

Economic Evaluation of Zero Tillage Wheat in Amritsar District of Punjab

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ABSTRACT

Zero tillage is a technique of conservation agriculture which has the potential to reduce the use of water, energy and other input costs. The present study has been undertaken to know the socio economic characteristics of adopter and non adopters of zero tillage technology, compare their input use patterns, workout the economics and resource use efficiency. To accomplish the task, a sample of 80 farmers i.e. 40 adopters and 40 non adopters was taken from Amritsar district of Punjab. The primary data thus collected from these respondents were analyzed using various statistical tools and regression analysis. The study has highlighted that zero till technology was adopted by relatively larger farmers with better mechanized farms. The human and machine labour use was lower on zero till farms. Resultantly the cost of cultivation was reduced by about 22.18 percent and returns over variable cost improved by about 11.7 percent with this technology. Regression coefficient was positively associated with seed rate and fertilizer whereas negatively associated with human labour and irrigation facilities indicating savings of human labour in case of zero tillage technology

KEYWORDS: Zero-tillage, Conventional tillage, Wheat, Adopters, Punjab.

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1. INTRODUCTION

Punjab is an important wheat growing state in the India having 3512 thousand ha of area under wheat and producing 17620 metric tons with yield per hectare of 5017 kgs.¹. After the green revolution, rice-wheat crop rotation remains dominant in indo-gangetic plain region. Although green revolution helped in improving the economic status of people in general and farmers in particular, but it is now realized that benefits of green revolution are associated with unanticipated drawbacks on environment in one hand and economics of farmers on the other hand, depleting natural resources and causing environmental degradations. The factor responsible for 1st green revolution seem to be exhausting rapidly and there is immediate need to develop the technologies which cannot only increase the wheat production but also decrease its cost of production without harming ecology.

In Punjab this technology primarily is being used for wheat crop. Thus, the present study has been restricted to wheat crop only. In general, zero tillage refers to planting of wheat and other crops with minimum of soil disturbance after rice but under conventional tillage, farmers sow wheat and other crops after giving 6-8 ploughing with disc harrow and cultivator followed by 2-3 planking. Naturally, the question arises as to how much tillage should be done to prepare the field for proper germination, growth and yield of the crop, if the weeds are controlled by the herbicides.

Zero tillage is not a new concept on a world scale, it is known by various names, including no tillage, zero tillage and direct seeding. Area under zero tillage is increasing at a faster rate, In 1999 no tillage was adopted on about 45 million hectare worldwide growing to 72 million hectare in 2003 and to 111 million hectare in 2009, corresponding to a growth rate of 6 million per year². No tillage is now being practiced from the Arctic Circle over the tropics to about 50 degrees latitude, from sea level to 3000 altitude from extremely rainy area with 2500 mm a year to extremely dry conditions with 250 mm a year. Punjab having net sown area of 4150 thousand hectare out of which Amritsar has an area of 219 thousand hectare (5.30 percent). But out of the total area under zero tillage wheat i.e. 119 thousand hectares, Amritsar contributed to 22 thousand hectares which comes out to be 18.5 percent¹. It shows that as compared to total cropped area of Amritsar which is only 5% of the state, area under no tillage is much higher i.e. 18 %. But there is still much scope for increasing the area under no tillage.

In the light of foregoing discussion it become requirement of time to conduct in-depth study to prove its benefits in comparison to conventional system in this technology demanding area. Hence, the present study was undertaken in Amritsar district during 2015-16 of Punjab state to analyse zero tillage technology on the basis of productivity, for timely sowing, crop stubble management, reduction in cost of production and maintenance of soil health.

2. REVIEW OF LITERATURE

Sidhu *et al.*³ estimated economic benefits of no tillage in wheat in Punjab (India). The profits increase of 800-2200Rs/ha/year was attributed to cost savings. Zero – tillage system is reported to ensure timeliness of sowing, precision in seeding, reduction of production cost⁴, improve soil properties⁵ yet maintaining and in many cases, even increasing crop yield⁶. Tripathi *et al.*,⁷ conducted study at area where zero tillage was adopted extensively in wheat sowing. They collected data from 70 farmers and concluded that farmers practising zero tillage saved 6.68 percent human labours, 46.30 percent machine labour and 17.65 percent irrigation water than conventional system. They also reported that zero tillage system reduces operational cost up to 12.73 percent and increases net return up to 16.89 percent. This analysis proved that this system offer ample scope to produce additional income and helps conservation of scarce resources.

Veeta *et al.*⁸ from a study reported that of ZT (zero- tillage) technology adoption revealed a significant gain with respect to input use, and consequently on the cost of cultivation and profitability. The results showed a yield gain of 7-8 percent due to adoption of zero tillage wheat over conventional wheat. Early sown ZT plots are found associated with a substantial efficiency gain (16 percent) compared to the late sown Conventional tillage wheat ones. The scale of cultivation and remoteness of the village are found determining factors of efficiency gain apart from ZT technology adoption. Mukesh *et al.*,⁹ reported from study conducted in Haryana with 180 sample farmers that household facilities, level of education, land size exert favorable influence on zero tillage adoption. From study they also concluded that zero tillage adopter sown next crop well in time due to zero till seed drill.

3. DATA BASE AND METHODOLOGY

In order to accomplish the objective of the study, a detailed field survey was conducted. The well elaborated questionnaire was used for survey. Since the zero till technology is mainly being adopted for the cultivation of wheat, the impact assessment study was restricted to this crop only. The survey was conducted in Amritsar district of Punjab. In the first step four blocks were selected i.e.; Chogawan, Harsha Chhina, Ajnala and Jandiala. At the second stage two villages from each of four blocks were purposively selected. Lists of the farmers adopting this technology consecutively for at least two years in each village were prepared. From these lists, using probability proportion size random sampling technique, 40 adopters were taken for the study. In order to undertake impact assessment task of this technology, almost an equal number of non-adopters from the same vicinity were also taken as a control group in the analysis. Therefore, a total sample of 80 farmers (40

adopters plus 40 non adopters) covering eight villages, four blocks, and one district of Punjab was finally chosen for the ultimate analysis.

A diagnostic analysis has been conducted to assess the contribution of various factors to yield. Since the contribution of zero tillage technology was assessed by making comparisons, two equations were constructed for the regression analysis. So for zero tillage wheat production technology the functional form was:

$$Y_z = b_0 + b_1SD + b_2SR + b_3IR + b_4FT + b_5WP + b_6LB + e$$

Whereas for conventional wheat production technology the regression equation was as under

$$Y_c = b_0 + b_1CT + b_2SR + b_3IR + b_4FT + b_5WP + b_6LB + e$$

Where Y_z = yield per hectare obtained by farmer applying zero tillage wheat production technology.

Y_c = Yield per hectare obtained by the farmer applying conventional wheat production technology.

SD = Per hectare cost of sowing using zero till drill

CT = Cost of tillage per hectare for seed bed preparation and sowing.

SR = Seed rate per hectare

IR = Irrigation measured in inches per hectare.

FT = Total nutrient per hectare used for wheat crop

WP = Cost of weedicide/Pesticide per hectare including application of these chemicals.

LB = Per hectare cost of labour used to adopt respective wheat production technology.

e = Random error term

Both the equation was estimated by using ordinary least square (OLS) method. The statistical package for social scientists (SPSS-16) was used to analysis the data.

4. RESULTS AND DISCUSSION

Table 1: Socio- Economic Profile of Adopters and Non- adopter Farmers in Amritsar District of Punjab

Particulars	Adopter Farmers	Non-Adopter Farmers
	Percentage or Number	Percentage or Number
General Information	40	40
Age (upto 50 years)	75 %	67%
Literacy level(upto 10+2)	85%	98%
Family size (Upto 6)	93%	87%
Average farm Size(Ha)	7.35	4.85
No of Tubewells per farm	1.85	1.25
Farmers owing farm assets(average number per respondent)		
Combine	.1	.09
Tractor	1.05	.98
Thresher	.25	.29
Zero till drill	.6	00
Cropping pattern of Sample respondents		
Kharif (area under paddy)	83 %	83%
Rabi (area under wheat)	71 %	51%

It is important to know the basic socio-economic characteristics of the respondent farmer which have direct relations with adoption of new technology. Adopter farmers of this technology were relatively younger in age, having smaller family size, had better educational standards, bigger land holdings and better irrigation facilities as compared to non adopter farmers.

All the farmers have assured irrigation facilities. The income of the farmer primarily depends on the size of operational holding. Higher the size of operational holding, higher will be the level of production, higher will be quantity of marketable surplus of various agricultural commodities. It is evident from table that the relatively bigger farmer adopted this technology. The combine availability per farm was found to be more (0.1) in case of adopters as compared to the non-adopters (0.09). Similarly; tractors availability per farm was also higher in case of adopters (1.05) as compared to (0.9) non adopters. The zero till drill available per adopter farm was 0.6. The availability of electric motors per adopter farm came out to be 1.85 against only 1.25 in case of non adopters. The overall position with regard to the ownership of farm machinery was found to be better in case of adopters than non-adopter. It is worth while to point out that in rabi season, wheat crop alone occupied about 71 percent of the total cropped area on sample farms. Similarly paddy was the major kharif crop. It

occupied about 83 percent of the area of adopter's farms. Hence, it can be inferred that the cropping pattern on the adopters as well as non-adopters farms was dominated by wheat in rabi and paddy in kharif season. Percent wheat area was less in non adopter farmers. Similarly total area under paddy was also less in non adopters. Overall area under crops was more in adopter respondents.

A. Input Use Pattern and Resource Use Efficiency

The average area, production and yield of wheat on the sample adopter farmers and non adopter farmers have been presented in table 2. The average area under wheat was found to be more in case of adopters i.e. 5.21 ha as compare to non adopters 2.48 ha. The average yield of wheat was also higher in case of adopters 48.46 q/ha than non adopters 46.98 q/ha. As a result of area and yield, production on farm was also higher in adopter farmers.

Table 2: Average Area, Production and Yield of Wheat of Sample Respondents, Punjab, 2015-16

Particular	Adopter	Non-Adopter	Mean Differences Adopters- Non adopter
Area	5.21	2.48	2.73(110.08)
Yield (qtls)/ha	48.46	46.98	1.48(3.15)
Production(qtls)	252.48	116.51	135.96(116.70)

Higher yield of adopter farmers may be due to early planting of wheat as no preparatory tillage is required, resulting crop established earlier than conventional system. Other reason may be that, in no tillage stress of excess water in not faced by crop.

I. Human labour use Pattern on the Respondent Farms;

The human labour is the main source of power in the Indian agriculture. Since the zero tillage technology is labour saving, the time spend by the human labour per hectare on adopter fields was lesser (75.23hrs) as compared to the conventional tillage farms i.e. 91.87hrs as shown in table 3. As the process of the land preparation is eliminated under this technology, the labour used for this operation have been saved to the tune of 16.67 hrs and in value terms the saving of Rs per/ha 499.1 in adopters as compared to non-adopters. The time incurred in sowing process is significantly higher in case of non-adopters. The total time consumed for the process of irrigating one hectare of the adopter farm was 48.6 hrs as against 56.15hrs in case of non-adopters, which was 15.7 percent lesser. The reason behind this difference is the presence of soil moisture after the paddy harvest and compact soil. Savings of time and value were also at the time of harvesting and turi making. In case of zero tillage number of sub divisions of fields was lesser and plot size was larger. However time required for fertilizer, plant protection and weedicide application were same in both cases.

Table3: Human labour Use Pattern on Zero Till and Conventional Method of Cultivation on Sample Respondent Holding, Punjab, 2015-16

Particular	Adopters		Non-adopter	
	Physical Term (hrs)	Value (Rs)	Physical Term (hrs)	Value (Rs)
Field preparation & sowing	4.00	120	12.00	360
Irrigation(Labour Charges)*	48.63	1458.9	56.15	1684.5
Fertilizer	3.00	90	3.00	90
Plant protection	8.30	249	8.27	248.1
Combine harvesting	5.30	159	6.30	189
Hey(Turi)	6.00	180	6.15	185
Total	75.23	2256.9	91.87	2864.5

**as electricity is free in Punjab for Agriculture.*

II. Machine Labour Use Pattern on the Respondent Farms:

As we discussed earlier that there is no need of land preparation on the farm under zero tillage technology, therefore there was no machine labour employed in cultivation process on the farm under this technology. The total machine hour used on the adopter farms (on other operation i.e. sowing, harvesting, threshing and turi making etc.) per hectare were lesser i.e. 58.03hrs as compared to the conventionally tilled farms where it were 74.45 hrs. The time period of about 16.42 hrs of machine labour (28%) saved on the adopter farms was due to the elimination of the cultivation process. These savings in value terms were amounted to beRs. 4175.6 per hectare (41.26 percent).Major saving (8.35hrs and Rs.3950) were at the time of sowing operation as field preparation process was eliminated in adopter fields.The time consumed in irrigating one hectare of zero tilled farms was found to be 48.63 hrs as against 56.15 hrs in case of conventionally tilled farm, which was 15.46 percent lesser. The reason behind this was the compact soil and less no of subdivisions which increase water and harvesters efficiency. However time required for fertilization, plant protectionand weedicide application weresame in both cases.

Table 4: Machine labour Use Pattern on Zero Till and Conventional Method of Cultivation on Sample Respondent holding, Punjab, 2015-16

Particular Component	Adopters		Non-adopters	
	Physical Term (hrs)	Value (Rs)	Physical Term(hrs)	Value (Rs)
Land preparation Sowing*	1.75	1750	10.10	5700
Irrigation	48.63	1458.9	56.15	1684.5
Harvesting	1.15	33.80	1.15	3380
Spraying	4.00	530.0	4.00	530
Hey (Turi)making	2.50	3000.0	2.50	3000
Total	58.03	10118.9	73.9	14294.5

*Adopters spent @Rs. 1000Per hectare whereas non adopters performed cultivation, planking and sowing at different rates.

B. Economics of Wheat Cultivation

Diffusion of any innovation depends upon its economic viability and its merits over existing system. The data regarding input in physical and value terms and output in physical & value terms have been given in table 5

Table 5: Economics of Wheat Cultivation Under Zero Till and Conventional Method of Cultivation on Sample Respondent Holding, Punjab, 2015-16

Particular	Adopters		Non-adopters	
	Physical Term	Value(Rs)	Physical Term	Value (Rs)
Seed kg/ha	103.12	1856.16	98.75	1777.5
Irrigation(no.)	4.51	-	4.32	-
Irrigation(hr)	10.78	-	12.99	-
Total irrigation hr(*)	48.63	1458.9	56.15	1684.5
Fertilizers				
Urea(kg)	307.5	1764	277..50	1651
DAP(kg)	136.25	2996.4	133.25	2930.4
Herbicides	450	1240	520	1300
Human labour(hr)	75.23	2256.9	91.87	2756.1
Machine labour(hr)	58.03	10118.9	73.09	14294.5
Total variable cost of cultivation (vc)	-	21,691.26	-	26502.4
Grain yield(qt per ha)	48.46	-	46.98	-
Price (Rs. Per qt)	1550	-	1550	-
Returns from grains in Rs. Per ha (A)	-	75113.00	-	72819.00
Turi yield (qt per ha.)	24.3	-	25.50	-
Returns from turi (B)	-	9720	-	10200
Gross return (A+B)	-	84833	-	83019
ROVC*(A+B-vc)	-	63142	-	56517
Percentage of ROVC to gross returns	-	74.43	-	68.07

*Return over variable cost

(*) as electricity is free in the state, electricity charges are calculated @30 Rs. Per hour (wear and tear charges of pump only).

I. Seed:

The usage of seed was higher under zero tillage method as compared to the conventional tillage. The average seed usage per acre was 103.12 kg with zero tillage technology as against 98.75kg in case of conventional technology. The seed worth the value of Rs.1856.16 and Rs.1777.5 were being used up on zero and conventionally tilled farm respectively. The reason for the slight high seed rate in case of adopter farms may be the fear of less germination.

II. Irrigation:

The total irrigation hrs required per hectare of wheat with zero till technology was found to be 48.63hrs as against 56.15 hrs for conventional method of cultivation. In value terms, the total expenditure incurred on irrigating one hectare of zero tilled farms came out to be Rs 1458.9 as against Rs 1684.5 on conventionally tilled farm. The total irrigation hrs saved in zero tillage were 7.52 hrs (Rs. 225.6) as against the non adopter farms.

III. Fertilizer:

The use of urea per hectare has been found more (307.5 kg) with zero till technology as compared to (277.50 kg) under conventional method. The urea worth the value of Rs1764 and Rs 1651 was being used on the adopter and non- adopter farm respectively. The mean difference of urea in quantity was 30 kg per hectare and in value it was Rs.113. The Di-Ammonium phosphate (DAP) Usage per hectare was also found slightly higher more i.e.136.25 kg in case of zero tillage technology as against 133.25 kg in case of conventional method valued at Rs. 2996.4 and Rs. 2930.4 respectively. The mean difference in quantity of DAP has been found 3kg. and in terms of value it was Rs. 66. The farmers used more of urea and DAP in the field, because of some misconceptions of lesser grain yield.

IV. Total Variable Cost of Cultivation:

The total variable cost of cultivation is the sum total of expenditure incurred on sowing to harvest of the crop, which include input cost: seed, pesticide, weedicides and fertilizer; human labour (for sowing, irrigation, fertilizer and weedicide application, turipreparations etc.), machine labour (for field preparation, sowing operation, irrigation, spraying pesticides, harvesting, turi making and transportation) electricity/diesel charges of tubewells. The total variable cost of cultivation was less in the case of zero tillage sown wheat; the reason for it was the low cost of sowing, irrigation and labour charges. Thus, the total cost of the cultivation was Rs 21691.26 and Rs. 26502.4 on the zero till farms and conventional farms respectively

V. Grain Yield:

The grain yield on zero till farms came out to be 48.46 quintal/ha valued at Rs 75113 as against 46.98 quintal/ha on conventional farms, valued at Rs 72819. By product (turi) yield was higher in conventional tillage method (25.5qt per ha) than zero tillage (24.3qt.). Value came out to be Rs. 10200 in non adopter and Rs. 9720 in adopter farms. Gross returns per hectare came out to be Rs.84833 and Rs. 83019 for adopter and non adopters respectively.

VI. Return Over Variable Costs (ROVC);

Though the yield is bit higher on the zero till farm, yet there was no significant difference in the grain yield. The return over variable costs was Rs 63142 and Rs 56517 in case of zero till and conventional farms respectively. It was due to lower variable costs and higher gross returns under zero tillage sown wheat. Percentage of returns to variable cost was 74.43 and 68.07 in zero tillage and conventional tillage respectively.

C. Diagnostic Analysis

A diagnostic analysis has been made to assess the contribution of various factors to yield. The principal objective of the model is to make comparison of wheat production technologies i.e. Zero tillage against the conventional wheat production system. Yield is the dependent variable, while seed rate, irrigation practices, weed control and labour were common explanatory variables for both the equations.. The estimated co-efficient of determination was 70 and 73 in case conventional and zero tillage system. This indicates contribution of variables is significant. The tillage contribution was positive but it was non- significant where as in case of zero tillage its contribution was negative and significant.

Table- 6: Regression Result of Conventional Tillage Technique and Zero Tillage Technique

Particular	Conventional Tillage Technique		Zero Tillage Technique	
	Coefficient	t-value	Coefficient	t-value
Constant	640.519	-	1126.15	
Tillage cost	.207	1.837*	-.121	0.196*
Seed Rate	20.546	1.686	23.851*	15.287*
Irrigation	.0166	0.197	-31.831	23.012
Fertilisers	44	3.372	45	2.527*
Weed control	.867	2.302	0.282	.662
Labour	-.243	-1.946	-.950	1.249
R ²	0.7034		0.7377	

*Significant at 5%level

Seed rate also contribute positively and significantly. Contribution of fertilizer used in wheat yield was positive and significant for both conventional and zero tillage system. Use of weedicides was positive in conventional, but less in zero tillage system. It indicates fewer weeds in zero tillage technology as compare to conventional system. Irrigation contributes positively in conventional tillage system and negatively in zero tillage system. It indicates less water is required in no tillage. Negative contribution of labour input shows that no tillage saveslabour cost as compared to conventional tillage system. In brief it could be stated that the zero tillage system was better in comparison to conventional tillage system. It affects positively the crop yield.

5. CONCLUSION

From the present study following conclusions could be derived:-

That zero tillage technology is a component of sustainable agricultural system. This technology is also economically viable as it reduces cost of cultivation, saves time, machinery use and other production resources and produces higher yield per unit area. The income of the farmers could be enhanced using this technique via increasing resource use efficiency, reducing turnover period (avoiding delay in sowing) and reducing machinery use. This technology reduces burden of harmful chemicals as in this system weed control is not a big problem.

Policy measures suggested for the rapid adoption of the technology

To encourage the rapid adoption of this technology the following suggestion can help to a great extent:

1. Keeping in view the multifaceted merits of zero tillage technology, the farmers may be encouraged by providing zero till drill at subsidized rates in the beginning or making available at cheap hiring rates through the help of agriculture department or the co-operative societies.
2. The intensities of field trials should be increased to demonstrate agronomic practices required for zero tillage technology via collaboration of department and farmers participatory approach.
3. Managing zero tillage will be highly demanding in terms of knowledge base and thus, there will be a great need of extension services.

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