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Response of Zero Tillage Technique on Wheat Production in the Middle Indo-Gangetic Plains of Nalanda (Bihar)

V. K. Singh[1*], Abhishek Pandey[2], V. Y. Deshpande[3] and B. Shivarudrappa[4]

[1]BISLD Bihar, BAIF Office, House No. 1, Road No. 8, East Patel Nagar, Patna 800023, India.
[2]BAIF Development Research Foundation, E-1, First floor, DDA Market, New Rajinder Nagar, New Delhi- 110060, India.
[3]BAIF Central Research Station, Urulikanchan, Pune 412202, India.
[4]BAIF Development Research Foundation, Flat No. 1111, Tower 3, Royal Lagoon Apartments, Nandankanan Road, Raghunathpur, Bhubaneshwar, Odisha-7540005, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author VKS designed the study, monitored the field experiment and collected data. Author AP analyzed the study, managed literature searches and wrote the final draft of the manuscript. Authors VKS and AP performed the statistical analysis. Authors VYD and BS provided the technical and administrative support. All authors read and approved the final manuscript.

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ABSTRACT

The present study was undertaken to compare the response of zero tillage method and conventional method on wheat production with respect to various growth, yield and economic parameters in the middle Indo-Gangetic Plains of Nalanda district of Bihar. The study was conducted during Rabi seasons of 2017-18 and 2018-19. Fourteen farmers were selected for the study, 7 of whom sowed with zero tillage machine and 7 followed broadcasting method. Four observation from each plot were taken, therefore, total 56 observations were taken for both the methods. Results showed that higher mean plant height was recorded by Zero Tillage (ZT) method (83.07±128 cm) followed by broadcasting method (79.57±187 cm) that shows significant difference. Significantly mean higher

**Corresponding author: E-mail: vinaykumar.singh@baif.org.in;*

no. of tillers per square meters was recorded by ZT method (556.57±21.28) as compared to broadcasting method (501.07±13.48). Mean spike length was significantly higher in case of ZT method (11.96±0.53 cm) compared to broadcasting method (11.03±0.22 cm). Significantly higher mean no. of grains per spike was recorded in ZT method (45.42±0.93) compared to broadcasting method (42.46±1.03). Significantly higher mean 1000- grain weight (g) were recorded in ZT method (42.07±0.61) compared to broadcasting method (40.03±0.67). Highly significant difference was recorded in grain yield (tonnes/ha) between ZT (3.82±0.03) and broadcasting method (3.68±0.04). Also, there were highly significant difference recorded in all the economic parameters between ZT and broadcast method. Cost of cultivation (Rs. /ha), gross monetary return (Rs. /ha), net monetary return (Rs. /ha) and BCR for ZT method are 37564±289, 70657±620, 33093±677 and 1.88±0.02. Corresponding values for broadcasting method are 40427±256, 68087±728, 27659±759 and 1.68±0.02. From the two years on farm research study it is concluded that the Zero tillage method of wheat cultivation is cost saving, more remunerative with timely sowing and helpful for areas where burning of paddy straw after paddy harvesting is widely prevalent. This method can be promoted among the farmers in Bihar and other middle Indo- Gangetic Plain regions for large scale adoption.

Keywords: Zero tillage; wheat yield attributing parameters; broadcasting; wheat- rice system; IGP.

1. INTRODUCTION

Around 77% of Bihar's population is engaged in Agriculture- related activities [1], which makes it significant source of wealth for the state. Bihar is part of the Middle Indo- Gangetic Plains (IGP) along with Eastern UP [2,3]. These areas are characterized by high fertility of land and scope of high crop productivity, similar to Trans IGP (Regions of Punjab and Haryana), and Upper IGP (parts of Uttarakhand and western UP). However, middle and lower IGP could not bear the fruits of Green Revolution started in late 1960s. Trans IGP and upper IGP managed to increase the yield of their crops manifold, particularly Rice and Wheat, due to technological advancement and favorable state policies after Green Revolution [4]. Rice and wheat accounts for almost 85% of total cereal production of India [5] and therefore its necessity and importance for food security, especially in food insecure region and poor state like Bihar, increases manifold. However, Bihar did not receive the same success like Punjab, Haryana and Western UP [6]. Despite having yield increasing capability, it remains a net importer of wheat [7], an important part of Bihar's diet. There is clear gap between production and consumption of wheat in Bihar and in order to provide food security to its people, this gap is filled by western IGP and Trans IGP regions [8]. These "food- security" – providing regions like Punjab, Haryana and Western UP account for major share total wheat production of the country. With growing population, demand of wheat and rice is also rising at rapid pace. To keep up with these rising demands, these regions have to enhance their crop production. However, recent studies show that regions of IGP have begun to show stagnancy in their crop production, even decline in the production in some parts [9,10,11,12]. Power- based water extraction methods has created huge issue of low water table in these areas causing deep environmental concern [13], furthering the cause of decline in wheat production. Due to this, Bihar will be facing two issues in coming future- A) Decreased import of wheat from trans and upper IGP, leading to food insecurity, and B) inability to be self- dependent as far as crop production, especially wheat, is concerned. Factors of low yield of wheat in Bihar are- small and fragmented landholdings, less developed irrigation infrastructure, frequent floods and droughts, weaker market institutions, late sowing and lack of adopting improved agricultural practices [14]. Now, in this context, it becomes very important for Bihar to enhance wheat production to meet both its and nation's rising demand by sharing the burden of north-west part of India. But this pursuit must be characterized by lower production cost, higher yield, environment- friendly practices by saving water and soil. In order to solve the issues, there was a need of technology which is less resource-degrading but productive and therefore, Zero Tillage (ZT) has been introduced in India and Bihar in late 1990s [15]. ZT is a mechanical innovation. Initially, it was experimented in better endowed areas like Trans and upper IGPs but due to yield saturation and water resource degradation, now in last decade, ZT has been experimented greatly in Bihar. There are few advantages shown by ZT which are as follows: a) There has been positive impact of ZT as it helps in reducing turnaround period (includes plowing, harrowing planking and seeding) for wheat after rice cultivation in Rice- Wheat system (RWS), b) uses less input [15], c) does not degrades the

environment substantially [16], d) ZT also improves soil health by increasing soil quality, fertility and other biological properties [12] e) it is claimed that it also reduces the incidences of weed [17], f) it also potentially reduces irrigation water- use [11], g) another important aspect of wheat cultivation is, it being capital and time-intensive as 25% of total cultivation cost is due to tillage operation [12]. While conventional tillage (CT) involves multiple passes ZT reduces total no. of field operations from average 7 to almost 1 [18] and also records the saving of around 8 hours/ ha, ZT seems to be both cost and time-effective. As most of the farmers in Bihar are poor, sometimes they do even get machines to till their land due to money and lack of enough resources for timely sowing. However, amidst all these benefits, one important aspect that always catches the attention of farmers is the yield benefit that this technology can provide to them. There has been very few farm- level studies regarding various growth and yield- related parameters. Most of the studies were confined to North- western part of India [15]. There seems to be very few ZT- related farm studies in Bihar, particularly Nalanda. In Nalanda, most of the farmers still use broadcasting method for sowing wheat and therefore, it is imperative to understand the effects of ZT on various growth, yield and economic parameters of wheat cultivation. However, there is bigger aspect of this study too which involves an important issue of stubble burning. In the year 2019, many farmers were fined in Nalanda for burning rice stubble just before wheat sowing. This issue severely deteriorates environment. Therefore, relevance of such studies increases manifold when such larger questions are needed to be answered. In the view of above- described reasons, farm- level study was conducted for two years, 2017-18 and 2018-19, in Nalanda district of Bihar to understand the performance of ZT for sowing of wheat in standing rice stubbles. The study is important because it will add up to the existing research and studies on the impacts of ZT on wheat cultivation, particularly in Bihar, which, in turn, can accelerate the growth of wheat production in Bihar by convincing farmers to use this technology.

2. MATERIALS AND METHODS

Chandi block of Nalanda district of Bihar has been selected for this study. Participating farmers for this study were part BAIF- BISA project, funded by the USAID. Project farmers were chosen based on the basis of their past experience for wheat cultivation and also those who were ready to use zero tillage technology for wheat sowing during rabi seasons of 2017-18 and 2018-19. 14 farmers fulfilling above conditions were selected from 4 villages. Out of 14 farmers, 7 farmers used zero tillage machine for sowing and remaining 7 farmers sowed seeds of wheat through broadcasting method. To provide ZT machine, custom hiring center in project area was established which provided advance agriculture equipment like seed drill, zero tillage and other equipment to farmers participated in this study. Before the study trial, farmers' training was conducted about use of Zero till seed cum fertilizer drill machine by the BAIF Expert and KVK Harnaur scientists. Four observations were taken from each farmer and therefore, total 28 observations were taken for both the methods. The Seed rate was 100 kg/ ha in ZT sowing method and 125 kg/ha used in broadcasting method of wheat sowing. The seeds were treated with Vitabax at the rate of 3 grams per kg of seeds for soil and seed- borne disease control. Uniform chemical fertilizer dose of 150:60:40 kg NPK/ha was applied as basal to both the treatments through Urea, DAP and MoP. Remaining 60 kg N/ha was applied in two splits as 30 kg at tilling stage and 30 kg at boot stage. For weed control, 2-4-D spray was used @ 1 Kg per hectare in about 600 liters of water after 28-30 days of sowing. All other remaining agronomic and other practices were same in both the treatments except land preparation.

Data on growth, yield and yield attributing characters were collected and analysed using two sample t-test statistical method. The study will try to understand the benefits of zero tillage techniques on wheat production, cost of cultivation and net income through comparative analysis of method of the wheat sowing.

3. RESULTS AND DISCUSSION

Table 1 represents effects of two different methods of wheat cultivation on growth and yield parameters. These parameters include growth parameter like plant height, yield attributing parameters like No. of tillers per square meters, Spike length and No. of grains/spike. It is revealed from Table 1 that maximum plant height in case of broadcast and ZT method are 79.57 cm and 83.07 cm, which shows significant difference. Similarly, no. of tillers per square meters, spike length and no. of grains/spike for broad cast method are 501.07 tillers per square meter, 11.03 cm, and 42.46 grains/ spike

Table 1. Effect of different wheat cultivation methods on different growth and yield attributing parameters

Cultivation method of wheat	Plant height (cm)		No. of tiller/m^2		spike length(cm)		No. of grains/Spike	
	Broadcast	Zero tillage	Broadcast	Zero tillage	Broadcast	Zero tillage	Broadcast	Zero tillage
Mean	79.57±1.87*	83.07±1.28*	501.07±13.48*	556.57±21.28*	11.03±0.22*	11.96±0.53*	42.46±1.03*	45.42±0.93*
Number of observations	28	28	28	28	28	28	28	28
P(T<=t) two-tail	-2.00	-2.00	2.20	2.20	2.58	2.58	2.13	2.13

*Significant difference; **Highly significant difference

Table 2. Effect of different methods of wheat cultivation on yield attributing and yield parameters

Cultivation method of wheat	1000- grain weight (g)		Grain yield (ton/ha)	
	Broadcast	Zero tillage	Broadcast	Zero tillage
Mean	40.03±0.67 *	42.07±0.61*	3.68±0.04**	3.82±.03**
Number of observations	28	28	28	28
P(T<=t) two-tail	2.23	2.23	2.68	2.68

*Significant difference; **Highly significant difference

Table 3. Economics of two different methods of wheat cultivation

Method of sowing	Cost of cultivation (Rs/ha)		Gross monetary return (Rs/ha)		Net monetary return (Rs/ha)		BC RATIO	
	Broadcast	Zero tillage	Broadcast	Zero tillage	Broadcast	Zero tillage	Broadcast	Zero tillage
Mean	40427±256**	37564±289**	68087±728**	70657±620**	27659±759**	33093±677**	1.68±.02**	1.88±.02**
Number of observations	28	28	28	28	28	28	28	28
P(T<=t) two-tail	-7.41	-7.41	2.68	2.68	5.34	5.34	6.61	6.61

* Significant difference; **Highly significant difference

respectively. There is more no. of tiller per square meter by ZT method than broadcasting which is contrary to the observation by Leghari et al. [19], Abbas et al. [20] but similar trends of results are obtained by Iqbal et al. [21]. Corresponding values in case of ZT method are 556.57 tillers per square meter, 11.96 cm, and 45.42 grains per spike respectively. ZT method performed better than broadcasting method on account of better nutrient utilization due to line sowing as significant difference has been found in these parameters.

Similarly, Table 2 shows other two yield attributing parameters of 1000- grain weight and grain yield. 1000- grain weight for broadcasting method is 40.03 g and 42.07 g in case of ZT, which shows significant difference between both the methods. Similar trend of results was obtained by Zamir et al. [22], Sharma et al. [23], Izumi et al. [24] and Merrill et al. [25]. Grain yield in case of ZT method (3.82 ton/ha) is significantly higher than broadcasting method (3.80 ton/ha). Similar trend in yield was also recorded by Naresh et al. [26] and Sidhu et al. [27].

The economics of two methods of wheat cultivation and thereby the benefit cost ratio have been presented in Table 3. It is indicated from the table that there was highly significant difference observed in the cost of cultivation, gross monetary return, net monetary return and Benefit- Cost Ratio due to the methods of zero tillage wheat cultivation. Cost of cultivation for ZT method (Rs. 37564±289) is lesser than broadcast method (Rs. 40427±256). Maximum net monetary return of Rs 33093/ha was recorded by Zero tillage wheat sowing method followed by broadcast sowing method with Rs 27659/ha. The higher cost benefit ratio 1.88 was recorded for ZT method followed by conventional transplanting method of rice cultivation, which is 1.68. Similar trend of economics was also observed by Iqbal et al. [21].

Similar trend and observation were found by Sidhu et al. [27] who reported that the cost of establishment with the Happy Seeder (custom or contract hiring) is about half the cost of establishment using conventional practice. These results are also in accordance with the results observed by Li et al. [28,29] and Kahloon et al. [30].

4. CONCLUSION

From the two years on farm research study it is concluded that the Zero tillage method of wheat cultivation is cost saving, more remunerative with timely sowing and helpful for areas where burning of paddy straw after paddy harvesting is widely prevalent. This method can be promoted among the farmers in Bihar and other middle and eastern IGP for large scale adoption.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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