International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 10, Issue 5, 2018, pp.-5260-5263.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

FARM LEVEL IMPACT OF ZERO TILLAGE IN WHEAT UNDER RICE-WHEAT PRODUCTION SYSTEMS

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Received: February 22, 2018; Revised: February 28, 2018; Accepted: March 02, 2018; Published: March 15, 2018

Abstract- This paper has compared the economics of wheat production with Zero tillage (ZT) and conventional tillage (CT) and assess the adoption pattern, changes in productivity and input use associated with ZT practices. Adoption pattern changes across the villages, districts by adopting ZT technology in rice-wheat production system, cost is decreased and yield is increased significantly and a high return per rupee of cost of ZT obtained, indicating the economic viability of the technology. To analyze the input use/factors influence wheat yield production function approach followed, it shows that late sowing of wheat under ZT practice is associated with decreasing in wheat yield. Hence, extension workers should concentrate on this aspect in their training and demonstration programmes. Technology intervention needs to be complemented with policy reforms (subsidy on inputs and infrastructure) to create an enabling environment for sustainable adoption of this conservation practice.

Key words- Zero tillage, Conventional tillage, production function, Haryana.

Citation: Meena Mukesh and Suryaprakash S. (2018) Farm Level Impact of Zero Tillage in Wheat under Rice-Wheat Production Systems. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 5, pp.-5260-5263.

Introduction

The irrigated rice-wheat systems consumes large amount of water with the increasing opposition for water from industrial, domestic and environmental sectors. Increasing water scarcity is also seen as a major supplier to stagnating efficiency in the rice-wheat cropping systems in the IGP [1]. To address efficiency and resources constraints, there has been an improved scientific interest in developing environmentally sustainable agronomic practices that are resource conserving, environmentally friendly and providing monetary profit to the farmers. By reducing the soil disturbance and providing residual cover, ZT or no till farming is found to increase the soil richness and water use efficiency, thus aiding cereal farmers to sustain the crop yield over a longer term [2, 3]. India is the major producer of wheat in the world (90 Mt, [4]) and now has registered only a sluggish productivity growth during the last two decades in India [5]. To address all the challenges and issues to date, most widely adopted resource conserving technology in the IGP has been ZT in wheat after rice, particularly in India. But the adoption of technology varied across different districts of Haryana. This study makes an attempt to know the farm level impact and adoption pattern of the ZT technology when compared with traditional method with respect to resource use and constraints.

Methodology

Study area

The study was carried out in three districts of Haryana *viz*., *Ambala, Kaithal* and *Kurukshetra* [Fig-1]. From each selected district, five villages were selected based on ZT adoption level provided by the CIMMYT, Thus a total of fifteen villages were selected. From each village 12 farmers were randomly to make a total sample of 180 farmers which performs Zero tillage (ZT) and conventional tillage (CT).

Cost returns Analysis

To study the economics of wheat cultivation, the cost-return analysis was used; Returns were estimated based on the price received for the output [6]. Comparative economics under CT and ZT is essential to assess the profitability of the adopted practice. As a component of economic analysis, various costs incurred in the cultivation of crop are categorized as Variable cost which includes all the operational costs *viz.* seed, fertilizer, plant protection chemicals, labour and cost incurred in land preparation. To calculate the impact of technology adoption on wheat profitability, gross return per rupees of paid out cost was calculated with or without family labour.

Production Function approach

The net yield effect of ZT was estimated econometrically by employing a production function approach. The prime objective of any farm is to coordinate the farm resources and its utilization in the production process so as to obtain a maximum profit out of it. In order to study the impact of related variables on wheat productivity production approach followed [7].

Regression analysis is a useful tool in analyzing the factor productivity in any production activity including farming. The Cobb-Douglas type of production function has been the most popular of different algebraic forms of production functions available, as it provides a compromise among (i) adequate fit to the data, (ii) computational simplicity, and (iii) sufficient unused degrees of freedom for statistical testing. One of its serious limitations is that it accommodates constant/ increasing/decreasing marginal productivity and does not allow an input-output curve embracing all the three relationships. Despite this limitation, it has the greatest use in diagnostic analysis as the regression parameters represent the elasticity's and reflects the marginal productivity at the geometric mean level of the inputs and the output. Because of such overwhelming advantages over the other forms, Cobb-Douglas type of production function was employed for the current study.

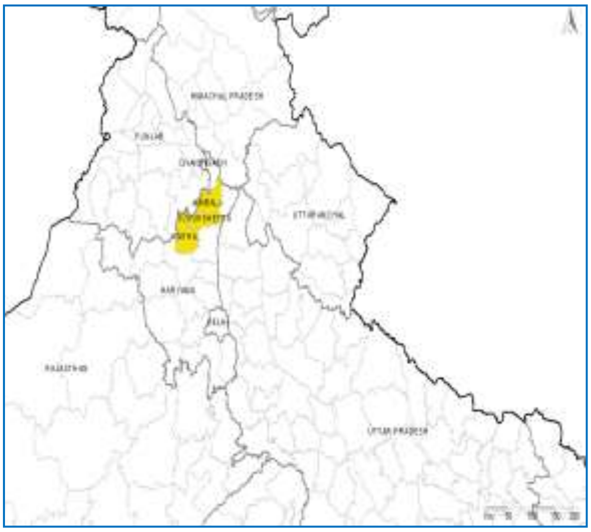

Fig-1 Map of study area

The specific Cobb-Douglas type of production function used for the study was:

$Y = a\, X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} X_8^{b_8} X_9^{b_9} X_{10}^{b_{10}} X_{11}^{b_{11}} X_{12}^{b_{12}}\ X_{13}^{b_{13}} X_{14}^{b_{14}} + u$……………………..[1]

Where,

Y = Wheat yield (quintal/acre)

α = Intercept, a scale parameter

X_1 = ZT adoption (dummy)

X_2 = Adoption of PBW 343

X_3 = Adoption of var. 711

X_4 = Farm yard manure (dummy)

X_5 = Application of nitrogen (Kg/acre)

X_6 = Application of phosphorus (Kg/acre)

X_7 = ZT irrigation interaction

X_8 = Irrigation (Number)

X_9 = Herbicide cost (Rs/acre)

X_{10} = land owned (acres)

X_{11} = Education of head of household (schooling years)

X_{12} = Age of the Household head (years)

X_{13} = District Kaithal (dummy)

X_{14} = District Ambala (dummy)

U = Error term

b_i = Output elasticity of respective input. The summation of these gives returns to scale.

The [Eq-1], upon logarithmic transformation takes the linear form; the parameters were estimated using the Ordinary Least square (OLS) method.

$$\ln y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} + b_{11} \ln X_{11} + b_{12} \ln X_{12} + b_{13} \ln X_{13} + b_{14} \ln X_{14} + U \quad \ldots\ldots \quad [2]$$

The regression coefficient thus obtained were tested for their significance using the t-test

The formula used for the t-test was

$$t = \frac{bi}{SE(bi)} \quad \ldots\ldots\ [3]$$

Where,

b_i is the regression coefficient of the independent variable

SE (*bi*) is the standard error of the regression coefficient b_i

t is calculated 't' value

Adjusted R^2 (the coefficient of adjusted multiple determination) was computed to test the goodness of fit of the model.

Results and Discussions

Adoption pattern

The size wise distribution pattern reveals that majority (52.22 %) is Full adopters (those who cultivate wheat only by ZT practice) and 22.22 percent and 25.56 percent respondents were partial adopters (those who cultivate wheat by using both ZT and CT) and non-adopters (those who cultivate wheat only by CT). Among total sample; small farmers (< 5 acre) constituted 17 percent as compared to 42 percent of medium farmers (5-10 acres) and 41 percent of large farmers (>10 acres). As could be observed from [Table-1], magnitude of small farmers (73 %) followed CT while most of large farmers (52 %) follow ZT. Among large farmers share of full adoption is more than partial adoption.

Table-1 *Size of category of sample respondents*

Size - Category	percentage of farmers among			Overall
	Full adopters	Partial adopters	Non-adopters	
Small farmer (< 5 acres; N = 32)	27	0	73	100
Medium farmer (5-10 acre; N=76)	30	19	51	100
Large farmer (>10 acre; N=72)	52	29	19	100

Age is one of the important factors which influence decision making of individuals for adopting new technology and it has bearing on the farmers' risk taking attitude and innovativeness in adopting new technologies [8]. Among respondents the mean age for full adopters, partial adopters and non-adopters was 42, 45 and 40 years, respectively [Table-2]. The reason behind adopting new technology was percentage of young respondents, which was more in case of full adopters (45.75 %) [9, 10]. It is observed that the level of education (in terms of years of schooling) was higher among ZT adopters (7.13 years) than non-adopters (6.76 years). The percentage share of social assets that affect the adoption pattern includes piped water, latrine, house size, gas connection and concrete floor was higher in case of ZT than the CT [11, 12]. Average size of cultivated land higher in ZT adopter (10.19 acre) compared to non-adopter (7.66 acre) [Table-3].

Table-2 *Age-wise distribution of respondents (Number)*

Sl. No.	Particulars	Full adopters	Partial adopters	Non adopters
1.	Young (<35 years)	43 (45.75)	19 (41.30)	18 (45.00)
2.	Middle aged (35-50 years)	42 (44.68)	18 (39.13)	19 (47.50)
3.	Old (>50 years)	09 (09.57)	09 (19.56)	03 (07.50)
	Total	94 (100.00)	46 (100.00)	40 (100)
	Mean age (years)	42	45	40

Note: Figures in parentheses indicate percentages to total

Table-3 *Socio economic profile of ZT adopters and non-adopters*

Characteristic	Adopters (N=94)	Non-adopters (N=40)
No. of adults in the household	4.97 (1.80)	5.28 (1.81)
Cultivated land owned by the household (Acres)	10.19 (9.86)	7.66 (4.76)
Education of head of households (Schooling years)	7.13 (3.17)	6.76 (3.04)
Piped drinking water (percentage)	96	77
Gas connection (percentage)	79	70
Concrete floor for house (percentage)	64	47
Toilet (percentage)	91	77

Note: Figures in parentheses indicate standard deviation

Zero Tillage adoption in Sample villages:

The Study confirms empirically significant level of adoption of ZT wheat in Rice-wheat production system among sample villages. The penetration of ZT is highest in *Ambala* (47 %) district followed by *kurukshetra* (30%) and *Kaithal* (23%). Significant variations among district have observed on ZT adoption. [Fig-2]

Impact of ZT adoption on wheat profitability

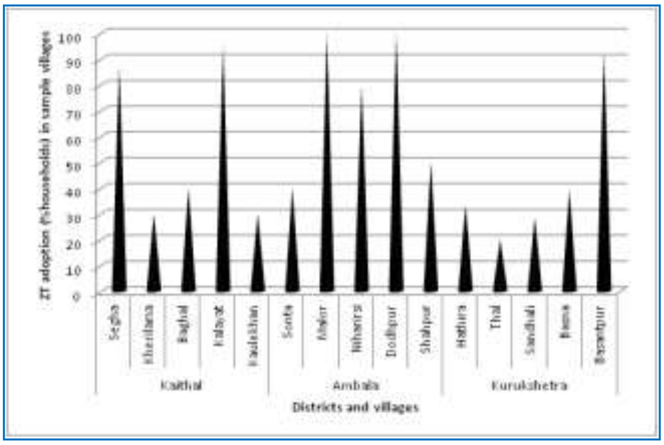

Fig-2 ZT adoptions in sample villages

Table-4 *Cost structure of wheat production (Rs/ha.)*

Variables	Mean		Percent differences
	ZT	CT	
Seed	1932	1993	-3.06
Fertilizer	4100	3600	13.89
weedicide	1800	1750	2.86
(i) Family labour (imputed)	1921	2002	-4.05
(ii) hired labour	1739	2039	-14.71
(i) Land preparation	0	2727	-100.00
(ii) Harvesting	1847	1874	-1.44
Total paid out cost	15055	16032	-6.09

Cost structure of the wheat shows a significant difference in the cost of cultivation due to the cost incurred in plot preparation (In case of CT, where farmer prepare the land by 4-6 tillage operations) [13]. The significant difference in yield is also observed (8.15%) because of the quick turnaround time between rice and wheat [Fig-3] [14]. The economics of wheat cultivation was assessed by using cost-return concepts; total cost of wheat cultivation was higher CT as compared to ZT practices. The cost of production (paid out cost + family labour) worked out to Rs. 440.65 and Rs. 383.54 per quintal, respectively. The gross return per rupee of paid out cost (B C ratio) was higher at 2.53 for ZT practice as compared to 2.05 for CT practice. [Table-5]

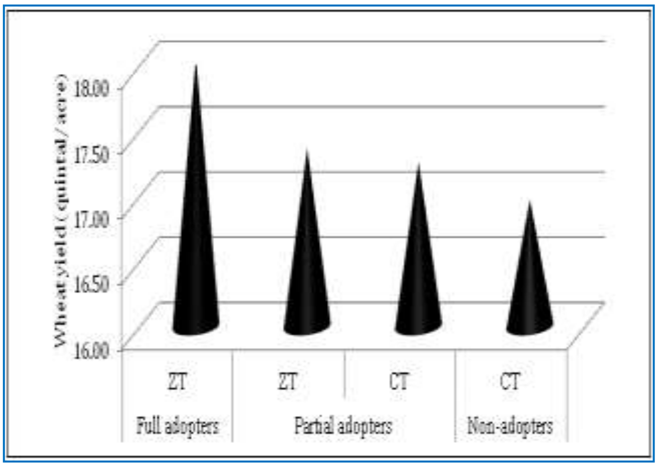

Fig-3 Wheat yield under ZT and CT

Factors influencing wheat yield:

No significant interaction effect of ZT with the nutrients observed in the study area, as on average farmers use more nitrogen (195 kg/ha.) than the recommended doses (148 kg/ha.) which when combined with zero potassium application, results in higher vegetative growth [15]. Interestingly no. of irrigation is also having no impact on wheat yield (salinity/sodality in study area) [16]. Other variables like Adoption of PBW 343 shows negative impact on wheat yield, because this is a long duration variety and it is not effective in case of late sown wheat [17]. The positive influence of land owned signifies that large farmers, with relatively better resources base, confidently perform farm operations [18]. The positive influence of ZT adoption signifies its effect on wheat yield, which makes way for its wider dissemination and adoption [19]

Table-5 *Impact of technology adoption on wheat profitability (Rs./acre)*

Variables	ZT	CT	Percent difference
Total paid out cost	6145.03	6543.97	-6.10
Paid out cost + family labour	6929.24	7361.40	-5.87
Yield (qtl/acres)	18.07	16.71	8.15***
Output price (Rs. /qtl.)	1080.00	1080.00	0.00
Gross return	15535.57	13384.03	16.08***
Net return over			
(i) Paid-out cost	9390.54	6840.06	37.29***
(ii) Paid- out cost + family labour	7847.27	5876.6	33.53***
per quintal cost of production with			
(i) Paid-out cost	340.13	391.72	-13.17
(ii) Paid- out cost + family labour	383.54	440.65	-12.96
Gross return per rupee of			
(i) Paid-out cost	2.53	2.05	23.61
(ii) Paid- out cost + family labour	2.24	1.82	23.31

Note: ***: Coefficients are statistically significant at 1 percent levels

Table-6 *Factor influencing wheat yield- results of production function analysis*

Variable	Coeff. (std err)	t	p> (t)	Sig.
ZT adoption (dummy)	0.238 (0.100)	2.38	0.02	***
Adoption of PBW 343 (dummy)	-0.057 (0.025)	-2.27	0.03	***
Adoption of var. 711(dummy)	-0.062 (0.034)	-1.82	0.07	***
Application of farm yard manure (dummy)	2.E-04 (0.005)	0.04	0.97	ns
N (kg/acre)	-0.102 (0.066)	-1.55	0.12	ns
P (kg/acre)	0.071 (0.041)	1.74	0.08	*
ZT Irrigation	-0.051 (0.031)	-1.66	0.10	*
Number of Irrigation	-0.011 (0.023)	-0.45	0.65	ns
Herbicide application (Rs/acre)	0.014 (0.028)	0.5	0.62	ns
land owned	0.002 (0.001)	2.76	0.01	***
Education of head of househols (years)	0.003 (0.002)	1.63	0.11	ns
Age of household head (years)	0.001 (0.001)	0.85	0.40	ns
District Kaithal (dummy)	-0.059 (0.031)	-1.92	0.06	***
District Ambala (dummy)	-0.068 (0.023)	-2.94	0.00	***
Model intercept	0.210 (0.425)	13.99	0.00	
R2	0.26			

NOTES: (i) Figures in parentheses show standard error.
*(ii) *, ***: Coefficients are statistically significant at 10 and 1 percent levels;*
ns: no significant difference at 10 percent level

Farmer's perception and constraints on adoption of ZT

Majority of the farmers opinions indicate an increase in yield/profit or decrease in weed infestation, fertilizer use and labour use (saving of labour is 26.99% by adopting ZT) [20, 21].

Policy Recommendation

- Late sowing of wheat under ZT practice is unwarranted as it leads to lower productivity. Hence, extension workers should concentrate on this aspect in their programmes.
- Absence of ZT drill is seriously hampering ZT adoption. Hence efforts should be made for the small and marginal farmers to acquire this critical implement.
- The field trials pertaining to retention of full/partial residues of preceding rice crop in wheat plots should be popularized as a resource conservation technology which can lead to higher adoption of ZT practice.
- Technology intervention needs to be complemented with policy reforms (subsidy on inputs and infrastructure) to create an enabling environment for sustainable adoption of this conservation practice.
- Use of the land laser leveler (LLL) should be popularized among the farmers to reduce the amount of water used in rice-wheat production system.

Conclusion

The study has shown that it is possible to save labour, machine and irrigation charges (cost of cultivation), weed infestation and increase in yield, profit by adopting ZT technology. However, since 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 8 per cent) observed. By adopting Zero tillage technology farmers could save scare resources and earn higher net return, so it is good alternative for saving scare resources and maximizing net farm income.

Application of research: This research study is applicable for the farmers adopting zero tillage and conventional tillage practices. It has comparison between adopters and non-adopters with respect to resource use

Research Category: Economics of wheat production

Abbreviations:
ZT - Zero tillage
CT- Conventional tillage
IGP- Indo Gangetic Plain
CIMMYT- International Maize and Wheat Improvement Center
OLS- Ordinary Least Square
B C- Benefit Cost Ratio
LLL- Land Laser Leveler

Acknowledgement / Funding: Authors acknowledges the financial support provided by the CIMMYT, New Delhi in terms of contingency grants for data collection. A special thanks to Dr. Vijesh V Krishna for his valuable suggestion, creative comments and help in data collection throughout study period. Authors are thankful to University of Agricultural Sciences (UAS), GKVK, Bangalore, 560 065

***Research Guide: Professor Dr S. Suryaprakash**
University: University of Agricultural Sciences (UAS), GKVK, Bangalore, 560 065
Research project name or number: MSc Thesis

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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