Mung Bean Yield: The Impact of Tillage Strategies on Soil Structure: 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 of the thirteen food legumes grown in India and the third most important pulse crop after chickpea and pigeon pea. Soil tillage systems can influence soil compaction, water dynamics and crop yield. These processes can be expressed as changes in soil microbiological activity, soil respiration and agricultural sustainability. The objective of this paper is to review the impact of tillage practices on soil properties and crop productivity of mung bean. The review synthesizes findings from recent studies and experimental data on tillage practices. Conventional tillage techniques include the incorporation of fertilizers and crop residue, seedbed preparation, aeration of organic matter and the release of nutrients. 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 shows positive effects on soil properties and yield of mung bean. Bulk density decreased due to tillage practices Since tillage fractures the soil, it disrupts soil structure, accelerating surface runoff and soil erosion. Tillage also reduces crop residue, which helps cushion the force of pounding raindrops, and disrupts the microorganisms in the soil, leading to poor soil health. This review summarizes the current knowledge about tillage practices and its impacts on soil properties.

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.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 [1]. 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 [2]. When conventional tillage was used, losses of soil organic carbon and deterioration in other characteristics were overstated [3].

Zero tillage ensures timely sowing [4] of crops, reduces production cost [5] and had a positive effect on physical, biological and chemical properties of soil [1]. Minimum and zero tillage system helps in timely planting and healthy germination using residual moisture in the soil[6]. 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 [7].

1.1.Effect of tillage practices on growth parameters

1.1.1Growth parameters of mungbean crop

Jan *et al.* [8]carried out field experiment at the New Developmental Farm of NWFP Agricultural University, Peshawar, with two tillage practices and three different phosphorous 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.

At University of Agriculture Peshawar, Pakistan, Amin *et al.* [9]conducted a field experiment to study the weed biomass and growth of mung bean as affected by tillage practices and sowing methods and they reported that higher plant height was recorded in a chisel plough + rotavator treatment whereas the highest weed dry biomass was recorded in tine cultivator twice practice.

Amanullah *et al.* [10]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 highest emergence and taller plants were recorded in maximum tillage treatment while lowest was recorded in zero tillage treatment.

Abid *et al.* [11] 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) and four cultivars. They found that the maximum number of branches, total leaf area, crop growth rate, leaf area index and leaf area duration was observed in the minimum tillage fb imazethapyr + imazamox treatment as compared to other treatments studied while highest plant height was recorded in conventional tillage + 2 hand weeding.

Hakim *et al*. [12] 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*. [13] carried out field experiment for two years and they reported that T_6 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*. [14] 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) and three varieties. They found that higher crop growth rate, relative growth rate, and net assimilation rate was recorded in the conventional tillage treatment. They also reported that the different root parameters studied was found to be non-significant.

Salgar *et al.*[15] investigated the performance of conservation tillage practices and nutrient management on growth of greengram at Research Farm of Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri with six tillage practices and two nutrients and they reported that highest plant height, number of branches, number of leaves plant^{-1}, leaf area plant^{-1} and dry matter was recorded in minimum tillage with crop residue treatment while lowest was recorded in conventional tillage without crop residue treatment.

Indra *et al*. [16] conducted a field experiment at Institute of technology and Sciences, Coimbatore, Tamil Nadu with two tillage systems (minimum tillage and conventional tillage) and five weed control treatment. They found that highest plant height, number of leaves, number of branches, leaf area per plant was observed in the conventional tillage treatment as compared to other treatment.

1.1.2Growth parameters of other crops

Khurshid *et al.* [17] 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) and they noted that maximum plant height was observed in conventional tillage treatment while the highest total dry matter was reported in deep tillage treatment.

Aikins and Afuakwa[18] 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.

Bilalis*et al*. [19] conducted a field experiment at Agriculture 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 highest leaf area index, dry weight and arbuscular mycorrhizal root colonization was found in no-tillage system.

Zamir *et al.*[20] 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 straw while the lowest plant height was found in zero tillage treatment.

Meena *et al.* [21] studied the tillage and residue management effects 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 CT+ R (conventional tillage + residue).

Sharifi *et al.*[22] 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.* [23] examined the effect of changes in soil properties and productivity under different tillage practices at Iran, and they found that higher plant height and leaf number plant-1 was observed in reduced tillage while lowest was recorded in no tillage treatment.

Sapre *et al.*[24] conducted a research trial at Directorate of weed research (DWR), Jabalpur (M.P.) for two years to study the effect of different tillage practices and weed management treatments on growth productivity and weed dynamics in rice-wheat-mung bean cropping system. They reported that highest plant height and number of branches plant-1 was observed in conventional tillage in rice + Sesbania-conventional tillage in wheat-zero tillage in mung bean whereas the highest values of total weed dry weight was observed in the T_2 (conventional tillage in transplanted rice-conventional tillage in wheat).

Shilpa *et al.*[25] conducted a field trial at research farm of Department of Agronomy, CSK HPKV, Palampur with three tillage systems (minimum tillage, minimum tillage with crop residue, and conventional tillage) and four fertility levels and they reported that higher plant height, dry matter, absolute growth rate, crop growth rate and relative growth rate was observed in the minimum tillage + crop residue treatment.

Ankit *et al.*[26] carried out field experiment for two years at CSKHPKV Palampur and rice wheat research station, Malan to study the influence of tillage practices on growth and growth indices of rice varieties. They reported that during both years of study highest plant height, dry matter accumulation, absolute growth rate, crop growth rate and relative growth rate was recorded in conventional tillage practice as compared to other treatments.

Ankit *et al*. [27] conducted a field trial to examine the effect of tillage and cultivars on growth and growth indices of rice at research farm, Department of Agronomy, CSK HPKV, Palampur with three tillage treatment (conventional tillage, minimum tillage without residue, minimum tillage with residue) with three rice varieties. They found that highest plant height, dry matter accumulation, tillers, absolute growth rate, crop growth rate, relative growth rate was obtained in conventional tillage treatment as compared to other treatment.

Behailu Mekonnen [28] conducted a field trial for two years at Teppi Agricultural Research centre to study the productivity and land use efficiency of maize-soyabean intercropping under different tillage practices. They reported that highest plant height leaf number, number of ears, length of ear was recorded in conventional tillage while lowest was observed in the zero tillage.

1.2 Effect of tillage practices on yield attributes

1.2.1 Yield and yield attributes of mungbean crop

Sekhon *et al*. [29] 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.* [30] conducted a trialat National Agricultural Research Centre, Islamabad, Pakistan, to evaluate and they observed that the highest grain yield was recorded in the conventional tillage while the lowest was recorded in the zero tillage while dry matter yield was highest in deep tillage treatment.

Sharma *et al.*[31] investigated the influence of tillage and nutrient source on yield sustainability and soil quality at Central Research Institute for Dryland Agriculture, Hyderabad,

with five treatments. They reported that the maximum grain yield was observed in the T_3 (2 Mg compost + 10 kg N through urea) while the lowest was observed in the T_1 (control) treatment.

Mohammad *et al.*[32]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 different treatment and they found that the maximum mung bean grain yield and straw yield was obtained in no-tillage (+ residues) treatment as compare to other treatments studied.

Meena *et al*. [21] 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 number 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.*[10] investigated the impact of different tillage system on growth and yield of mung bean varieties under dryland conditionat Agricultural Research Station Ahmadwala, Karak. They observed that highest number of pods plant $^{-1}$, grains pod^{-1}, thousand-grain weight, biological yield and grain yield was resulted in the maximum tillage as compared to other treatments studied.

Abid *et al.*[11] 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) and four cultivars. They found that maximum number of pods plant^{-1}, number of seed pod^{-1}, seed yield, biological yield was observed in the T_3 treatment (Minimum tillage fb Imazethapyr + imazamox) whereas the highest pod length, test weight, number of nodules was recorded in T_4 (conventional tillage + two hand weeding).

Suryavanshi *et al.*[33] conducted a field experiment at Directorate of Weed Research, Jabalpur M.P with fifteen treatments. They reported that the highest pods plant^{-1}, seed yield and stover yield was observed in the T_5 (ZT + GR (M) – ZT + MR (Msr) – ZT + MsR (G) treatment as compared to other treatments studied.

Sapre *et al.*[24] conducted a field experiment for two years at Directorate of Weed Research (DWR), Jabalpur (M.P.) with the five-tillagetreatment and three weed management practices. They observed that the maximum no. of pods plant^{-1} and seed yield was observed in T_1 treatment (conventional tillage in rice + Sesbania-conventional tillage in wheat-zero tillage in mung bean) while the lowest was recorded in T_3 treatment (ZT+S(R) – ZT(W) – ZT(M)).

At Punjab Agricultural University, Ludhiana, Kumar *et al.* [13] 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).

Alhammad*et al.*[34] conducted a field experiment for three years at Agriculture Research Center in Pusa, Bihar with the five tillage treatment and three weed management practices. They observed that maximumnumber of seed per pod^{-1},grain yield and straw yield was observed in T_3 treatment (conventional till direct seeded rice – conventional till wheat – zero till greengram) whereas highest number of pods plants^{-1} was recorded in T_2 treatment (conventional till transplanted rice – zero till wheat - zero till green gram) while lowest was observed in T_4 treatment (zero till direct seeded rice – zero till wheat – zero till green gram)

Indra *et al.* [16] conducted a field experiment at Institute of technology and Sciences, Coimbatore, Tamil Nadu with two tillage systems (minimum tillage and conventional tillage) and five weed control treatment. They found that highest seed yield, biological yield and harvest index was observed in the conventional tillage treatment as compared to other treatment.

1.2.2 Yield and yield attributes of other crops

Khurshid *et al.*[17] conducted a 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 they found that conventional tillage recorded significantly higher number of grains cob^{-1}, 1000 grain weight, number of cobs plant^{-1}whereas maximumgrain yield was observed in deep tillage treatment.

Chakraborty *et al.* [35] 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 plotsat Indian Agricultural Research Institute, New Delhi. 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.

At Agricultural University of Athens GreeceBilalis*et al*. [19] to study the different tillage system and fertilizers practices. They found that the highest seed yield and 1000 grain weight was found in minimum tillage as compared to other treatments studied.

At Bangladesh Agricultural Research Institute (BARI) Gazipur Bangladesh Salahin*et al.*[36]conducted a field experiment for three consecutive years with nine treatment combinations 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 treatment in which tillage was done upto 20 cm depth as compared to other eight treatments studied.

Alam *et. al.* [37] conducted a field experiment at Bangladesh Agricultural Research Institute (BARI) Gazipur, 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) while the lowest was recorded in zero tillage treatment.

Prasad *et al*. [38] 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.*[39] 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*. [22] conducted a field experiment at Gargan Agricultural Research Station, Iran, with four different tillage and they found that during first year higher 1000-grain weight, number of pods plant^{-1} grain yield and harvest index was recorded in no tillage grain drill treatment whereas during second year no tillage planter treatment resulted higher yield.

Khorami*et al.*[23] examined the effect of changes in soil properties and productivity under different tillage practices at Agriculture and Natural Resources Research and Education Centre of Fars Province, Iran, and they noted that the higher grains spike^{-1}, 1000 grain weight and harvest index was recorded in the conventional tillage treatment whereas grain yield was observed in the reduced tillage.

Arya *et al.*[40] 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.* [41] 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.

Ankit *et al.* [42] conducted a field experiment at research farm, Department of Agronomy, CSK HPKV, Palampur with three tillage practices (conventional tillage, minimum tillage without residue retention and minimum tillage with residue retention) and three rice cultivars. They reported that higher grain yield, straw yield, biological yield and harvest index was observed in the conventional tillage as compared to other treatment.

Ankit et al. [27] examined the effect of different tillage systems and cultivars on yield and yield attributes of rice at Experimental Farm, Department of Agronomy, CSK HPKV, Palampur with three tillage treatment (conventional tillage, minimum tillage without residue,

minimum tillage with residue retention) and three rice varieties. The result showed that maximum number of panicles m^{-2}, number of grains $panicle^{-1}$, panicle length, 1000 grain weight, grain yield, straw yield, biological yield and harvest index was noted in conventional tillage while minimum yield and yield attributes was reported in the minimum tillage with residue.

Saini *et al.*[43] conducted a field trial for two consecutive years at two locations (CSKHPKV Palampur and rice and wheat research station, Malan) to study the impact of cultivation practices and varieties on productivity and profitability and nutrient uptake in rice-wheat cropping systems. They noted that during both years of field study in both crops highest grain yield, straw yield and biological yield was reported in conventional tillage while the lowest values was recorded in the natural farming treatment.

Saini *et al*. [44] investigated a field experiment at Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur with four tillage system and three rice genotypes. They reported that higher grain yield and straw yield was recorded in conventional tillage treatment while lowest was recorded in natural farming treatment.

1.3 Effect of tillage practices on soil properties

Anikwe*et al*. [45] 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 they noticed that soil bulk density was lower in the tilled plot as compared to that of no-tilled plots.

Bilalis*et al.*[19] investigated a field experiment at Agricultural University of Athens, Greece, and they observed that soil organic matter and total nitrogen was observed in no tillage while the lowest was observed in conventional tillage treatment.

Salahin*et al.*[36]conducted a field experiment for three years to study 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 Bangladesh and they observed that the observed that higher bulk density and particle density was noted in T_1 (tillage upto 8cm depth) while lower was in T_3 (tillage upto 20cm depth).

Alam *et al.* [37] carried out field experiment at Bangladesh Agricultural Research Institute (BARI) for two years with different tillage systems and cropping patterns and they noted higher bulk density and particle density was observed in zero tillage treatment while the highest values of porosity was recorded in deep tillage treatment.

Prasad *et al.* [38] carried out a field experiment at 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, soil pH, and bulk density as compared to conventional tillage.

At Hunan Province and Nanning, Guangxi Province Huang *et al.*[46] 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*. [39] conducted a field experiment for two years at Research Farm, Department of Agronomy, Bahauddin Zakariya University, Multan and they noted that during both years the higher values of soil bulk density and soil porosity was highest in zero tillage under the fallow-wheat cropping system as compared to other treatments studied.

Salahin*et al.*[47] examined the effect of tillage and residue retention on soil properties 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 treatment.

Ahmad *et al.*[48] conducted a field experiment at the Indira Gandhi Krishi Vishwa Vidyalaya, IGKV, Raipur with the three tillage practices and nine weed management practices and they observed that higher microbial activity, nodulation, and nitrogen uptake of crops and weeds was obtained in conventional tillage as compared to the minimum and zero tillage practices.

Khorami*et al.*[23] 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 recorded higher soil bulk density and lower cumulative water infiltration.

Abid *et al*. [11] 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) and four cultivars. The study revealed that the highest level of organic carbon, nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}), and potassium (kg ha^{-1}) was observed in the minimum tillage as compared to other treatments studied

Suryavanshi *et al*. [33] conducted a field experiment at Research Farm, of ICAR-Directorate of Weed Research, Jabalpur (M.P) with different treatments and they noted that higher soil bulk density, available nitrogen, phosphorus, potassium and organic carbon was recorded in the T_5 (ZT + GR (M) - ZT + MR (Msr) – ZT + MsR (G) treatment while lowest values were found in T_1 (CT (M) – CT (Msr)) treatment.

At DWR Jabalpur M.P a two-year trial was conducted by Sapre *et al*. [24] with five tillage and three weed management practices. They noted that higher electrical conductivity, organic carbon, nitrogen, phosphorous and potassium content was observed in T_4 ((ZT + S + MR (R) – ZT + RR (W) – ZT + WR (M)) treatment whereas in case of soil pH lower values were recorded in this treatment.

Naeem *et al*. [41] investigated a two-year field experiment at Bahauddin Zakariya University, Multan, Pkistan with different tillage practices and cropping systems. They found during both years of study highest bulk density was found in zero tillage treatment whereas in case of porosity highest values were observed in bed sowing method treatment.

1.4 Economics

1.4.1 Economics of mung bean crop

Cameron and Trivedi [49] 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 [50] conducted a field experiment at Indian Agricultural Research Institute, 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 during both summer and rainy season highest values of cost of cultivation, net returns, and

B:C ratio was observed in the conventional tillage treatment while lowest was observed in zero tillage.

Tripathi *et al.*[51] examined the performance of the Impact of Zero Tillage on the Economics of Wheat Production in Haryana and they noted that higher gross income and net income was reported in zero tillage while lowest was observed in the conventional tillage.

Meena *et al*. [21] 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 they noted that cost of production, net returns and B: C ratio was recorded in CT+R whereas the higher values of gross returns was reported in ZT + R treatment.

Kumar *et al.*[52] conducted a field experiment at Krishi Vigyan Kendra Poonch of SKUAST-Jammu (J & K) and they reported that higher B: C ratio in a variety of mung bean SML 818 and lower B: C ratio was recorded in SML 668 to be 3.20 to 6.56.

Singh *et al*. [53] conducted a field study to access the impact analysis of frontline demonstrations on pulses in Punjab and they found that higher gross returns and net returns was found in FLD plots throughout the year in which the study was conducted while the cost of cultivation was lower in these plots throughout the years.

Parlawar*et al.*[54] carried out a field experiment at Akola, and they found that maximum gross monetary returns, net monetary returns, and B: C ratio was reported in the broad bed and furrow treatment and it is proved as the most economic and remunerative tillage practice.

Abid *et al.*[11] studied the performance of green gram cultivars under different tillage methods at Kerala Agricultural University. They reported that maximum cost of cultivation was found in conventional tillage + hand weeding treatment while higher gross returns and B: C ratio was observed in minimum tillage fb mazethapyr + imazamox treatment.

Hussain *et al.*[55] examined the effect of zero tillage on the productivity of the traditional mungbean-wheat cropping system in Punjab, Pakistan and they found that the highest gross returns, net returns, and B:C ratio was observed in zero tillage treatment as compared to other treatment studied (conventional tillage).

1.4.2 Economics of other crops

Erenstein and Laxmi [56] 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*. [57] investigated the performance of economics of zero tillage and conventional methods of rice and wheat production in Haryana. They noted that highest values gross returns and net returns was reported in zero tillage whereas the total operational cost was higher in conventional tillage.

Laik *et al.*[58] conducted a study to enhance productivity, alleviate environmental and management constraints, and enhance farmers' income in the rice–wheat cropping system of the Eastern Indo-Gangetic Plains of India (E-IGP)and they showed that the highest net returns was observed in S_4 (potato and maize–rice–cowpea rotation) whereas highest B:C ratio was recorded in S_3 due to its lower cost of crop cultivation.

At Ambala Haryana a field study was conducted by Mehala *et al*. [59] to study the economic impact of zero tillage on wheat cultivation. They reported that highest operation cost and gross returns were observed in the conventional tillage practice while net returns and benefit cost ratio was higher in zero tillage practice.

Shahzad *et al.*[39] studied the performance of economic assessment of conventional and conservation tillage practices in different wheat-based cropping systems of Punjab, Pakistan at Zakariya University, Multan. They reported that the highest total income, total expenses, gross income, net income, and B: C ratio were observed in both bed sowing methods while the lowest was recorded in zero tillage treatment.

Saini *et al.*[43] conducted a field trial for two consecutive years at (CSKHPKV, Palampur to study the impact of cultivation practices and varieties on productivity and profitability and nutrient uptake in rice-wheat cropping systems. They noted that during both years of field study in both crops highest cost of cultivation, gross returns, net returns and B:C ratio was observed in

conventional tillage while lowest was recorded in while lowest was recorded in natural farming treatment.

Ankit *et al.* (42) studied the productivity and profitability of rice as influenced by different tillage systems and cultivars at CSK Himachal Pradesh Agricultural University, Palampur and they reported that higher cost of cultivation, gross returns and B:C ratio was reported in the conventional tillage treatment as compared to other treatment.

Shilpa *et al.*[25] conducted a field study on tillage practices and different nutrient sources at CSK Himachal Pradesh Agricultural University, Palampur for two years. They noted that higher gross returns, net returns, and B:C ratio was reported in the conventional tillage while the lowest values were observed in the zero tillage.

Conclusion

It may be concluded tillage is an important practice used in agriculture, especially in food production. Conventional tillage have the potential to mitigate some of the impacts of climate change by improving the growth of crop. Conventional tillage practices are capable of improving the profitability of farming and making soils more resilient to local demands. Tillage have its own positive and negative effects on the absorption of residue, retained soil moisture and other soil properties, such as soil pH, soil organisms, water capacity, soil structure and bulk density.

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