

## **Adaptation and Impact of Zero Tillage Technology for Wheat Cultivation in Eastern Region of Bihar**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors SKG and SK designed the study and conducted the experiments in field and wrote the first and final draft of the manuscript. Authors RKS and SKP edited the first draft. Author SR managed the literature searches. Authors SP and ABP managed the analyses of the study. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The present study aims to determine the adaptation and impact of zero tillage technology for wheat cultivation in Eastern region of Bihar.

There is an increasing recognition among policy-makers of the largely untapped potential of the Eastern Indo-Gangetic Plains (IGP) for meeting state- and national-level food needs in India. Zero-tillage (ZT) technology has been proven for enhancing wheat productivity and, hence, food security in the IGP while reducing production costs – a 'win-win' which support rapid/fast technology scaling even though adoption remains modest to date. ZT technology is well known in the form of CA, that involves continuous minimum mechanical soil disturbance, permanent organic soil cover with crop residues or cover crops and diversified, efficient and economically viable crop rotations provide opportunities for saving on inputs, improving resource use efficiency and mitigating greenhouse gas

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(GHG) emission and climate change adaptation. Under the Farmers First project, an attempt was made to introduce ZT technology among two adopted villages under Goradih block of Bhagalpur district in Bihar, India. The result has shown that ZT is gaining popularity amongst the farmers in the adopted villages for establishing wheat crop for higher income and sustainability of the farming community. This technology allows rice-wheat farmers for direct drilling of wheat sooner after rice harvest without any preparatory tillage, so that wheat crop heads and fills grain before the onset of pre-monsoon. This involves sowing with a specially-designed zero-till seed-cum-fertilizer drill/planter, which has inverted 'T' type furrow opener to make a narrow slit in the soil for placing seed and fertilizer. Wheat was sown by zero tillage technology that helped in advancing sowing time, reduced cost of cultivation in terms of land preparation (Rs.3850/ha), saving in labours time (6-7 hrs/ha), fuel (44 ltr/ha), environmental pollution (60%) as well as water-saving (33%).

*Keywords: Zero tillage technology; adaptation; environmental pollution and wheat.*

## 1. INTRODUCTION

The ZT history in India has been variously documented [1,2]. In India, research on ZT for wheat started almost four decades ago. Several state agricultural universities tried ZT in the 1970s but their efforts failed due to technical difficulties, such as the lack of adequate planting equipment and the difficulty in controlling the weeds chemically. ZT, as applied to the rice-wheat systems in the IGP, has three distinctive features that distinguish it from related systems elsewhere [1,3,4]. First, ZT is typically only applied to the wheat crop in the double-cropped system, with the subsequent rice crop still intensively tilled. Thereafter, ZT wheat after rice does not necessarily entail an increased reliance on herbicide, reflecting that paddy rice fields are relatively weed-free at harvest time. Third, ZT wheat does not necessarily imply the retention of crop residues as mulch. In fact, the prevailing Indian ZT seed drills are relatively poor in trash handling, but for better or for worse, this was not a major issue given the limited biomass remaining in rice-wheat systems after the prevailing rice crop and residue management practices [5,6]. This technology is being increasingly adopted by farmers in the rice-wheat belt of the Indo-Gangetic plains (IGP) because of advantages in saving of labour, water, fuel, cost along with timeliness in operations/practices, particularly early planting of wheat. Recent estimates revealed that CA based resource-conserving technologies (RCTs) are being practised over nearly 3.9 m ha of South Asia [7]. Several studies conducted across the production systems under varied ecologies of South Asia revealed potential benefits of CA based crop management technologies on resource conservation, use efficiency of external inputs, yield enhancement, soil health improvement, and adaptation to changing climates [8,9,10,11,12]. In

India's rice-wheat systems, adoption of ZT is primarily limited to the wheat crop and concentrated in the NW IGP. The RWC used to compile on an annual basis estimates of the scale of adoption of various resource-conserving technologies [13]. These estimates are primarily expert estimates at the state level using a range of indicators. Estimates of ZT area are often based on the sales of ZT drills and average area coverage per drill [14]. In these estimates, it is problematic to separate ZT from RT so that these two technologies are typically lumped together (ZT + RT).

Bihar, one of the most populous states of India and has predominantly an agrarian economy and considered as "Future Food Bowl" of India where major population reside in the rural areas and depend on agriculture. Apart from above, around 90% farmers are small and marginal farmers. Hence, the goal of the agricultural production system should be to maximize the income of landowning and landless rural populace to improve their livelihoods. The agriculture in Bihar is more vulnerable to the effect of different vagaries owing to complex, diverse and risk prone agro-climatic regions, production systems and farm typologies. Despite the availability of fertile soil, adequate rainfall and sufficient groundwater, agricultural productivity in Bihar is very low, primarily due to complex, diverse and risk-prone agro-ecologies, lack of adoption of improved management practices, value addition and exclusion of small and marginal farmers from the agricultural value chain.

The Farmer FIRST Programme (FFP) is an ICAR initiative to move beyond the production and productivity, to privilege the smallholder agriculture and complex, diverse and risk-prone realities of the majority of the farmers through enhancing the farmers-scientists interface. It is a

farmer-centric programme for research problem identification, prioritization and conduct of experiments and its management in farmers' conditions. The focus is on farmer's Farm, Innovations, Resources, Science and Technology (FIRST). Farmers tend to face problems related to production and natural resource management but they might not have found out solutions to overcome them. In such situations, Farmer FIRST is an opportunity for the researchers, extension professionals and farmers to work together and find appropriate ways through assessing different solutions. In order to use this opportunity to help the farmers of Bihar state in enhancing their farm production and productivity in a sustainable manner a project titled "Cross-Sectional Livelihood Improvement and Income Enhancement through Agro-Enterprise Diversification" was envisaged.

The State of Bihar with a geographical area of 94.2 thousand square km is divided by river Ganges into two parts, the north Bihar with an area of 53.3 thousand square km, and the south Bihar having an area of 40.9 thousand square km. Based on soil characterization, rainfall, temperature and terrain, three main agro-climatic zones in Bihar have been identified. These are Zone – I (North West Alluvial Plain), Zone – II (North East Alluvial Plain), and Zone-III (South Bihar Alluvial Plain), each with its own potential and prospects. Agriculture is the single largest private-sector occupation in Bihar and can be considered the riskiest business. The percentage of the population employed in the agricultural production system in Bihar is estimated to be around 80% which is much higher than the national average. The high concentration of population, largely dependent on agriculture coupled with low yields of the major cereal crops, flood and draught are the major bottlenecks in the state agriculture. To mitigate above challenges, the project was initiated in two villages namely Birnaudha and Barhari under Goradih block of Bhagalpur district of Bihar for maximising the profitability of the farmers through introduction of short to medium duration as well as high yielding varieties of rice for timely establishment of wheat crop, and showing of wheat through Zero Tillage technology. Rice – Wheat is the major cropping system in both of the selected villages and the results of Participatory Rural Appraisal (PRA) revealed that delay in the sowing of wheat crop due to cultivation of long duration rice varieties in the previous season results in a significant reduction in wheat crop yields. Zero tillage

reduces tillage to only one pass. It allows timelier sowing, which raises yields and lowers costs by saving soil, fuel, tractor costs, water, fertilizer and herbicides. It helps farmers to seed a crop directly into the cultivated field just after they harvest of the previous crop with the least disturbance of the soil. It eliminates or reduces time and energy-intensive conventional tillage operations reducing the cultivation costs and risk of Phalaris minor in wheat apart from improving crop yields and farmers profits.

### 1.1 Experimental Site

Study area (Birnaudha and Barhari village) is situated 15 km away in South of the University Head Quarter at Sabour. Birnaudha is a village in Goradih block of Bhagalpur district situated at 25.095N - 86.760E. In Birnaudha, 750 acre of land area is under agriculture, with half of its agriculturally operated area being cultivated without any source of irrigation. The village Barhari is located at 25.095N and 86.760E, having 1100 acres of cultivable area. In the majority (around 52%) of the area, wheat is the major Rabi crop covering an area of around 400 acres, followed by maize cultivated over approximately 250 acres of land. These villages were selected because of urgent need for developmental intervention due to high proportion of resource-poor and socio-economically backward classes. Purpose of a selection of these villages was to enhance the innovative experimental capabilities and income of the resource-poor farmers, farm women and youth who are in most urgent need of external technological and management intervention for kick-starting the development. Similarly, in Birnaudha, agriculture is the major source of livelihood. Around three fourth of the population have operational landholdings of which more than 80% of the landholdings are small and marginal. Agriculture accounts for around 1100 acres of geographical area of the village. Based on the analysis of the facts and agro-ecosystem, a discussion between the farmers and the experts following conclusions were made.

- Both the villages have high potentiality for agricultural development due to fertile lands, favourable topography and available irrigation facilities and potentialities.
- Even though the high-value crops are cultivated, the cultivation is limited to a relatively small area that too in natural cropping season adopting poor management practices

- There is a significant amount of loss in wheat yields due to delayed sowing of wheat which is the result of adopting long duration rice varieties in Kharif season.

## 2. MATERIALS AND METHODS

The field demonstrations on Zero Tillage has been initiated at farmer's field of Birnaudha and Barhari villages in Bhagalpur district during *rabi* season under the Farmer FIRST programme since 2016 (Fig. 1). As a part of this investigation, zero till cultivation of wheat was carried out around in 10-12 clusters in each village under rice-wheat based cropping system.



Fig. 1. Sowing of wheat with zero tillage machine



Fig. 2. Performance of Zero tilled wheat crop

### 2.1 Fertilizer Management and Seed Treatment

Nitrogen and Phosphorus were applied as per Recommended Dose of Fertilizer (120: 60: 40) through die-ammonium phosphate (DAP), urea and potash per hectare. The fertilizers were placed 2-3 cm deep below the seed placement, and the seed rate used was 100 kg/ha. The seed

was treated before sowing with carbendazim (*fungicide*) @ 2.5-3.0 g/kg of seed and *Azotobactor* @ 10 g/kg seed. Sowing was done with the help of zero tillage machine. First dose of 40 kg N (1/3 part of total nitrogen) and full dose of phosphorus (60 kg/ha) were applied as basal application through DAP and Urea. Remaining 80 kg of nitrogen were applied into two equal split at after first irrigation (20-22 DAS) and after the second Irrigation at CRI stage respectively.

### 2.2 Pest Control

Manual inter cultivation was done with the help of hand plough and Khurpi to check the weed growth in wheat crop. The control measures for insects, pests and diseases incidence were also taken from time to time with the help of entomologist and pathologist. For control of broad leaf weed, 2, 4-D ethyl ester 38 % EC @ 1.25 liter/ha and for broad and Nero leaf, Clodinafop @ 400 - 500 ml/ha were used as post-emergence at 30 to 35 DAS.

### 2.3 Availability of Zero Tillage M/C

Due to lack of awareness farmers were not using Zero Tillage machines for a showing of wheat, and they were continuously facing the problem of late sowing of wheat year after year. During first year of the study, there was a single Zero Tillage Machine available in both the villages, keeping this in view, one number of machine was distributed among the group of farmers in each villages. The specification of distributed Zero Tillage machine is as below:

Name	National Zero Till Ferti-Seed Drill
Model	NZTD
No. of Rows	11
Row to row spacing	7" Standard & adjustable
Fertilizer Metering	Agitator & Sliding Orifice type
Seed Metering	Fluted Roller

## 3. RESULTS AND DISCUSSION

Under the Farmers First Project, The number of machines owned by farmers now increased up to 5 in 2018 from 1 in 2016. The area of cultivation of wheat through ZT in acre, year-wise is shown in Fig. 3. While, the numbers of ZT machines owned by farmers year wise is shown in Fig. 4. The increase in numbers of ZT machines, as well

as number of acres in each year, has been found increasing mainly due to increased awareness among the farmers and reduced cost of cultivation. The role of progressive farmers, who adopted this technology also served as a simulator for other farmers, who had certain apprehensions with the ZT technology, and who had not used this technology in past.

Conventional tillage and crop establishment methods such as puddled transplanting in the rice-wheat (*Oryza sativa* L.–*Triticum aestivum* L.) system in the Indo-Gangetic Plains (IGP) require a large amount of water and labour, both of which are increasingly becoming scarce and expensive. Keeping above in view, ZT technology was introduced in adopted villages for reducing the input cost, such as, labor, diesel, electricity and seed. During 2016-17, when the project was started in the selected villages of Birnaudha and Barahari villages under Goradih block of Bhagalpur district, very few farmers were using ZT technology. Upon perusing various farmers under the project site, a total of 34.70 acre of land was shown through ZT machine. Next year, upon looking after the result of ZT technology, some more farmers showed interest in using ZT machine for the sowing of wheat, and we were able to reach up to 47.80 acre. In 2018-19, we reached up to 69 acre of ZT - wheat crop. Simultaneously, a number of ZT machines, owned by farmers also increased from 1 to 5 during these three years. Farmers who had adopted ZT method in wheat production were interested to continue with this method of sowing in future. According to farmers, ZT method was good in terms of seed germination and yield of wheat than the CT method. Sowing of wheat crop could be accomplished 10 to 12 days earlier

than in CT method. Zero tillage considerably reduced the use of tractor and saved time and diesel in field preparation. A comparison of yield and economic performance has been shown between zero till and conventionally tilled wheat in Table 1, while, Table 2 show-s the benefits of zero tillage method over farmers practices in view of water, fuel and time savings. All these experimental field data has been collected from 20 farmers from each village, and comparison has been made as below:

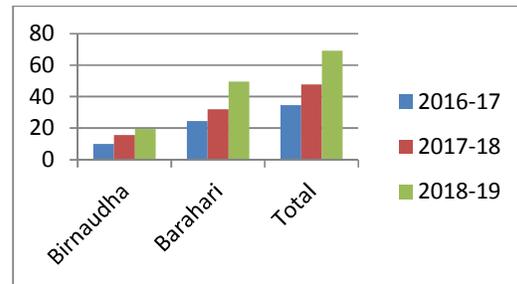


Fig. 3. Year wise area covered under Zero Tillage (Acre) in project sites

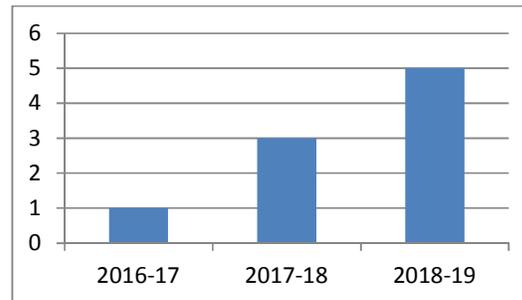


Fig. 4. Year wise numbers of ZT machines owned by farmers in project sites

Table 1. Comparison of yield and economic performance between ZT and CT wheat

Tillage	Grain Yield	Straw yield	Cost of cultivation	Gross return	Net return	Benefit cost ratio
Zero till wheat	36.94	48.71	26306	77939	51633	2.96
Conventional wheat	33.69	42.08	31554	70726	39172	2.24

Table 2. Comparison of various activities and expenditure between Farmers Practice (FP) and Zero Tillage (ZT) wheat

Activity	FP	ZT	Savings
Time for Land Preparation (Hours/ha)	8-10	2.5-3.0	6-7
Fuel consumption (diesel in ltr/ha)	72	28	44
Environmental Pollution (CO <sub>2</sub> emission in kg)	191.52	74.45	60%
Water Savings (Electricity in Hours)	32	24	33%
Expenditure of land preparation (in Rs.)	6300	2450	3850

#### 4. SUMMARY AND CONCLUSION

The study has revealed that it is possible to save machine labour and irrigation water under zero tillage than under conventional method. Due to resource-saving in zero tillage technology. Hence, this technology is an important alternative to save scarce resources and enhance net farm income. By adopting this technology, farmers could save scarce resources and reduce the cultivation cost. The availability of zero-till seed drill needs to be accorded more attention to foster the adoption of zero tillage technology for wheat production. From demonstrations, it has been found that there is a clear advantage of zero tillage technology over the conventional method of showing wheat. While total cost of cultivation reduced, Gross return and Net return increased in the case of zero tillage in comparison to the conventional method of wheat showing. Which is due to more grain and straw yield in the case of ZT method. Zero Tillage showing of wheat has also contributed towards certain advantages upon conventional tillage methods, like reduction in a number of field operations from an average of seven to one, translating into 6-7 hours per ha saved in tractor time (a 60-70% saving), and farmers also saved about 44 litres of fuel per ha. It also reduced water usage by about 33%, improving soil structure, fertility and biological properties, and reducing the incidence of weeds, primarily due to the earlier emergence of wheat and reduced soil disturbance. It also helps in reduced production costs by 10-15%. The use Zero Tillage method also reduced environmental pollution (CO<sub>2</sub> emission) by about 60%. From above-mentioned findings, it is evident that use of ZT method should be increased for more profitability of farmers, and awareness programs regarding use of ZT method should be made on large scale among the farmers.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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