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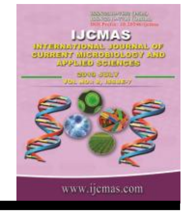

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Conservation Agriculture Based Tillage Options for *Rabi* Crops Cultivation in Eastern India: Effects on Productivity and Profitability

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A B S T R A C T

In conventional tillage, the traditional practice of opening and turning the soil greatly contributes towards the quick oxidation of organic matter in the soil, quantitative loss of residual soil moisture and high labour and energy input thereby resulting in the poor economic returns for the farmers. However, in some situations tillage causes the soil degradation which results into development of compacted soil having low soil organic carbon (SOC) and restricted drainage. So, the experiment was conducted to specify the tillage practices which can keep protecting the soil healthy for longer period. This experiment was devised to evaluate the effect of long term CA practices like zero tillage and permanent beds on production, productivity and economics of the 5th year rabi season crops as compared to their performance against the business as usual practice i.e., conventional tillage practice for different Rabi season crops. The experiment had a split plot design, replicated thrice with three main plot treatments viz. zero tillage (ZT), conventional tillage (CT) and permanent bed (PB) and four sub plot treatment viz. wheat, rabi maize, mustard and chickpea. The results revealed that higher grain yield of wheat was recorded under PB (5488 kg ha^{-1}) over ZT and CT while, higher grain yield of rabi maize (11279 kg ha^{-1}), mustard (970 kg ha^{-1}) and chickpea (1936 kg ha^{-1}) was recorded in ZT over CT. The highest net return (Rs 64,779 ha^{-1}), and B: C ratio (2.09) was recorded under ZT which was at par with PB (Rs 61,789 ha^{-1} and 2.02). Among rabi crops, highest net return was recorded in maize (Rs. 1,00,509 ha^{-1}) followed by chickpea (Rs. 57,975 ha^{-1}) while B:C ratio was highest for chickpea (2.70) followed by rabi maize (2.05), wheat (1.74) and mustard (0.77).The experiment shows that conservation agriculture-based Zero tillage and permanent bed tillage practices along with residue retention resulted in significant increase in biomass production and productivity of rabi crops with higher net returns and B:C ratio than conventional tillage practice.

Introduction

Bihar is one of the most important states in the Eastern India and Middle Indo Gangetic plains in terms of crop production with its burgeoning population of 104 million people (MoA 2013) and steadily increasing population efforts to enhance agricultural productivity is utmost important to ensure food security. Rice – Wheat is the dominant cropping system of the state with wheat being the major rabi season crop. However, in the last few years' maize crop has emerged as a potential replacement for wheat during the rabi season due to its temporal suitability, profitability (Ali *et al.,* 2009) and market demand (Pandey *et al.,* 2008; Gill *et al.,* 2008). In Bihar, generally rabi crops grown after the harvest of predominant kharif rice or kharif maize which is determined by distribution of the monsoon because, sometimes due to delayed monsoon or due to long duration rice cultivars harvesting of the rice gets delayed resulting sowing of the next rabi crops gets delayed due to adoption of conventional tillage by the farmers. Tillage is one of the fundamental agro-technical operations, performed to achieve soil environment favorable for crop growth and development. In conventional tillage, the traditional practice of opening and turning the soil greatly contributes towards the quick oxidation of organic matter in the soil (Gathala *et al.,* 2011), quantitative loss of residual soil moisture and high labour and energy input thereby resulting in the poor economic returns for the farmers (Aryal *et al.,* 2015). However, in some situations tillage can lead to soil degradation which results into development of compacted soil having low soil organic carbon (SOC) and restricted drainage. Conventional tillage (CT) practices being highly intensive in nature, leads to gradual decline in soil organic matter through accelerated oxidation, with a consequent reduction in the capacity of the soil to regulate water and nutrient supplies to plants. The tillage operations are energy and input intensive as well as create difficulty in the timely seeding of the succeeding crop (Bhushan *et al.,* 2008; Jat *et al.,* 2009). CT for crop production needs higher labour and fuel cost which results in lower economic returns to the growers pushing them towards continuous trap of poverty (Jat *et al.,* 2012). Moreover, CT along with faulty agricultural practices such as deforestation, selection of inappropriate crop sequences and burning of crop residues etc. directly and indirectly reported to be associated with wide range of agricultural challenges such as water and labour crises, extensive land degradation, poor soil fertility and agricultural related climate change which put larger pressure on available agricultural land in order to feed the ever rising human and animal population (Stocking and Murnaghan, 2001). Therefore, in current scenario there is an urgent need to identify, demonstrate and to recommend tillage practices which are alternate to CT systems and can deal with the above mentioned challenges, so that agriculture may come out as a source of farmers' prosperity.

Conservation agriculture (CA) based crop management practices such as zero tillage (ZT) and permanent beds (PB) along with crop diversification is quite helpful to maximize the yield by utilizing the soil and other natural resources without creating a negative impact on the environment. Conservation agriculture (CA) based crop management technologies have been intensified to overcome the aforesaid problems. It mainly refers to the crop establishment through minimal disturbance of soil, retaining crop residues on the soil surface and spatial variability of crops to derive maximum input benefit (Hassan *et al.,* 2005) and minimize the adverse footprint on soil health. The main component of CA being crop establishment on flat surface without tillage i.e. zero tillage (ZT) or on permanent raised beds (PB) without any tillage. ZT and PB involving lesser soil disturbance, soil cover and cost-effective cropping sequences, found to be helpful in lowering the production cost in addition to providing environmental services in terms of lower carbon emission and better soil health. ZT and PB has been reported to decrease biological oxidation of SOC, increases water holding capacity, prevents land degradation by lowering the intensity of soil erosion (Six *et al.,* 2002). This has led to a major shift in adoption of ZT wheat after kharif crop. Most of the research work on conservation agriculture mainly concentrated in the Western part of IGP where wheat under CA practice has been intensively documented. The middle and Eastern IGP with a much different agro ecological scenario, the efficacy of CA practices on performance of rabi season crops is yet to be explored. So, precise information on the potential benefits of CA adoption for the region is scarce. So, this experiment was conducted for conservation agriculture based tillage options for rabi crop cultivation in Eastern India. Our main focus is to change the traditional tillage practices with some new tillage practices which can enhance economic condition of farmers as well as improve the soil health for longer period. The results from the experiment shall also help to understand the likely adoption benefits of CA for different cool season crops in the region.

Materials and Methods

A field experiment was conducted during the Rabi season of 2017-18 on “Conservation agriculture based tillage options for rabi crop cultivation in Eastern India” at the research farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar to assess the effects of different tillage methods on growth, productivity and profitability of Rabi crops. The climatic conditions under which the experiment was carried out, the materials used and techniques employed during the course of investigation are described in this chapter.

Experimental site

The experiment was carried out at experimental farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar (India) during 2017-18 in rabi season. The experimental plots had uniform topography with homogeneous fertility.

Weather condition of experimental site

The geographical location of the experimental site of Bihar Agricultural University, Sabour comes under the Middle Gangetic plain region of Agro-climatic Zone III A. It is situated at longitude 87^{0}2’45” East and latitude 25^{0}15’4” North at an altitude of 37.19 meters above mean sea level. The climatic condition of this place is tropical to subtropical of somewhat semi-arid in nature and is characterized by very dry summer, moderate rainfall and very cold winter.

Rainfall and temperature

The average rainfall is about 1407 mm (10-years average) which is unimodal type mostly precipitating during middle of June to middle of October, where potential evapo-transpiration is lower than the rainfall. The minimum and maximum day temperature is 18ºC and 35ºC during summer season whereas 15ºC and 25ºC are the minimum and maximum day temperature during winter season respectively. During the crop season there was cool and bright climate prevails throughout the dry season.

Weather condition during crop season

The data on weather parameters such as distribution of rainfall, maximum and minimum temperature and relative humidity recorded from meteorological observatory of Bihar Agricultural University, Sabour during the crop season are graphically depicted in Figure 1.

Experimental details

Treatment details

The experiment was laid out in split plot design with 12 treatment combinations comprising of three tillage treatments; T_1 -

zero tillage (ZT), T_2- permanent bed (PB) and T3- conventional tillage (CT), in main plot, four rabi crops viz. C_1- Rabi Maize (var. P 3396), C_2- Wheat (var. HD 2967), C_3-Mustard (var. JG 14) and C_4-Chickpea (var. Rajendra Suphlam) in sub plot. The fertilizer dose was 150:75:50, 120:60:40, 20:50: 0, 80:40:40 (N: P_2O_5: K_2O kgha^{-1}), respectively. Nitrogen was applied in three splits, half as a basal dose at the time of sowing, one fourth before first irrigation and one fourth before third irrigation while full dose of P_2O_5 and K_2O were applied as basal. Before sowing of crop in the plots a uniform application of pre emergence herbicide – Pendimethalin @ 3L a.i. ha^{-1} was sprayed for management of weeds and the crop was sown two days after application of herbicide.

In zero tillage, crops were grown on zero tilled plots without disturbing the soil except for seed or fertilizer placement, with 30 per cent maize residue retained in the plots from the earlier maize crop in rotation. The conventional tilled plots were ploughed with two passes of tractor drawn disc plough followed by two ploughing with cultivator and one planking. The field was uniformly leveled to the specified plot dimension and impermanent bed**,** crops were grown on permanent bed plots without disturbing the soil except for seed or fertilizer placement, with 30 per cent maize residue retained in the plots from the earlier maize crop in rotation. The width of the beds (mid-furrow to mid-furrow) was 67 cm, with 37 cm wide flat tops, and 30 cm furrow width. The prices in rupees of the inputs that were prevailing at the time of their use were considered for working out the cost of cultivation. Net returns ha^{-1} were calculated by deducting the cost of cultivation ha^{-1} from gross income. To interpret the effect of different treatments, the data collected in course of experiment were analyzed statistically by applying the analysis of variance techniques laid down by Cochran and Cox (1967), Panse and Sukhatme (1978) and Gomez and Gomze (1984). Relevant data were statistically analyzed separately to interpret the results and the mean data for each parameter has been presented. For comparison of 'F' values and for determination of critical difference at 5% level of significance, Fischer and Yates Table (1963) were consulted.

Results and Discussion

Effect of different tillage practices on total biological yield and grain yield of different crops

The data of biological yield and grain yield of different rabi crops has been presented in the table 1. The total biological yield showed variable response in different crops due to alteration in tillage practices. In wheat due to tillage practices biological yield was significantly higher with PB over CT. The maximum biological yield was recorded in PB (14132 kg ha^{-1}) which was significantly higher as compared to CT (12017 kg ha^{-1}) but biological yield in ZT wheat (13339 kg ha^{-1}) was at par with both PB and CT. In maize biological yield in ZT (25359 kg ha^{-1}) was significantly higher with CT (22262 kg ha^{-1}) and biological yield in PB (23786 kg ha^{-1}) was statistically at par with ZT as well as CT. In mustard there was no significant effect of tillage practices on biological yield. The maximum biological yield was recorded in CT (4255 kg ha^{-1}) which was statistically at par with ZT (3906 kg ha^{-1}) and PB (3875 kg ha^{-1}). In chickpea also there was no significant effect of tillage practices on biological yield. However, the maximum biological yield was recorded in ZT (5194 kg ha^{-1}) which was statistically at par with CT (5020 kg ha^{-1}) and PB (4822 kg ha^{-1}).

In wheat the maximum grain yield was recorded in PB (5488 kg ha^{-1}) which was significantly higher as compared to CT (4442 kg ha^{-1}) and statistically at par with ZT grain yield (5463 kg ha^{-1}). The grain yield was 19.1% and 18.7% higher in PB and ZT as compared to CT plots respectively. In maize the grain yield was significantly higher with ZT (11279 kg ha^{-1}) over CT (9427 kg ha^{-1}). The grain yield of maize in PB (10863 kg ha^{-1}) was found statistically at par with ZT. The grain yield was 16.4 % and 13.2% higher in ZT and PB as compared to CT plots respectively. In mustard there was no significant effect of tillage on grain yield.

However, maximum grain yield was recorded in ZT (970 kg ha^{-1}) which was statistically at par with PB (955 kg ha^{-1}) and CT (931 kg ha^{-1}). The grain yield was 4.0% and 2.5% higher in ZT and PB as compared to CT plots respectively. In chickpea there was significant effect of ZT on grain yield as compared to PB and CT. The maximum grain yield was recorded in ZT (1936 kg ha^{-1}) which was significantly higher over PB (1790 kg ha^{-1}) and CT (1705 kg ha^{-1}). The PB and CT crops produced almost similar yields while ZT plots produced 8% and 13% higher yield over PB and CT plots respectively.

The tillage had significant influence in straw yield of wheat only and there was no significant effect of tillage was found in stover yield of maize and straw yield of mustard and chickpea. In wheat straw yield was significantly higher in PB (8644 kg ha^{-1}) over CT (7575 kg ha^{-1}). The straw yield in ZT (7876 kg ha^{-1}) was found statistically at par with PB as well as CT. In maize the maximum stover yield was recorded in ZT (14080 kg ha^{-1}) which was statistically at par with CT (12835 kg ha^{-1}) and PB (12923 kg ha^{-1}). In mustard the maximum straw yield was recorded in CT (4175 kg ha^{-1}) which was statistically at par with ZT (3718 kg ha^{-1}) and PB (3695 kg ha^{-1}). In chickpea the maximum straw yield was recorded in CT (3314 kg ha^{-1}) which was statistically at par with ZT (3259 kg ha^{-1}) and PB (3032 kg ha^{-1}). Zero tillage had a significant influence in increasing the crop yield followed by permanent bed.

Due to early sowing under zero tillage and permanent bed condition resulted in early establishment of the crop and consecutive higher dry matter accumulation. The reduction in tillage is expected to result in a progressive change in the total porosity of soil and also consecutive changes in bulk density. However due to increased porosity the water capacity of the soil is increased with ZT and PB as a result the plant can utilize the major proportion of soil moisture for its growth and development. The reduction in tillage is expected to result in a progressive change in the total porosity of soil and also consecutive changes in bulk density. Considering the final biomass at harvest, wheat recorded significantly higher biomass under PB (14132 kg ha^{-1}) over conventional tillage (12017 kg ha-1) while in maize it was significantly higher under ZT (25359 kg ha^{-1}) than CT.

The positive effect of ZT and PB on grain yields of all the rabi crops (wheat, maize mustard and chickpea) was found in this experiment. All yield component of wheat, maize, mustard and chickpea was significantly higher in ZT compared to CT. Ultimately significant higher value of yield attributes of these four rabi crops were positively related to grain yield of the crops but grain yield of wheat was found significantly higher under PB whereas in rabi maize and chickpea yield was significantly higher in ZT. The results are in consistent with earlier studies from South Asia which showed higher crop yields under ZT compared to CT in rice-wheat and maize-wheat systems (Jat *et al.,* 2013; Gathala *et al.,* 2013; Singh *et al.,* 2016).The significantly higher wheat grain was recorded in the PB plots compared with CT plots, which could be attributed to the higher spike density, number of grains per spike and 1000-grain weight.

Fig.1 Weather condition during experimental season (2017-18)

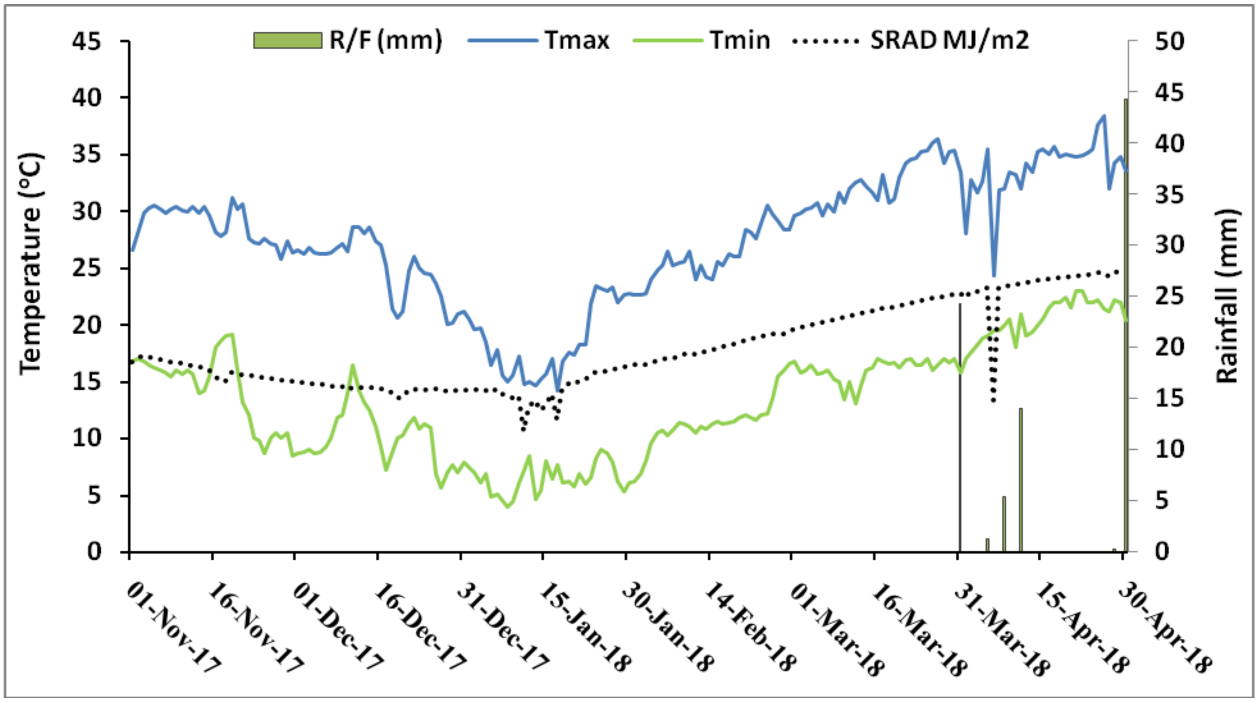

Table.1 Biological, grain, straw yield and harvest index of *rabi* crops as influenced by tillage methods

Rabi crops/ Tillage	Biological Yield (kg ha^{-1})	Grain yield (Kg ha^{-1})	Straw/ Stover yield (kg ha^{-1})	Harvest Index (%)
Wheat				
ZT	13339 ab	5463 a	7876 ab	41 a
CT	12017 b	4442 b	7575 b	37 b
PB	14132 a	5488 a	8644 a	39 ab
Maize				
ZT	25359 a	11279 a	14080 a	45 a
CT	22262 b	9427 b	12835 a	42 a
PB	23786 ab	10863 a	12923 a	46 a
Mustard				
ZT	4687 a	970 a	3718 a	21a
CT	5106 a	931 a	4175 a	18 b
PB	4650 a	955 a	3695 a	21 a
Chickpea				
ZT	5194 a	1936 a	3259 a	37 a
CT	5020 a	1705 b	3314 a	34 b
PB	4822 a	1790 b	3032 a	37 a

Table.2 Equivalent yield and economics of *rabi* crops as influenced by tillage methods

Treatment	Wheat equivalent yield (kg ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B.C. ratio
Tillage					
Zero Tillage	**5468**	30083	**94862**	**64779**	**2.09**
Conventional Tillage	4664	34295	80917	46622	1.33
Permanent Bed	5288	29954	91743	61789	2.02
S Em (±)	**138**		**2396**	**2396**	**0.08**
C.D at 5%	**542**		**9406**	**9406**	**0.31**
Rabi Crops					
Wheat	5131	32767	89022	56255	1.74
Rabi Maize	**8643**	49441	**149950**	**100509**	2.05
Mustard	2194	21892	38073	16181	0.77
Chickpea	4591	21675	79650	57975	**2.70**
S Em (±)	**90**		**1567**	**1567**	**0.06**
C.D at 5%	**268**		**4655**	**4655**	**0.19**
Interaction					
ZT-W	5463	31029	94782	63753	2.05
ZT-M	**9264**	47437	**160724**	**113288**	2.39
ZT-Mu	2235	20887	38780	17893	0.86
ZT-C	4908	20980	85162	64182	3.06
CT-W	4442	35597	77069	41473	1.17
CT-M	7742	51811	134330	82519	1.59
CT-Mu	2146	25849	37240	11391	0.44
CT-C	4324	23923	75029	51106	2.14
PB-W	5488	31677	95216	63539	2.01
PB-M	8922	49074	154796	105722	2.15
PB-Mu	2202	18940	38200	19260	1.02
PB-C	4539	20123	78760	58637	2.91
S Em (±)	156.39		**3356**	**3356**	**0.12**
C.D at 5%	**464.66**		**9970**	**9970**	**NS**

ZT-Zero tillage; CT-Conventional tillage; PB-Permanent bed; W-Wheat; M-Maize-; Mus-Mustard; C-Chickpea

The present findings are well supported by Dhillon *et al.*, (2000) and Hobbs and Gupta (2003) who also reported higher yields of wheat in bed-planted wheat than flat-planted wheat. The significantly higher yield of maize and chickpea in ZT system could be due to the compound effects of additional nutrients (Blanco-Canqui and Lal, 2009; Kaschuk *et al.*, 2010), lesser weed population (Ozpinar, 2006; Chauhan *et al.*, 2007), improved soil physical health (Jat *et al.*, 2013; Singh *et al.*, 2016), better water regimes (Govaerts *et al.*, 2009) and improved nutrient use efficiency compared to CT (Unger and Jones, 1998). In addition to all these factors, the root growth found better under CA compared to CT due to lesser compaction (Passioura, 2002; Blanco-Canqui *et al.*, 2006). The harvest index showed variable response in different crops due to alteration in tillage practices (Table 1). In wheat maximum harvest index was recorded in ZT (41%) which was significantly higher as compared to CT (37%). The harvest index in PB (39%) was found statistically at par with ZT as well as CT. In maize there was no significant difference in harvest index due to tillage practices. However, the maximum harvest index was recorded in PB (46%) which was statistically at par with ZT (45%) and CT (42%). In mustard maximum harvest index was recorded under ZT (21%) and PB (21%) which was significantly higher over CT (18%). In chickpea maximum harvest index was recorded in ZT (37%) and PB (37%) which was significantly higher over CT (34%).

Wheat equivalent yield

There was significant influence of tillage, rabi crops and their interaction on wheat equivalent yield (Table 1). In main plot due to tillage practices wheat equivalent yield was significantly higher in ZT (5468 kg ha^{-1}) over CT (4664 kg ha^{-1}) while wheat equivalent yield in PB (5288 kg ha^{-1}) was statistically at par with ZT. In sub plot due to rabi crops wheat equivalent yield was significantly higher in rabi maize (8643 kg ha^{-1}) over wheat (5131 kg h1^{-1}), chickpea (2194 kg ha^{-1}) and mustard (4591 kg ha^{-1}). The interaction effect of tillage and rabi crops was differed significantly, where wheat equivalent yield was at par in ZT-maize (9264 kg ha^{-1}) and PB-maize (8922 kg ha^{-1}) but significantly higher compared to rest of the interaction.

The wheat equivalent yield was 14.7% and 11.8% higher in ZT and PB as compared to CT plots respectively. The lowest wheat equivalent yield was recorded in mustard crop irrespective of tillage systems.

Effect of different tillage practices on economics

Economics of rabi crops was significantly influenced by different tillage methods and rabi crops. The cost of cultivation for different rabi crops was almost similar in PB (Rs. 29954 ha^{-1}) and ZT (Rs. 30083 ha^{-1}) but was lower than CT (Rs. 34295 ha^{-1}). As a result, the net return and benefit cost ratio (B: C ratio) was significantly higher with ZT and PB over CT (Table 2).

Due to tillage practices the maximum net return and B: C ratio of Rs. 64779 ha^{-1} and 2.07 respectively was recorded with ZT which was significantly higher over CT (Rs. 46622 ha^{-1}and 1.33) while statistically at par with PB (Rs. 61789 ha^{-1} and 2.02). Among rabi crops maximum net return Rs. 100509 ha^{-1} was recorded in rabi maize which was significantly higher as compared to other rabi crops but chickpea recorded maximum B: C ratio (2.70) which was significantly higher over other rabi crops. Interactions between tillage and rabi crops showed significant influence on gross return, net return and B: C ratio. ZT-maize (Rs. 160724 ha^{-1}) recorded significantly higher gross return as compared to CT-maize (Rs 134330 ha^{-1}) while gross return in PB-maize (Rs. 154796 ha^{-1}) was statistically at par with ZT-maize. Gross return of wheat was found significantly higher in PB-wheat (Rs. 95216 ha^{-1}) over CT-wheat (Rs 77069 ha^{-1}) while statistically at par with ZT-wheat (Rs. 94782 ha^{-1}). Gross return of chickpea was found significantly higher in ZT-chickpea (Rs. 85162 ha^{-1}) over CT-chickpea (Rs 75029 ha^{-1}) while statistically at par with PB-chickpea (Rs. 78760 ha^{-1}).

Tillage practices contribute significantly to the labour cost as well as land preparation cost for any crop production system resulting in lower economic returns (Gowing and Palmer, 2008). The return compared to the investment was much higher with ZT system compared to the CT system. In the present experiment due to ZT and PB the cost of cultivation reduced by 12.3 and 12.6 per cent and gave 28 and 24 per cent higher net return as compared to CT, respectively. The B: C ratio was 36.6 and 34.1per cent higher in ZT and PB as compared to CT respectively. The higher net return and B: C ratio in ZT and PB were attributed mainly to lower cost of cultivation and the higher yield levels which eventually led to the increase in net return over CT. On average more than half of the benefits were due to cost savings and the rest part was mainly due to yield increase with ZT system. These increments in net returns were mainly due to non- requirement of preparatory tillage unlike in CT where 4–5 tillage operations were performed before sowing of crops. Similar results pertaining to the tillage system were also reported by many researchers (Yadav *et al.,* 2017; Parihar *et al.,* 2016; Singh *et al.,* 2014).

The grain yield of wheat obtained under PB and ZT was 19.1% and 18.7% higher than CT respectively. The grain yield of maize was 16.4 % and 13.2% higher in ZT and PB as compared to CT plots respectively. The mustard crop under PB and CT produced almost similar yields while ZT plots produced 8% and 13% higher yield over PB and CT plots respectively. Tillage methods showed significant effect on straw yield of wheat crop only, which was maximum and 12.36% higher under PB as compared to CT. The harvest index (H.I.) of wheat, mustard and chickpea were 9.8%, 14.28% and 8.1% higher under ZT than CT. The wheat equivalent yield was 14.7% and 11.8% higher in ZT and PB as compared to CT plots respectively. Among rabi crops maize equivalent yield was found maximum in rabi maize followed by wheat, chickpea and mustard. ZT and PB resulted in 12.3% and 12.5% lower cost of cultivation while 28.0% and 24.5% higher net return over CT respectively. Among rabi crops highest net return was found in maize followed by chickpea. B: C ratio was 36.6% and 34.1% higher in ZT and PB over CT respectively. Among rabi crops maximum B: C ratio was recorded in chickpea (2.70) followed by maize (2.05).

Based on one-year data of experiment it can be concluded that the conservation agriculture-based zero tillage and permanent bed tillage practices along with residue retention resulted in significant increase in total biological yield, grain production and productivity of rabi crops with higher net returns and B:C ratio than conventional tillage. The overall improvement in soil condition resulted in higher wheat equivalent yield (WEY) of rabi crops especially in wheat followed by maize, chickpea while the least increase in WEY was recorded in mustard as compared to conventionally tilled rabi crops.

With all these evidence we can say that zero tillage along with partial residue retention can be adopted for sustainable and profitable cropping in the region.

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