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Economic And Environmental Benefit Of Zero-Tillage In Chandauli District Of Uttar Pradesh, India

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Abstract: Zero-tillage is one of the improved agronomic practices for sowing wheat crop just after harvesting of paddy crop without land preparation. Zero-tillage helps farmers to reduce the use of inputs of crop production which leads to reduction in cost of cultivation. It also reduces the carbon emission due to the reduction in burning of diesel fuel for land preparation and sowing of wheat crop. Present study was an attempt to analyse the economic and environmental benefits of zero-tillage in Chandauli district of Uttar Pradesh. The study revealed that young farmers and family size were positive and significantly influencing the zero-tillage adoption. Per hectare economic benefit was estimated to be Rs 10426.91. After adoption of zero-tillage, per hectare 44 per cent diesel was saved which leads to reduction of 8.18 kg per hectare carbon emission. Among some constraints which hindering the adoption of zero-tillage in study area was high density of weed in agricultural field, poor soil quality, upland area and uncertainty of irrigation.

Keywords: Resource Conservation Technologies, Wheat, Logit model, Economic Benefit; Environmental Benefits, Zero tillage, Energy Saving.

I. INTRODUCTION

Past growth of production and productivity of rice and wheat has been mainly attributed by introduction of high yielding varieties triggered with irrigation facility. Irrigation facilities helped farmers to grow more crops during the year with higher doses of inputs use. The by-product of uncontrolled use of inputs is over exploitation of natural resources (Sangar et al., 2004). The long-term experiment on rice-wheat showed that rice yield declining at the rate of 0.02 tonne per hectare per year in Indo-Gangetic Plain (Dawe et. al, 2003; Duxbury et al. 2000). Further augmentation in rice and wheat productivity more emphasis is needed on resource conservation agriculture. Out of several options of resource conservation technologies, the zero/reduce till-surface residue management system has benefited the farmers by receiving higher productivity gain, good soil health and significant reduction in cost of cultivation in Eastern Indo-Gangetic Plain. Permanent zero tillage through crop residue management system provides permanent soil cover and minimum soil disturbance which helps farmers to minimise seasonal weed infestation resulted resource poor, small and marginal farmers of Eastern Indo-Gangetic Plain have now begun adopting resource conserving technologies (RCTs). It has been realized that benefits of RCTs can be further improved by adopting remunerative cropping system/catch crop (Singh et al., 2005).

Presently, Indo-Gangetic Plain is experiencing rapid expansion of wheat zero/reduce tillage a surge of interest in RCTs. The wheat zero tillage is seen by many merely the first step is broad movement towards the development and adoption of an ever richer collection of resource conserving, conservation agriculture technologies (Harrington and Erenstein, 2005). Farmers have been practicing rice-wheat cropping system in Eastern Uttar Pradesh over the past couple of decades.

Looking the benefits of zero tillage, present study was an attempt to analyse the environmental and economic benefit of zero-tillage in Chandauli district of Uttar Pradesh. The objectives of the present study was: [a] to compare the cost of cultivation of wheat under Zero-tillage and conventional method; [b] to analyse the economic and environmental benefit of Zero- tillage; [c] to determine the relative importance of various factors influencing adoption of Zero-tillage; and [d] to find out the constraints associated with adoption of Zero- tillage.

II. MATERIALS AND METHODS

A. SAMPLING PROCEDURE

Chandauli district was purposively selected on the basis of highest adoption of zero-tillage. Out of nine blocks, two blocks viz., Barhani and Sahabganj was selected purposively on the basis of highest and lowest adoption of zero-tillage respectively. Barhani village from Barhani block and Khilchi village from Sahabganj block were selected purposively on the basis of availability of adopters and non-adopters. From each village, 10 zero-tillage adopters and 10 non-adopters was selected randomly. Thus, altogether, 40 respondents are finally selected from both villages.

B. COST OF CULTIVATION

The cost of cultivation of wheat crop for zero- tillage adopters and non-adopters were calculated by using method suggested by the Commission on Agricultural Cost and Prices (CACP):

COST A_1: All the input cost + depreciation on implements and farm buildings+ land revenue, cesses and other taxes+ interest on working capital+ miscellaneous expenses

COST B_1: Cost A_1 + interest on value of owned fixed capital assets (excluding land)

COST C_1: Cost B_1 + rental value of owned land+ rent paid for leased-in land

COST C_2: Cost C_1 + imputed value of family labour

COST C_3: Cost C_2 + 10 percent of cost C_2 as account for managerial input of the farmer.

C. ECONOMIC AND ENVIRONMENT BENEFITS

The economic benefits of zero-tillage were worked out using economic surplus model (Alston, 1995).The model is given below:

$$\Delta CS = PQ\, Z\, (1 + 0.5\, Zn)$$
$$\Delta PS = PQ\, (K - Z)\, (1 + 0.5\, Z\eta)$$
$$\Delta TS = \Delta CS + \Delta PS = P\, QK\, (1 + 0.5\, Z\eta)$$

Where Z = K ε/ (ε+ η); K is vertical shift in supply function as proportion of initial price; η is elasticity of demand (absolute); and ε is elasticity of supply.

The environmental benefits realized by adopters of zero tillage are reduction in carbon emission. For the estimation of reduction of carbon emission, first of all quantified the diesel saving on farm operations then multiplied by the one litre equal to 2.6 kg of CO_2 (Jat et al., 2006) and one kg CO_2 is 0.27 kg of carbon (Paustin et al., 2006).

D. FACTORS INFLUENCING ADOPTION OF ZERO-TILLAGE

For identification of relative importance of various factors influencing adoption of RCT_S in different Agro-climatic zone was worked out by using binary logit model (Mallada, 1992). The algebraic form of model is given below:

$$p_i = \frac{1}{1+e^{-Z_i}}$$

Where, p_i is a probability of adoption of conservation tillage technology for the i^{th} farmer and ranges from 0 to 1. e^{-z} represents the base of natural logarithms and Z_i is the function of a vector of n explanatory variables and expressed as follows:

$$Z_i = \beta_0 + \sum \beta_i X_i$$

Where, β_0 is the intercept and β_i is a vector of the relationship between p_i and X_i, which is non-linear, can be written as follows:

$$p_i = \frac{1}{1+e^{-(\beta_0+\beta_1 x_i \ldots\ldots \beta_n x_n)}}$$

Finally, the logit model is obtained by using the logarithm

$$L_i = L_n\left[\frac{p_i}{1-p_i}\right] = z_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + \beta_n x_n$$

E. IDENTIFICATION OF CONSTRAINTS

The Garret Ranking was used to rank the constraints associated with the zero tillage adoption. The percentage of each rank thus obtained was converted into scores by referring to the table given by Henry Garret. The score of all the factors were arranged in order of their ranks.

$$Percent\ Position = \frac{100\,(R_{ij} - 0.5)}{N_j}$$

Where, R_{ij} is the rank given for i^{th} item j^{th} individual and N_j is the number of items ranked by j^{th} individuals.

III. RESULTS AND DISCUSSIONS

A. FACTORS INFLUENCING ADOPTION OF RCTS

A binary logit analysis was undertaken to determine quantitatively how the relevant factors interact to influence farmers in their adoption of zero-tillage. The likelihood ratios that are considerably high and significant at one per cent level, thus the model in general explained factors associated with the adoption of zero-tillage (Table 1). The Nagelkerke R^2 values are ranged from 0 to 1 and it is a more reliable measure of the relationship. In model, it was indicates a fair relationship of 49.2 per cent between the predictors and the prediction. The model explained about 75 per cent of the total variation in the sample for use of zero-tillage. Among the explanatory variables used in the model, two variables were significant with respect to adoption of zero-tillage with less than 10 per cent of the probability level.

Result shows that the Age (1) group coefficient was positive and significant at one per cent level and the odd ratio associated with this group was 23.392. This implies that farmers in young age group (less than 50 years) have a higher probability of adoption of zero-tillage. Hence when farmers who comes young age group was raised by one unit (one person) the odds ratio was 23.392 times as large and therefore, farmers are 23 more times likely to belong to the adoption group. The older farmers have fewer chances to adopt zero-tillage in the study area. This effect can be explain by the fact that young farmers are more aware of the latest technology and have risk taking ability. Family size coefficient showed the positive and significant at 10 per cent level. Odds ratio associated with family size was 1.402 means increase in one person in family, 1.4 more times likely to belong in adoption group as compare to non adoption.

Another important factor which affects the adoption of zero-tillage was soil type as observed by the study. Most of the part where calcareous soil was found, zero tillage technology was successfully adopted because it had higher water retention capacity and which made better placement of seeds and fertilizers together in line using zero-tillage technology.

Variables	Coefficient	S.E.	Wald	Sig.	Odds ratio
Age (1)	3.152	1.005	9.837	.002	23.392***
Adult Members	-.275	.321	.734	.392	.760
Area	.554	.351	2.490	.115	1.740
Family size	.338	.196	2.971	.085	1.402*
Income	-.006	.005	1.306	.253	.994
Constant	-3.848	1.562	6.068	.014	.021**

-2 Log likelihood ratio = 37.035
Cox & Snell R Square = .369
Nagelkerke R Square = .492
Chi-square value = 18.417***

Correctly predicted over all sample = 75.0
Correctly predicted adopters = 75.0
Correctly predicted non-adopters = 75.0

****Significant at 1% level, ** significant at 5% level and* significant at 10% level.*

Table 1: Binary logit model estimates for factors affecting the adoption of RCTs

B. COST OF CULTIVATION OF WHEAT CROP

Different inputs are used in the cultivation of wheat crop which are presented separately for zero-tillage adopters and non-adopters in Table 2. Among different inputs of crop production, highest expenditure was made by zero-tillage adopters on fertilizers use which account for 13.14 per cent of total cost of cultivation, while in case of non-adopters, the highest expenditure was born on irrigation and it account for 11.71 per cent of total cost of cultivation. There was significant difference observed between zero-tillage adopters and non-adopters in using different inputs of wheat production. For the land preparation, zero-tillage adopters incurred lower machine hours (3.75) as compare to non-adopters (6.68). In case of zero-tillage adopters, per hectare total working capital was Rs 23421.55, whereas in case of zero-tillage non-adopters it was Rs 24268.69.

Particulars	Zero-tillage Adopters			Zero-tillage Non-adopters		
	Physical Unit	Amount (Rs)	% to total cost (C3)	Physical Unit	Amount (Rs)	% to total cost (C3)
1. Human labour						
a. Family labour - Male	2.61	521.42	1.07	2.55	509.78	1.08
b. Hired labour - Male	6.29	1258.22	2.58	9.09	1818.44	3.84
2. Machine labour (Hrs)	3.75	1868.75	3.84	6.68	3326.86	7.03
3. Seed (Kg)	148.06	4404.89	9.05	151.96	4095.20	8.65
4. Fertilizer (Kg)						
a. Nitrogen	230.28	1611.97	3.31	228.42	1598.95	3.38
b. Phosphetic	180.11	4322.54	8.88	128.49	3083.80	6.52
c. NPK	-	-	-	1.68	5.03	0.01
d. Zn	5.63	343.66	0.71	1.27	63.55	0.13
e. Sulpher	0.18	9.10	0.02	0.52	33.59	0.07
f. Others	2.11	105.63	0.22	1.68	100.56	0.21
5. Insecticides & Pesticides	-	260.00	0.53	-	285.00	0.60
6. Irrigation (Hrs)	29.85	4946.82	10.16	32.59	5539.84	11.71
7. Harvesting and Threshing		2976.53	6.11		2987.43	6.31
Sub-Total		***22629.52***	46.47		***23448.01***	49.55
8. Interest on working capital		792.03	1.63		820.68	1.73
9. Total Working Capital		***23421.55***	48.10		***24268.69***	51.29
10. Land revenue		-	-		-	-
11. Rental value of own land		18889.57	38.79		16207.05	34.25
12. Rental Value of leased-in land		1957.09	4.02		2542.95	5.37
13. Cost of Cultivation		***44268.21***	90.91		***43018.69***	90.91
14. Cost A1		22900.13	47.03		23758.92	50.21
15. Cost B1		22900.13	47.03		23758.92	50.21
16. Cost C1		43746.79	89.84		42508.92	89.83
17. Cost C2		44268.21	90.91		43018.69	90.91
18. Cost C3/ Cost of Cultivation		***48695.03***	**100.00**		***47320.56***	**100.00**

Table 2: Cost of cultivation of wheat crop

C. INCOME AND COST OF PRODUCTION

The reduction in use of inputs of wheat production by zero-tillage adopters did not affect negatively on grain yield of wheat negatively, but zero-tillage were obtained additional yield of 4.85 quintal grain and 5.30 quintal by-product over non-adopters (Table 3). Due to higher yield, zero-tillage adopters got higher gross income and net income over all costs as compare to non- adopters. Zero-tillage adopters had lower cost of production of wheat crop in all respect of costs over non adopters and noted highest difference in cost C_3 (Rs. 221.05). Return per rupee of expenditure was favourable in all cost principles for zero-tillage adopters while low return was observed in cost C_3 for non adopters.

Particulars	RCTs Adopter	RCTs Non-adopter
1. Crop yield (Qts/Ha)		
a. Main product (Wheat grain)	32.01	27.16
b. By-product (Wheat *bhusa)*	32.45	27.16
2. Market price (Rs/Qt)		
a. Main product (Wheat grain)	1330.00	1330.00
b. By-product (Wheat *bhusa)*	475.00	475.00
3. Gross Income (Rs/Ha)	57984.57	49019.87
4. Net Income Over		

a. Cost A1	35084.44	25260.95
b. Cost B1	35084.44	25260.95
c. Cost C1	14237.77	6510.95
d. Cost C2	13716.35	6001.17
e. Cost C3	9289.53	1699.30
5. Input-Output Ratio Over		
a. Cost A1	1:2.53	1:2.06
b. Cost B1	1:2.53	1:2.06
c. Cost C1	1:1.33	1:1.15
d. Cost C2	1:1.31	1:1.14
e. Cost C3	1:1.19	1:1.04
6. Cost of Production (Rs/Qt)		
a. Cost A1	715.47	874.85
b. Cost B1	715.47	874.85
c. Cost C1	1366.79	1565.26
d. Cost C2	1383.08	1584.03
e. Cost C3	1521.38	1742.43

Table 3: Income and Cost of Production of Wheat Crop

D. ECONOMIC BENEFITS OF ZERO-TILLAGE

Zero-tillage adopters got additional benefit of main product and by-product by 4.85 quintal and 5.30 quintal, respectively. All factors of economics benefits increased in monetary term except seed and fertilizer. Per hectare economic benefit due to adoption of zero-tillage in the study area was estimated to be Rs 10426.91 (Table 4). In case of zero-tillage adopters, sample farmers in the study area were spending more money on seed and fertilizer as compared to non-adopters.

Sl. No.	Particulars	Amount (Rs/hectare)
1.	Due to reduction in cost of labour	548.58
2.	Due to reduction in cost of machine labour	1458.11
3	Due to reduction in cost of seed	-309.69
4	Due to reduction in cost of fertilizer	-1507.42
5	Due to reduction in cost of pesticide	25.00
6	Due to save in irrigation cost	593.02
7	Due to reduction in cost of harvesting	10.90
8	Due to yield benefits (main & by-product)	8964.70
9	Due to diesel saving (@ Rs. 55/Lt)	643.72
	Total	**10426.91**

Table 4: Economic Benefits of zero-tillage

E. ENVIRONMENT BENEFITS OF ZERO-TILLAGE

Adoption of zero tillage is advantageous for environment protection. Per hectare diesel consumption was reduced by 44 per cent (11.65 liters) after adoption of zero-tillage for land preparation and sowing of wheat crop than non-adopters. Due to reduction in diesel consumption, the carbon emission from land preparation and sowing of wheat crop was reduced by the 8.22 kg per hectare (Table 5).

Particulars	**Wheat**	
	Adopter	**Non-adopter**
Diesel consumption (Lt/Ha)	15.00	26.70
CO_2 emission (Kg/Ha)	39.00	69.43
Carbon emission (Kg/ Ha)	10.53	18.75
Reduction in carbon emission (Kg/Ha)	8.22	

Table 5: Environment benefits of RCT

F. CONSTRAINS ASSOCIATED WITH ZERO-TILLAGE ADOPTION

Zero-tillage adoption is not free from impudence and several constraints associated with adoption of zero-tillage in the Chandauli district is presented in Table 6. With the help of Garrett score, ranks are assigned for each constraint. Weed problem placed first rank among all constraints with 79.10 Garrett score. Second important constraint associated with zero-tillage adoption was poor soil quality followed by upland field, uncertainty of irrigation, not sure of profit and high cost of machine.

Reasons	**Garrett Score**	**Ranking**
Weed problem	79.10	I
Poor soil quality	78.85	II
Upland field	60.30	III
Uncertainty of Irrigation	58.70	IV
Not sure of profit	56.45	V
High cost of Machine	53.15	VI
Less yield under zero-tillage	49.50	VII
Does not own zero-tillage Machine	49.05	VIII
Labour issues	48.85	IX
Not sure about technology	47.30	X
Non-availability of zero-tillage on hire	46.50	XI
Non-availability of zero-tillage on Time	44.90	XII
Custom hiring of zero-tillage is high	34.75	XIII
Lack of financial support	24.15	XIV
Credit unavailability	18.35	XV

Table 6: Constrains associated with RCT adopters

G. CONDITION FOR ADOPTION OF ZERO-TILLAGE

The most important condition for adoption of zero-tillage by zero-tillage non-adopters sample farmers in the study area was availability of irrigation water (Table 7). If non-adopters sample farmers get irrigation facility then they adopt zero-tillage for wheat crop. The second rank for condition for adoption of zero-tillage was that if they convinced of yield benefits and more observation about zero-tillage on other's field. The least important condition for adoption of zero-tillage was better repair services of zero-tillage machine and availability of skilled labour for operating zero-tillage machine.

Condition for adoption of zero-tillage	Garrett Score	Rank
1. Irrigation water availability	69.00	I
2. If convinced of yield benefit	68.90	II
3. More observation on other field	58.80	III
4. If zero tillage is available on subsidy	45.35	IV
5. If custom hiring rate is low	45.25	V
6. If better repair service is available	38.70	VI
7. Non-availability of skilled labour	25.00	VII

Table 7: Condition for Adoption of RCTs in future

IV. CONCLUSION AND POLICY IMPLICATIONS

The zero-tillage with crop residue management system has potential to enhance crop productivity of wheat crop in different regions of the country. Zero-tillage not only saves the inputs of crop production but also reduces the negative environmental consequences. Results of the present study

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showed that young farmers and family size has positive and significant impact on adoption of zero-tillage in the study area. After adoption of zero-tillage, the gross and net income was higher for zero-tillage adopters due to increase in wheat yield (grain and by-product) and reduction in input use. After adoption of zero-tillage carbon emission was also reduced. Weed problem, poor soil quality, upland and uncertainty of irrigation are major constraints associated with RCT adopters. For the popularisation of zero-tillage in the study area government should target young farmers and encourage and provide training for adoption of zero-tillage.

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