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Effects of Zero Tillage Technology in Wheat under Humid Subtropical Climate of Begusarai, Bihar, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted in Rabi of 2019-20, 2020-21 and 2021-22 in Begusarai district of Bihar under Frontline Demonstration programme on "Zero Tillage (ZT)" technology in wheat cultivation by KVK (Krishi Vigyan Kendra) Begusarai. The data on Productivity, Economics, Extension gap and Water saving were calculated and compared with the farmer's practice (FP). In ZT wheat cultivation, saving in cost of crop establishment, water saving and net return were observed more than FP. The average productivity was recorded 50.37 q/ha and 43.13 q/ha in case of ZT and FP respectively, correspondingly crop establishment cost in case of ZT was found 30.55 per cent lower

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than FP. Similarly, overall average net return in case of ZT wheat cultivation was recorded as Rs 70813/ha per hectare which is 61 % higher than FP. The average calculated B:C ratio for ZT and FP was 3.47 and 2.06 respectively. The average extension gap, Technology gap and Technology index for three consecutive years were perceived 7.24 q/ha, 7.55 q/ha and 18.66 % respectively. It has been observed that there was decreasing trend of extension gap and technology gap in the selected area which reflects the satisfactory adoption rate of the demonstrated technology for the cultivation of wheat. It was recorded that ZT is significantly superior over the FP in terms of several parameters under the study.

Keywords: Extension gap; FLD; mechanization; wheat cultivation; zero tillage.

1. INTRODUCTION

Bihar is blessed with good soil and adequate water resources but it's yields have been lagging below India's average. Farmers in Bihar cultivate wheat on more than 2 million ha of land and produce 5-6 million tonnes of it every year. Wheat occupies 28% of the gross cropped area of Bihar and 70% of the sown area in the Rabi season [1].Today, the average hectare of Bihar farmland produces 2.9 tons of wheat – significantly below the average yield in India of 3.4 tons reported by CIMMYT in 2023. Begusarai lies in the middle part of Gangetic plain which is a low-lying flat terrain (MSL 45m-32m). This area has slope from southern side to southeastern side. It creates access for several streams. Geomorphologically, Begusarai district is a part of Gandak- Kosi confluence. Southern part of this district appears to be an elevated landmass and serves as a safer destination during flood. Begusarai district is divided into three major flood plains viz. Kereha-Old Bhagmati flood plains, Burhi Gandhak flood plains and Ganga flood plains.Wheat is the single largest crop of Begusarai district and covers about 61720 ha area with an average yield of 3742 kg/ha, the highest in Bihar, in year 2019-20 as per Bihar Economic Survey 2020-21. The most widely adopted resource conserving technology in the Indo-Gangetic Plains (IGP) of South Asia is zero-tillage wheat, particularly in India [2]. Zero tillage is sowing of next crop without tillage in weed free paddy harvested field at optimum moisture level by the Tractor drawn Zero tillage implement. This not only advances sowing time but also reduces the tillage cost and diesel consumption consequently reduces greenhouse gas emission. Zero tillage is also known as zero till, no till, direct seeding and direct drilling [3]. Zero tillage is the technology in which wheat can be sown without tillage operation just after harvesting of paddy. The prevailing ZT technology in the IGP uses a tractor drawn zero-till-ferti-seed drill to seed wheat directly into unploughed fields in a single pass of the tractor. The typical ZT drill has inverted-T openers and opens a number (6–13) of narrow slits for placing seed and fertilizers at the depth of 5.0–7.5 cm into the soil (Mehla et.al 2000). It consists of two boxes on the top, one is seed box and another is fertilizer box, fluted roller (seed metering mechanism), seed tube, furrow opener, frame structure, ground wheel, chain & sprocket mechanism, seed and fertilizer adjusting lever etc. By seed and fertilizer adjusting lever seed rate and fertilizer rate can be adjusted respectively. For the control of depth of operation, depth controlling wheels (Guage wheel) are also given in ZT. Whereas Tillage is the mechanical manipulation of soil to provide favourable condition for crop growth. Soil tillage consists of breaking the compact soil surface to a certain depth and loosening the soil mass to improve soil-seed contact and enable the roots of the crop to penetrate and spread into the soil. It is the first operation for the crop production and requires higher amount of energy as well as it is a high cost operation. Primary tillage and secondary tillage are required for the complete seedbed preparation, which is costly and time consuming for the farmers [4,5].

Farmers generally perform tillage operation as many as possible with the belief that more tillage would result in more crop yield. The late-sown crop resulted lower yield, which encountered higher temperature in its terminal growth stages [6]. This loss in yield can be saved through early seeding of wheat by zero tillage techniques. This technique advances the sowing operation by 10-15 days and also reduces the cost of production by saving energy [7]. Keeping this in view frontline demonstration on ZT technology in wheat cultivation was conducted with the following objectives-

i. To evaluate the effect of ZT technology on economic return for the wheat cultivation and compared with farmer's practice under

humid subtropical climate of Begusarai district.

ii. To evaluate the extension gap and technology gap for ZT technology in wheat cultivation.

2. MATERIALS AND METHODS

Total 20 frontline demonstration were conducted in Rabi 2019-20, 2020-21 and 2021-22 at randomly selected farmer's field of Bhagwanpur, Cheria Bariyarpur and Khodawandpur blocks of the district Begusarai of Bihar in rice-wheat cropping sequence to ratify the impact of ZT technology for wheat cultivation. Begusarai lies on the northern bank of the river Ganges and is located at latitudes 25.15N & 25.45N and longitudes 85.45E & 86.36E. Begusarai is 16th in terms of population (29,70,541) and 27th in terms of area (1,918 sq.km.) in the state of Bihar. Five villages were covered among the three blocks namely Bhagwanpur, Rampur, Barkurba, Gopalpur, Khodawandpur. The location of farmer's field in Bhagwanpur lies at Latitude 25.553278° longitude 86.00573°, in Rampur lies at latitude 25.621432 ° longitude 86.024118 ° , in Barkurba latitude 25.605067 ° longitude 86.077752 ° , in Gopalpur lies at latitude 25.632184 ° longitude 86.025752 ° , in Khodawandpur lies at 86.02824 ° [8,9].

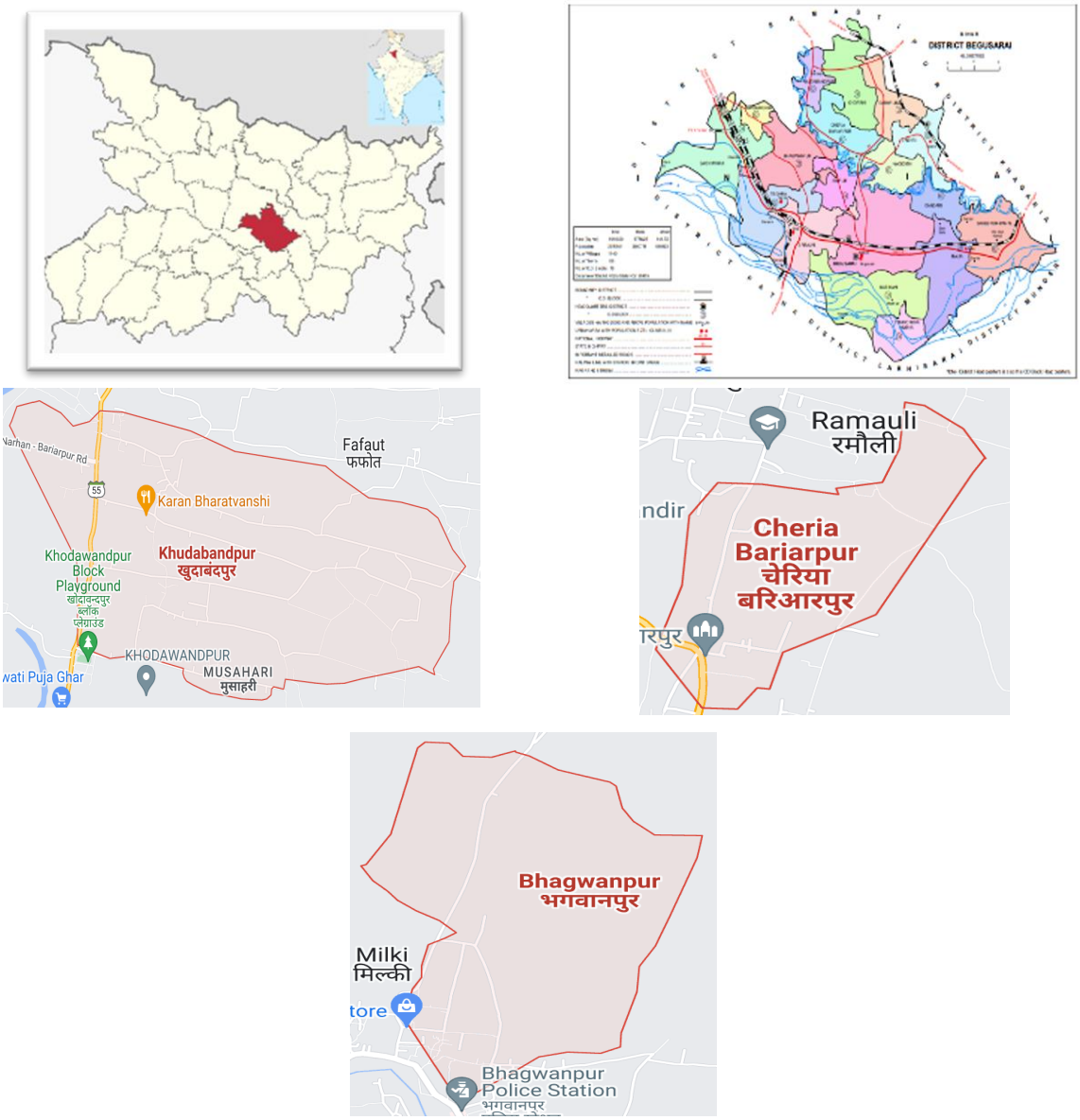

Fig. 1. Map of Operational Blocks in the Begusarai district of Bihar

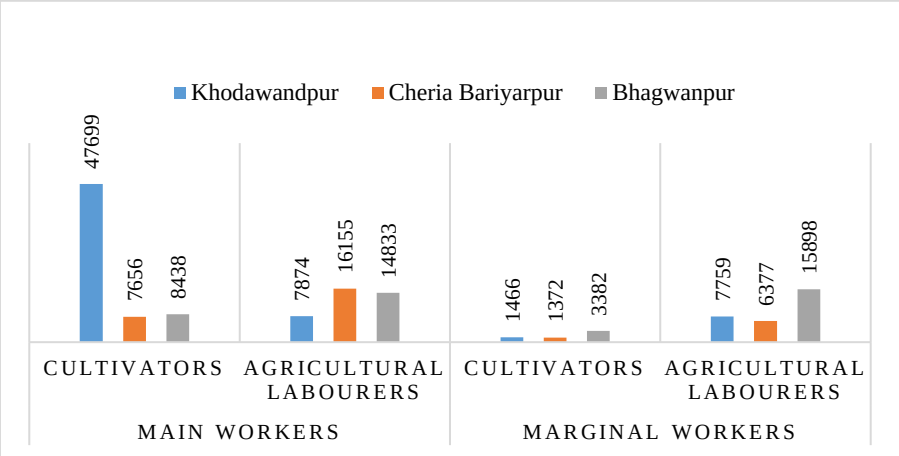

Fig. 2. Workers population related to agricultural activities
Source- District Sensus Handbook Begusarai

As per the census of India 2011, Khodawandpur occupies total 47.27 square kilometer area under rural whereas Cheria Bariyarpur and Bhagwanpur occupies total 103.86 and 113.41 square kilometer area respectively under rural section. Total number of households were 19150, 31044 and 35035 in Khodawandpur, Cheria Bariyarpur and Bhagwanpur respectively. Total population of Khodawandpur, Cheria Bariyarpur and Bhagwanpur were 90358 (47074 males, 43,284 females), 146680 (76665 males, 70,015 females) and 172676 (91222 males, 81454 females) respectively. There are main workers and marginal workers in the operational blocks.

The location has a humid subtropical, dry winter climate and winter season starts from mid-October and ends in month of February. Type of soil was sandy loam. All the farmers have average land holdings between 1 to 2 ha. The major crops of the selected areas are paddy, maize, wheat, some spices and vegetable crops like potato, cauliflower, cabbage etc. In Rabi season, they mainly grow wheat for domestic as well as income purpose. Each demonstration was 0.4 ha area and as a critical input seed and zero tillage implement was supplied to the farmers by KVK and other inputs were applied as per the recommendation and the variety of wheat was HD-2967. The sowing of wheat was done from 10th November to 15th November by ZT technology and in case of FP it was sown from 25th November to 10th December and harvesting was started from 31st March to 15th April. In FP, they firstly prepared seedbed before sowing. In seedbed preparation two pass of disc harrow and one pass of rotavator were done. Then seed was broadcasted and followed by one pass of rotavator and one pass of cultivator. Farmers are used to hire the tractor along with implements for these operations. Whereas in ZT method, seed is being sown in single pass of zero tillage machine. Total 20 frontline demonstrations in 8 ha area were conducted. Along with the FLD farmers were also trained about the calibration, care & maintenance of Zero Tillage implement. The prevalent hiring charge of different machineries in the district is given in Table 1.

Table 1. Hiring charges of different implements along with tractor in Begusarai

Machine/ implements	Hiring Charges (Rs/ha)
Tractor with Rotavator two passes	6075
Tractor with disc harrow, two passes	4050
Tractor with Zero Tillage	2700
Self-Propelled Reaper Cum binder	5063

Due to short stubble and absence of weed application of weedicide was not done. Directly sowing of seed as well as application of fertilizer (except potash) was done by the Zero Tillage in a single pass. Application of potash was done before sowing as it creates problem of clogging in seed metering mechanism of zero tillage. First irrigation was given after 21 days after sowing at crown root initiation stage (CRI).

The data such as per cent increase in grain yield, benefit cost ratio (BCR), water saving, Extension gap, Technology gap, Technology index was

recorded from the selected FLD plots and farmers practice and presented in term of percentage by using following formulas:

% increase in grain yield=(Deminstration yield-Local check yield)/(Local check yield) X 100

$$\text{B: C Ratio} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

On the basis of data collection from the both FLD plots and control plots the extension gap, technological gap, technological index was calculated by using following formula-

Extension gap = Demonstration yield-Farmers yield

Technology gap = Potential yield-Demonstration yield

Technology index =(Potential yield - Demonstration yield)/(Potential yield) ×100

3. RESULTS AND DISCUSSION

Harvesting of crops of all the demonstration plots were done under the supervision of KVK scientists. Productivity of both ZT and FP plots were compared and it was observed that average yield of demonstrated plots was 16.78 per cent higher than that of FP (Table 3).

3.1 Crop Establishment Cost

Table-1 revealed that the total cost of crop establishment in case of FP was Rs 10125/ha whereas it was Rs 2700/ha in case of ZT. Farmers are using broadcasting method for the application of fertilizer and seeds. Due to this operation increase in application rate of NPK, non-uniformity in fertilizer application and increase in crop lodging due to western wind and yellowing of crop after first irrigation were observed. Increment in total cost of fertilizer were found 19.94 per cent as compared to demonstrated technology. So total input was higher in FP whereas output was found less due to risk of crop lodging, attack of insect pest (Late sowing of wheat) etc.

In the Zero tillage method the cost of seedbed preparation was completely saved. The average cost of cultivation of wheat in zero tillage method was estimated about Rs 28518 /ha and minimum chance of losses were observed while on the contrary the same was estimated about Rs 41066/ha which is 30.55 per cent higher than ZT method.

3.2 Grain Yield

Results of three years Front Line Demonstration were recorded and given in Table-3. As per the observation an average yield was recorded 50.37 q/ha of demonstration plot whereas under farmers practice it was recorded 43.13 q/ha. These results clearly indicated that the average grain yield of demonstration plot is 16.78 per cent higher than the FP. Meena et al. [10] also observed the higher wheat yield in zero tillage as ZT wheat farmers could sow the crop much earlier than their conventional counterpart and early sowing is associated with higher yield, a significant and positive yield impact (increased by 15.73 %) observed in the study area. Punia et.al. [11] also found the same. The yield of wheat could be increased over the yield obtained under farmer's practices by the use of Zero tillage technique [12].

Fig. 3. Different stages of ZT wheat at farmers field

Table 2. Comparative cost analysis of both wheat establishment methods

Particulars	Farmers Practice (Rs/ha)	Zero Tillage Technology (Rs/ha)
Weedicide cost	1350	0
Fertilizer cost (NPK)	4888	3913
Tillage and sowing cost	10125 (2 passes of disc harrow & 2 passes of rotavator)	2700 (Single pass of Zero tillage machine)
Irrigation cost	10135 (3 irrigation)	6757(2 irrigation)
Harvesting cost	5063	5063
Miscellaneous Cost	10000	10000
Total	41561	28433

Irrigation cost= @ Rs 50/ 148 m^2)

Table 3. Economic Impact of Zero tillage technology under FLDs

Year	Particulars	Cost of Cultivation	Yield	Gross Return	Net Return	BCR	No. of irrigation	Depth of irrigation	Irrigation water (%)
2019-20	FP	40,500	42.80	82,390	41,890	2.03	3	30.8	30.19
	ZT	28,455	49.79	95,845	67,390	3.36	2	21.5	
2020-21	FP	41,200	43.50	85,912	44,712	2.08	3	31.2	27.24
	ZT	28,200	50.75	1,00,231	72,031	3.55	2	22.7	
2021-22	FP	41,500	43.10	86,846	45,346	2.09	3	30.7	28.99
	ZT	28,900	50.58	1,01,918	73,018	3.52	2	21.8	
Average	FP	41,066	43.13	85049	43,982	2.06	3	30.9	28.80
	ZT	28,518	50.37	99331	70,813	3.47	2	22	

Table 4. Productivity and gap analysis of ZT and FP

Year	Yield (q/ha)		Change in Yield (%)	Extension gap (q/ha)	Technology gap (q/ha)	Technology Index (%)
	ZT	FP				
2019-20	49.79	42.80	16.33	6.99	12.69	34.2
2020-21	50.75	43.5	16.66	7.25	5.57	12.32
2021-22	50.58	43.10	17.35	7.48	4.38	9.48
Average	50.37	43.13	16.78	7.24	7.55	18.66

3.3 Economic Return

The inputs and outputs prices of commodities prevailed during the study of demonstration were taken for calculating net return and Benefit-cost ratio [Table 3]. The cultivation of wheat under FLD gave higher average net return which is Rs. 70,813 per ha as compared to farmers practice i.e. Rs 43,982 per ha. BCR of three consecutive years were calculated which is given in Table 3 and average net return was found 61 per cent higher in case of ZT wheat cultivation as compared to FP. The average benefit cost ratio of ZT wheat cultivation was found 3.47 as compared to 2.06 under farmer's practice. Chourasiya et al. [13] also reported that due to reduced cost of cultivation and higher crop yield, the gross and net return was also higher in zero tillage as compared to the conventional sowing. Similarly, Kushwah et al. [14] also reported the same. Saving in water was observed 28.80 per cent higher than FP in case of ZT wheat cultivation.

3.4 Extension and Technology gap

An extension gap between the ZT and FP was calculated on an average basis. It was found 7.24 q/ha (Table 4). This gap might be imputed to the adoption of Zero tillage technology which encourage the correct seed rate at certain depth, uniformity in fertilizer application at optimum depth (just 1 cm below the seed), timeliness sowing, line sowing which reduces the losses due to western wind, moisture conservation due to the existence of crop residue. Chourasiya et al. [13] also calculated and found that an extension gap between demonstrated technology and farmers practices on an average basis was 5.99 q/ha. On the basis of extension gap awareness among the farmers were created and convinced to adopt the technology for the cultivation of wheat so that an extension gap may be reduced and to enhance the productivity. The average technology gap and technology index was found 7.55 q/ha and 18.66 per cent respectively. The technology gap and technology index has steadily declined every year (Table 4) which indicates ZT wheat cultivation is adequate for transferring to the farmers of Begusarai district and also sufficient extension services for transfer of the technology [15,16,17].

4. CONCLUSIONS

Zero tillage technology is beneficial and helpful for increasing income generation under humid subtropical climate especially for marginal and small farmers. As advanced and timely sowing is possible due to mechanization, beneficial effect of early sowing on grain and straw yields of wheat may be obtained by zero tillage technology. In ZT wheat cultivation yield and net return 16.78 % and 61 % higher than FP respectively. Correspondingly average 28.80 % irrigation water was saved in ZT wheat cultivation. It improves water productivity by utilizing residual moisture for sowing and eliminates pre-sowing irrigation. ZT also improves soil physical characteristics in due course of time due to the presence of crop residue. It can reduce the impact of climate change, increasing fuel cost and frequent change in weed flora in wheat field. As wheat is the single largest crop of Begusarai district and covers about 61720 ha area, therefore by the adoption of ZT wheat cultivation in whole district, it can fetch additional income of Rs 87.05 crores, decrease diesel consumption by 78% and additional production of 49376 ton per year.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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