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Economic Impact of Wheat Sowing Through Zero Tillage Technique against Broadcasting under Hot Sub-humid (Moist) Eco-Region Uttar Pradesh, 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

Aims: The production of cost of wheat is higher in farmers practice than the zero tillage sown of wheat due to non-adoption of recommended resource conservation technology, high-yielding varieties and advanced technologies by the farming community in the eastern plains of Uttar Pradesh. To replace this anomalous, we conducted 204 front-line demonstrations (FLDs) at farmers' fields in various adopted villages by Krishi Vigyan Kendra, Deoria.

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Place and Duration of Study: The study was carried out by the Krishi Vigyan Kendra, Malhana, Deoria, under the Indian Institute of Vegetable Research, Varanasi, UP.
Methodology: Prior findings were examined to identify any gaps and to enlist everyone's assistance in disseminating such a technology of global relevance. In the eight years from 2011–12 to 2018–19, a total of 204 FLDs were carried out at the 230 farmer's fields in the 32 villages where wheat was sown by zero tillage.
Result: Rice-wheat cropping systems are the most often used agricultural method in Uttar Pradesh, India's hot, sub-humid (wet) eco-region. It provides farmers and agricultural labourers with a source of subsistence and revenue and is a crucial aspect of the region's infrastructure for food safety. In order to attain sustainable yield, it is always thought necessary to employ other alternatives of conserving essential inputs by adopting resources conservative techniques (RCT), such as zero tillage and broad bed furrow (BBF). According to the economic analysis of the data presented in the current study, zero tillage wheat farming is the most cost-effective and appealing alternative for the agricultural community of eastern Uttar Pradesh. When compared to the broadcasting method, the zero tillage technique yielded a higher return and a lower cost of cultivation per acre. Finally, the use of this strategy raises farmers' net returns, improves their social standing, living conditions, livelihood, and ultimately reduces poverty in the farming community.
Conclusions: The new approach lowers production costs while producing equivalent wheat yields to other methods, which leads to higher net returns. Farmers in the area have begun to appreciate the technology's reduced tillage costs. Rice-wheat is the prevalent farming system practiced by the majority of farmers in the region. In the future, the prospect of extending the method to sow wheat after other crops should be investigated.

Keywords: RCT; zero tillage; broadcasting; cost of cultivation; net return and B: C ratio.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's main cereal crop in terms of acreage and production, and it is grown in the majority of the world. It is a vital and important staple meal for the bulk of the world's population. It has largely contributed to the success of the green revolution and has greatly aided in the journey of our country from a "ship to mouth" condition to one of being self-sufficient. India produces 101.19 million tons of wheat, second only to China in terms of production, on 29.58 million hectares of land at a productivity of 3507 kilograms per hectare [1]. Uttar Pradesh, Madhya Pradesh, Punjab, Rajasthan, Haryana, Bihar, Gujarat, and Maharashtra major contributing states in both area and production. Among them, Uttar Pradesh leads in both area and production, while Punjab leads in productivity. It is grown on a 9.54 million hectare (ha) area in Uttar Pradesh, generating 32.75 million tons with a productivity of 34.32 q ha^{-1}, significantly less than the national average of 34.40 q ha^{-1} along with other states such as Punjab and Haryana [1]. Production must be increased further to satisfy the needs of an expanding population, to maintain enough buffer stock, and to fulfill the increasing demand of food processing industries.

Tillage is the mechanical management of soil to make it more suitable for seeding and planting. Consistency in using Long-standing traditional tillage techniques have led to exposed land surfaces, declining soil fertility, significant water loss, soil erosion, and a declining ecological habitat. Encourage systematized protective tillage and soil moisture conservation appropriate for intense agricultural locations in order to achieve sustainable agricultural expansion. According to Hatfield and Karlen [2], reduced tillage approaches have significant environmental advantages over conventional tillage systems. Tillage technologies based on conservation agriculture, such as zero tillage, strip tillage, reduced tillage, and raised bed planting, are gaining appeal among farmers due to specific advantages over traditional tillage [3]. Zero tillage is the most advantageous conservation agriculture-based technology in terms of reduced soil degradation, more microbial activity, more efficient use of inputs, improved soil fertility, and a more sustainable ecosystem [4,5]. According to Qaisrani et al. [6], zero-tillage involves opening a small slot or band that is just wide enough and deep enough to achieve proper seed placement. This technique results in lower land preparation costs and less disturbance to the soil because there are fewer tillage operations and

consequently fewer tractor and tillage implement trips over the soil.

Additionally, a zero-tillage system with residue management supports the natural retention of organic matter in topsoil and the preservation of soil moisture [7]. The most useful conservation agriculture techniques for dry soil are zero tillage and strip tillage, which have been developed by various organizations using a power tiller (two-wheel tractor). In India, a number of promotional initiatives are being implemented to assess how well-established conservation agricultural practices operate in the field. The rice-wheat farming strategy was the main focus of earlier promotional work.

The majority of farmers do not fully embrace agricultural technology in all areas. As a result, there consistently seems to be a discrepancy between the technology that scientists advocate and its modified version at the level of the farmer. Thus, the main obstacle to raising agricultural productivity in the nation is the technology divide. It is necessary to reduce the technological gap between agricultural technology developed by scientists and its application by farmers on their farms. The current inquiry attempted to look at the production gaps between farmers' yield and that of the Front Line Demonstration trial, the level of technological adoption, and the benefit-cost ratio.

1.1 Agricultural profile of Deoria (Study Area)

This district is located between 26° 6′ north and 27° 8′ to 83° 29′ east and 84° 26′ east longitude out of which district Kushinagar was created in 1994 by taking north & east portion of Deoria district. Net sown area and net irrigated areas of the district are 79.5% and 85.9% respectively. Therefore cropping intensity of the district is 158% [8]. In the district, there is an average annual rainfall of 1120 mm and climate is defined by the hot and humid rainy season, the cold and dry winter, and the hot and dry summer. Due to the highly varied and heterogeneous conditions of its production, wheat yields are low in Deoria. Spreading Direct Seeded Rice and Zero Tillage Wheat, which are adaptive in most agro-climatic zones, was done to increase rice and wheat yield while preventing socio-economic imbalances. Indian agriculture has undergone several changes since independence; the green revolution encouraged farmers to invest in inputs, but declining factor productivity and rising cultivation costs due to rising input prices stole the farmers' profitability. The issue has gotten worse as a result of rising diesel, tractor, fertilizer, seed, and agricultural equipment prices. Therefore, it is absolutely necessary to make considerable efforts to lower cultivation costs and enhance production in order to maintain sustainability and boost farmers' profit margins. The need of the hour is to communicate about natural resources through technology that conserves resources. As a result, Krishi Vigyan Kendra has introduced Zero tillage technology in wheat in the district of Deoria with the assistance of CSISA project.

2. MATERIALS AND METHODS

The study was conducted by the Krishi Vigyan Kendra, Malhana, Deoria, under the auspices of the Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, with the assistance of CSISA. This under the supervision of the Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, and the study was carried out by the Krishi Vigyan Kendra, Malhana, Deoria, with the assistance of CSISA project. Front line demonstrations (FLDs) at selected farmer's fields were used to evaluate this comparative study of wheat sowing using zero tillage technique and broadcasting in hot sub-humid (wet) Uttar Pradesh, India, from 2011–12 to 2018–19. A survey with over 100 progressed farmers was done in 2009–10 by Krishi Vigyan Kendra, Deoria. The survey revealed that only two useless zero-till machines were available at the time in this district. The farmer's field produced wheat an average of about 30 quintals per ha, and there was hardly any zero-till land. Following a survey, demonstrations of zero tillage wheat were launched during the 2009–10 in Rabi season. The initial round of demonstrations was planted in 15 acre area at 15 farmer's fields across three villages. We have been working to promote technology in Deoria to get ever since the preliminary results were promising. However, in the Bhatparrani block of the district, this approach may cover up to 60.5 acres with 42 farmers in 6 villages in 2010–2011. It was determined to expand coverage and adoption in the district with more villages and farms after taking the farmers' feedback into consideration. Prior findings were examined to identify any gaps and to enlist everyone's assistance in disseminating such a technology of global relevance. In the eight years from 2011–12 to 2018–19, a total of 204 FLDs were carried out at the 230 farmer’s fields in the 32 villages where wheat was sown by zero tillage (Table 1).

The study regions' sandy soils have a moderately to well-drained texture and a shallow tubewell ground water irrigation system. The research locations have well to extremely good soil fertility. The crop was sown following the paddy harvest, between the third and second weeks of November, and it was harvested in April. A basal application of Dia ammonium phosphate (DAP) (grade NPK 18:46:0) @ 52 kg/acre and Muriate of Potash @ 25 kg/acre were applied during the zero-till seed cum ferti-drilling of the wheat crop at a seed rate of 50 kg/acre. Urea, the final dose of nitrogen, was delivered in two split applications at a rate of 50 kg/acre. Weeds population were the major threat in wheat sown by zero tillage technique therefore spray of herbicides to control *Phalaris minor*, broad leaf weeds and sedges at 25 DAS. The resource conservation technique (ZT) was compared with broadcasting technique using by the farmers. The FLDs were conducted to determine the gaps between the broadcasting

Table 1. Details of front line demonstrations (FLDs)

S. No	Year	Details of Front Line Demonstrations (FLDs)		
		Area (acre) under FLD	Number of farmers	Number of village
1	2011-12	20	19	05
2	2012-13	25	32	08
3	2013-14	32	39	06
4	2014-15	24	27	08
5	2015-16	12	13	04
6	2016-17	12	13	05
7	2017-18	12	15	04
8	2018-19	12	13	05
Total		**204**	**230**	**32**

Table 2. Agronomical practices used for wheat growing under FLDs and farmer practice

S.No	Particulars	Demonstrations practice	Farmers Practice
1.	Farming Situation	Irrigated and sandy loam	Irrigated and sandy loam
2.	Method of sowing	Zero tillage sowing	Broadcasting
3.	Seed rate (Kg/acre)	50	64
4.	Fertilizers(Kg/acre)	120:60:40, N:P:K	120:60:40, N:P:K
5.	Date of sowing	Third week of November to first week of December	Last week of November to second week of December
6.	Irrigation facilities	Shallow tubewell	Shallow tubewell
7.	Number of Irrigation	3	4
8.	Herbicides	Pre & Post emergence	Post emergence
9.	Date of Harvesting	April	April
10.	Harvesting method	Combine harvester	Combine harvester

approach and zero tillage, which was estimated using industry-standard techniques. The agronomic methods used in the current study in connection to FLDs and farmer practices are listed in Table 2.

The critical inputs in the form of quality seeds of recommended high yielding varieties for FLDs were provided to the farmers by Krishi Vigyan Kendra (IACR-IIVR), Deoria. The farmers were facilitated in performing of field operation like sowing technique, watering, fertilizer application, weed control measures, crop harvesting, post harvest technique, threshing and storage *etc.* The trainings on zero tillage, method demonstrations, field visits to the farmers and field days were organized during the study period. The data was recorded on input wise cost of cultivation and grain yield from FLDs at the farmer's field for comparative study. The Net return and benefit cost ratio is calculated with following formula.

Net return = Gross return (Rs. /ha) – Cost of cultivation (Rs. /ha) …… (1)

B: C= Gross return (Rs. /ha)/ Cost of cultivation (Rs. /ha) …….. (2)

3. RESULTS AND DISCUSSION

3.1 Economic Impact on Cost of Cultivation

Zero tillage combined with farmer practices led to a 100% reduction in tillage operation costs and an increase in yield per acre (Fig. 1). In accordance with farmers' practice, the preparation of land for wheat sowing requires two plowing operations: one after harvesting the previous crop and the other two after pre-sowing. Data depicted in Fig. 1 shows that 11.1 percent less cost is required to seed and seed sowing than farmers' practice during the past 8 years analysis of the wheat crop. Zero tillage combined with farmer practices led to a 100% reduction in tillage operation costs and an increase in yield per acre (Fig. 1). In accordance with farmers' practice, the preparation of land for wheat sowing requires two plowing operations: one after harvesting the previous crop and the other two after pre-sowing. In addition, placing fertilizer (such as a DAP or NPK mixture) below the wheat seed in a zero-tillage crop has an advantage over farmers' traditional fertilizer delivery techniques (such as broadcasting). The cost of weed control with zero tillage is 33.3 percent higher than farmers' practices over the analysis period from 2011–12 to 2018–19 (Fig. 1). Under wheat that was sown with zero tillage, two herbicide sprays were used: one was pre-emergence and the other was post-emergence. According to the farmer's practice, post-emergence herbicide application consists of a single spray. As a result, under the zero tillage seeded wheat system, weed control is more expensive than what farmers now do.

3.2 Impact on Grain Yield

Zero tillage sown of wheat was evaluated against broad casting (farmers practice) through front line demonstration on selected farmer's fields in Deoria district during Rabi Season 2010–11 to 2018–19. The results demonstrated technologies compared with farmers practices are presented in Table 3. The average yield of ZT sown wheat was recorded at 47.55 q per ha. In the 8 years of study period, which was 13.9% higher than the broad casting method. Similar trend was reported by Keil et al., [9] under ZT in the Eastern Indo-Gangetic Plains. Better performance and on-farm demonstration of local methods are enough to entice the farming community to grow what crop. The results indicated that the FLDs have had a good impact on the farmers' community of Deoria district, as motivated by the recently introduced resources conservation technologies in the farmer's fields.

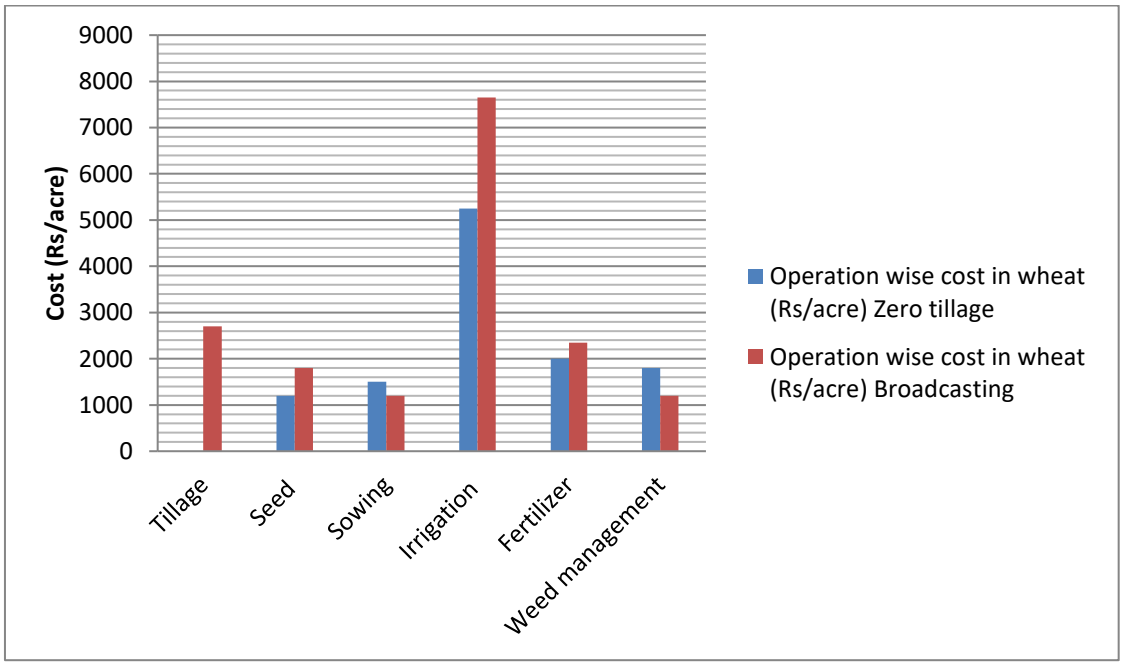

Fig. 1. Comparative study of average cost of operation of ZT and broadcast during study period

Table 3. Average grain yield, gross cost, gross return, net profit and B: C ratio of wheat under ZT and Farmer Practice (FP) during 2010-11 to 2018-19

Year	Grain Yield (qt/ha)		Economic of Demonstration (Rs)				Economic of FP (Rs)			
	FLDs	F P	Gross Cost	Gross Return	Net Return	B:C	Gross Cost	Gross Return	Net Return	B:C
2011-12	39.6	38.5	25470	39500	14030	1.5	24260	35300	11040	1.4
2012-13	40.3	38.1	20550	54600	34050	2.6	26010	54460	28450	2.1
2013-14	44.8	37.4	30240	73200	42960	2.4	31220	62100	30900	1.9
2014-15	50.4	38.6	25270	88350	63080	3.4	32810	88200	55390	2.6
2015-16	50.8	39.0	35290	77880	42590	2.2	36340	75180	38840	2.0
2016-17	57.6	55.1	42970	95415	52445	2.2	43650	94598	50948	2.1
2017-18	58.2	52.9	39325	90230	50905	2.2	44960	79626	34666	1.7
2018-19	57.6	51.2	38440	92160	53720	2.3	45620	81920	36300	1.7
Average	47.55	41.72	32194	76417	44222	2.3	35609	71423	35817	1.9

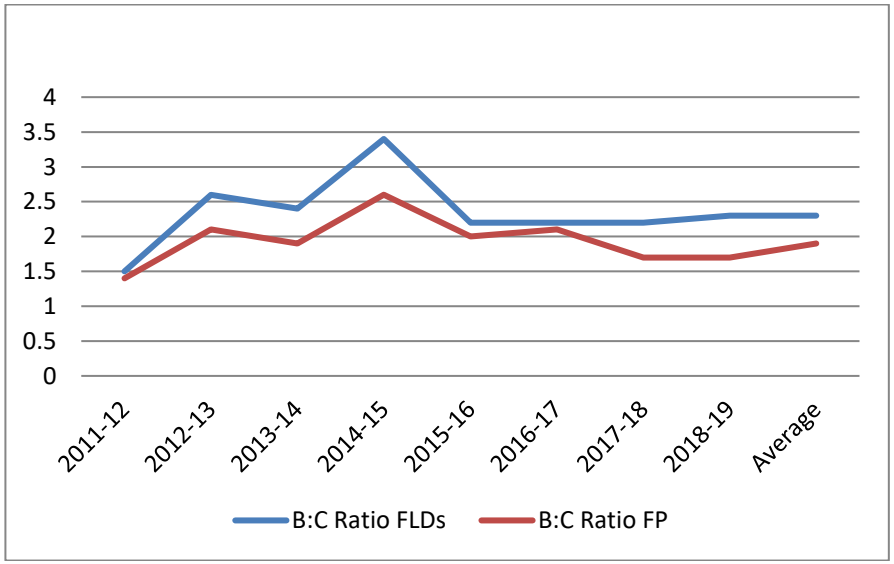

Fig. 2. B:C Ratio of FLDs and farmer practices

3.3 Impact on Economics of Wheat Cultivation

The cost of cultivation per acre under zero tillage was 27.90% cheaper than farmers' practices for the 8 years of the study period, according to the data in Table 3. Similar information was provided in mung beans under ZT by Sindh et al., [10]. Over the course of the eight-year trial period, ZT's average gross return was found to be 6.99 percent greater than farmers' practices. Table 3's additional data revealed an average net profit gain of 23.46% over farmers' practices over the research period. According to Micheni et al*.,* [11], a similar trend of the results was observed during on-farm conservation agriculture experimentation in a maize-league cropping system. Additionally, the data showed that during the course of the eight-year research period from 2010–11 to 2018–19; the benefit–cost ratio was on average 21% greater under ZT than FP. The benefits-cost ratio acquired under the zero-tillage system was higher than that of the farmer's practice (traditional system), which shows that the zero-tillage system is more profitable than the usual technique, according to the aforementioned data. The results reported by Uddin and Dhar [12] follow a similar trend. Additionally, the data showed that during the course of the eight-year research period from 2010–11 to 2018–19; the benefit–cost ratio was on average 21% greater than FP. The benefits-cost ratio acquired under the zero-tillage system was higher than that of the farmer's practice (traditional system), which shows that the zero-tillage system is more profitable than the usual technique, according to the aforementioned data. The results reported by Uddin and Dhar [12]follow a similar trend. In the eastern region of Uttar Pradesh, modern and prosperous farmers should choose a zero-tillage planting condition. The good benefit-cost ratio persuaded the farmers of the intervention's usefulness and demonstrated the intervention's commercial viability. In this investigation, the benefit cast ratio had a direct impact on the wheat variety's output. The yield has increased over the corresponding conventional practice as a result of the adoption of recommended practices in front line demonstration trials on wheat. Suryawanshi and Prakash [13] reported similar outcomes in their study on the promotion of oil seeds in Maharastra [14].

3.4 Farmer’s Response

Farmers initially had a lot of questions about this technique because they believed their own beliefs and were constantly mocking and disparaging zero tillage wheat. They believed that zero tillage wheat would either not germinate or, if it did, would not produce a productive wheat crop. However, after witnessing the demonstration's initial performance, their perspective began to gradually change, and they are now enthusiastic about using the technology, which might eventually become standard procedure.

4. CONCLUSION

Wheat grown with Zero-till technology is projected to expand swiftly in the rice-wheat zone. The study demonstrates that zero-tillage technique improves the efficiency of water and fertilizer use. However, there was insufficient information to indicate whether the technique had a good or negative impact on the occurrence of weeds in wheat crops. The new approach lowers production costs while producing equivalent wheat yields to other methods, which leads to higher net returns. Farmers in the area have begun to appreciate the technology's reduced tillage costs. Rice-wheat is the prevalent farming system practiced by the majority of farmers in the region. In the future, the prospect of extending the method to sow wheat after other crops should be investigated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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