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Problems and Prospects of Rotavator Use in Etah District of Uttar Pradesh

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ABSTRACT

Rotavator is playing an important role in reducing number of tillage for land preparation for sowing of wheat crop which leads to reduce the cost of land preparation and sowing of wheat crop and cost of other inputs. This leads to overall saving of money, time and fossil fuel. Present study was an attempt to find out the impact of rotavator on wheat production and problems associated with the adoption of rotavator in Etah district of Uttar Pradesh. Results suggest that cost of wheat cultivation for rotavator adopters was lower (Rs 48581.62/ha) than the non-adopters (Rs 50890.66/ha). Per hectare net income for rotavator adopters was estimated to be Rs 45719.32, which was higher than the non-adopters (Rs 26249.25). Major influencing factors for adoption of rotavator in the study area was land holding size, age of respondents and education level of respondents. After adoption of rotavator, per hectare carbon emission from wheat field was reduced by 15.58 kg as compared to non-adopters. Irrigation water saving was estimated to be 946.39 m^3 per hectare. The most important reason for adoption of rotavator in the study area was reduction in weed problem. The most important factor that influenced farmers for non-adoption of rotavator in the study area was high cost of the rotavator. The most important condition for adoption of rotavator by sample farmers in future was if custom hiring rate for rotavator is low. Therefore, government should provide more subsidies on purchase of rotavator and tractor to enhance the adoption of rotavator in the study area.

Key words *Rotavator, Conservation agriculture, Irrigation water productivity, Economic benefit, Environmental benefit, Net economic benefit.*

Achieving food security for growing population along with sustaining agricultural system under the depleting natural resources, negative impacts of climate variability, mounting cost of inputs and unstable food prices are the major challenges before most of the Asian country (Bhan and Behera, 2014). Indian agriculture has transformed their position from food deficit to food surplus and it was obtained due to increase in crop yield and lesser expansion of area under crop production. In high intensity agricultural production areas like Punjab, Haryana and Western Uttar Pradesh, per unit crop yield has attended maximum level of output. Despite higher doses of inputs use, some pockets are showing declining trend (Aulakh, 2005). With intensive tillage-based agriculture, the organic matter of soil steadily decreasing, leading to decline in crop productivity, followed by the visible signs of soil degradation and finally desertification (Shaxon and Barber, 2003). The poor response to higher doses of fertilizer in Indo-Gangatic Plains can be attributed to poor soil health resulting from overexploitation of natural resources (Aulakh, 2005).

Conventional method of crop production is based on intensive tillage with mechanical power is responsible for soil erosion, surface and groundwater pollution and less water use efficiency (Wolff and Stein, 1998). Moreover, it is implicated in land resource degradation and contribution to global warming problems (Boatmann *et al.*, 1999). A paradigm shift in farming practices through eliminating unsustainable parts of conventional agriculture (ploughing/ tilling the soil, removing all organic material, monoculture) is crucial for future productivity gains while sustaining the natural resources. The resource conservation technologies (RCTs) have been developed in order to: [a] reduce the use of and damage to natural resources through agricultural production; and [b] increase the efficiency of resource utilisation. The different options of resource conservation technologies are targeting the two most crucial natural resources i.e. water and soil, but some also affect the efficiency of other resources and inputs of crop production viz., labour, farm power and fertiliser etc. Zero-tillage or reduced tillage, is one of the important options of resource conservation technologies.

Rotavator is playing an important role in reducing number of tillage for land preparation and sowing of wheat crop. Rotavator is rotary tillage implement drive by tractor, which cuts, pulverize, mixes and level the soil in single pass. It can be use in any types of soil. It is now gaining popularity among the farmers in different part of Uttar Pradesh. It is more suitable in those agricultural fields which has full of weed, stubbles of sugarcane, cotton, banana and jowar etc. Some part of Uttar Pradesh, rotavator is used for sowing of wheat crop just after harvesting of paddy crop without land preparation and they mix wheat seed and fertiliser in the soil in one pass of rotavator. Rotavator helps farmers to reduce the cost of land preparation and sowing of wheat crop and cost of other inputs which leads to saving of money, time and fossil fuel.

Looking the importance of rotavator, present study was an attempt to find out the impact of rotavator on wheat production and problems associated with the adoption of rotavator in Etah district of Uttar Pradesh.

DATA AND ANALYTICAL TOOLS

Data and Source of Data

Present study was based on the primary data which was collected using pre-tested schedule from the rotavator adopters and non-adopters. Primary data include quantity of inputs used for wheat production, their price, wheat yield both main and by-products and their price, reason for adoption of rotavator and constraints faced by producers etc.

Sampling Procedure

Uttar Pradesh being highest wheat producing State was purposively selected for the present study. The Uttar Pradesh is divided into nine agro-climatic zones. Out of nine agro-climatic zones, South Western Dry Plain agro-climatic zone was purposively selected. The South Western Dry Plain agro-climatic zone consists of seven districts. Out of these districts, Etah district was selected purposively, because rotavator adoption was highest in Etah district. The Etah district consist of eight development blocks, out of these development blocks, two blocks viz., Awagarh and Nidhauli Kalan development block was purposively selected. The criteria for selection of block was done on the basis of one having highest adoption of rotavator and another having lowest adoption of rotavator. From each selected development blocks, one village (Punehra village from Awagarh development block and Gerhana from Nidhauli Kalan development block) was selected purposively. From each selected village, 10 rotavator adopters and 10 rotavator non-adopters were selected using snowball method sampling. Total sample size was 40 consisting 20 adopters and 20 non-adopters.

Analytical Tools

Cost of Cultivation

For the estimation of cost of cultivation of crops grown by rotavator adopters and non-adopters were calculated by using cost concept developed by the Commission for Agricultural Costs and Prices (CACP) method. The different cost was calculated as:

Cost A1: includes value of hired human labour + value of hired/own bullock labour + value of owned/hired machinery labour + value of seed (both farm produced and purchases) + value of insecticides and pesticides + value of manure (owned and purchased) + value of fertilizer + depreciation on implements and farm buildings + irrigation charges + land revenue, cesses and other taxes + interest on working capital + miscellaneous expenses

Cost B1: Cost A1 + interest on value of owned fixed capital assets (excluding land)

Cost C1: Cost B1 + rental value of owned land (net of land revenue) and rent paid for leased-in land

Cost C2: Cost C1+ imputed value of family labour

Cost C3: Cost C2 + 10 percent of cost C2 as account for managerial input of the farmer

Factors Influencing Adoption of Rotavator

For identification of relative importance of various factors influencing adoption of Rotavator was worked out by using binary logit model [Mallada (1992); Green (2008) and Gujarati (2003)]. The algebraic form of model is given below:

$$Pi = \frac{1}{1 + e^{-z(i)}}$$

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

$$Z_i = \beta_0 + \sum_{i=1}^{n} \beta_i X_i$$

Where, β_0 is the intercept and β_i is a vector of unknown slope coefficients. The relationship between P_i and X_i, which is non-linear, can be written as follows:

$$p_i = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \dots \beta_n X_n)}}$$

Finally, the logit model is obtained by taking the logarithm

$$L_i = L_n \left[\frac{p_i}{1 - p_i}\right] = Z_i = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n$$

Economic and Environmental Benefit

The economic benefits were due to the reduction in cost of inputs used for wheat production and increase in income due to the increase in crop yield. Environmental benefits comprises of reduction in carbon emission from cultivation of wheat crop and reduction in irrigation water use. For estimation of economic and environmental benefit, following method was used:

Economic Benefit

The economic benefit of RCTs was worked out using economic surplus model as suggested by the Alston *et al.* (2005). The model is given below:

$$\Delta\, CS = PQ\, Z\, (1 + 0.5\, Z\eta)$$

$$\Delta\, PS = PQ\, (K - Z)\, (1 + 0.5\, Z\eta)$$

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

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

Environmental Benefit

Reduction in Carbon Emission

The environmental benefits realized by adoption of rotavator were reduction in carbon emission, improvement of carbon/organic content through residue management in soil. To find out the carbon emission following methodology was adopted:

1 liter Diesel = 2.6 kg of CO_2 (Jat *et al.*, 2006)

1 kg CO_2 = 0.27 kg of carbon (Paustian *et al.*, 2006)

Reduction in Irrigation Water Use

The farmers of the study area were using surface or ground water for irrigating wheat crop. For the quantification of irrigation water use for irrigation purpose, following formula was used (Singh *et al.* 2014):

$$Pd_{(m^3/Hr)} = \frac{HP * 75 * Pe}{1000 * DW}\ x\ 3600$$

Where, *Pd* is pump discharge rate measured in m^3 per hour, *HP* is the pump capacity, *Pe* is the pump efficiency, and *DW* is depth to water level plus head of delivery pipe measured in meter.

Constraints Ranking

The Garrett Raking was used to rank the constraints associated with the rotavator adopters. The percentage position of each rank thus obtained was converted into scores by referring to the table given by Henry Garrett. 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.

RESULTS AND DISCUSSION

Socio-Economic Profile of the Sample Farmers

The average age of rotavator adopters was lower (50.15 years) than the non-adopters (53.60 years). The average farming experience for rotavator adopters was found to be 31.70 years which was quite higher than the non-adopters i.e. 31.20 years. Average year of education of sample farmers was found to be 10.70 and 10.40 year for rotavator adopters and non-adopters respectively.

In case of rotavator adopters, 35 per cent respondents was doing only crop production, 50 per cent respondents were doing crop and livestock production and remaining 15 per cent respondents was involve in crop production and business. In case of rotavator non-adopters, 50 per cent respondents were engaged in crop production only, 45 per cent respondents were involved in crop and livestock production and remaining 5 per cent respondents were doing crop production along with service.

The average family member for rotavator adopters was 11.45 persons per family which was larger than the non-adopters i.e. 9.10. Out of total family members of the respondents, about 37.12 and 35.16 per cent family members of rotavator adopters and non-adopters respectively were belonging to children category having their age of less than 18 years.

The average size of land holding for rotavator adopters and non-adopters in Etah district was found to be 2.83 and 2.35 hectares respectively. The rice-wheat based cropping system was found in the study area. All the land holding area of the sample farmers were allocated for crop production during kharif and rabi season. During summer season, sample farmers were allocating small size of land holding under summer crop. The major source of irrigation water was groundwater and farmers were using electric and diesel operated pump for pumping groundwater. Per hectare average rental value of land was found to be Rs 60937 per year.

Cost of Cultivation

Average cost of wheat cultivation for rotavator adopters was lower (Rs 48581.62) than the non-adopters i.e. Rs. 50890.66 (Table 1). Out of total cost of cultivation, share of input cost for rotavator adopters and non-adopters was estimated to be 75.68 and 78.52 per cent respectively. The contribution of rental value of own land and leased-in land to cost of cultivation was estimated to be 12.58 and 9.65 per cent for rotavator adopters and non-adopters respectively in the study area. The share of imputed value of family labour for rotavator adopters and non-adopters was found to be 3.02 and 2.19 per cent respectively.

The contribution of chemical fertiliser to total cost of cultivation was estimated to be 11.18 and 9.91 per cent for rotavator adopters and non-adopters respectively. The share of expenditure on irrigation was estimated to be 7.46 and 10.73 per cent of cost of cultivation for rotavator adopters and non-adopters respectively.

Income from Wheat Production

Per hectare average wheat yield was estimated to be 45.36 and 37.21 quintal for rotavator adopters and non-adopters respectively. Per hectare average by-product (wheat *bhusa*) yield was found to be 44.20 and 38.83 quintals for rotavator adopters and non-adopters respectively.

The average market price received by the sample farmers in the study area for wheat (grain) and by-product (wheat *bhusa*) was found to be Rs 1565.00 and Rs 527.50 per quintal respectively. Per hectare average gross income obtained by the rotavator adopters and non-adopters sample farmer was estimated to be Rs. 94300.95 and Rs 77139.91 respectively (Table 2).

In case of rotavator adopters, per hectare net income over cost C3 was estimated to be Rs 45719.32, whereas in case of non-adopter it was Rs 26249.25 per hectare. The benefit cost ratio (B-C ratio) for wheat production for rotavator adopters was estimated to be 1.94 over cost C3 which was higher than the non-adopter i.e. 1.52. Per quintal cost of production for wheat grain was estimated to be Rs 1071.03 for rotavator adopters and Rs 1367.52 for non-adopters, which was lower than the market price i.e. Rs. 1565.

Factor Influencing Adoption of Rotavator

For identification of factors influencing adoption of rotavator in Etah district was estimated using binary logit model. In case of dependent variable for rotavator adopters and non-adopters used binary value i.e. one for adopters and zero for non-adopters. The independent variables were farming experience in year, land holding size in hectare, age of respondents in year, family size in number and education level of the respondents in year.

The results suggest that the education level of the respondents was positively and significantly associated with the adoption of rotavator in the study area (Table 3). It means if education level of respondents increase then more chances of adoption of rotavator in the study area. The land holding size of the respondent was positively associated with the adoption of rotavator in the study area. The age of respondents was found significant and negatively associated with adoption of rotavator in the study area. If age of respondents is increase then there is chance of non-adoption of rotavator in the study area.

Agronomic and Economic Benefit

After adoption of rotavator by the farmers in the study area were getting higher yield of main and by-production

Table 1. Cost of Cultivation of Wheat (Rs/Ha)

Particulars	Rotavator Adopter			Rotavator Non-adopter		
	Physical Unit	Amount (Rs)	% to total cost (C3)	Physical Unit	Amount (Rs)	% to total cost (C3)
1. Human labour (Number)						
a. Family labour - Male	6.52	1467.44	3.02	4.96	1115.55	2.19
b. Hired labour - Male	4.51	1014.15	2.09	5.93	1333.47	2.62
2. Machine labour (Hrs)	13.85	8310.00	17.11	16.29	9771.95	19.20
3. Seed (Kg)	138.32	4536.80	9.34	161.78	4618.94	9.08
4. Manure (Qts)	52.88	1031.12	2.12	52.72	1186.19	2.33
5. Fertilizer (Kg)		5430.03	11.18		5045.82	9.91
a. Nitrogen	197.24	1380.71	2.84	195.16	1366.10	2.68
b. Phosphetic	160.37	3848.78	7.92	152.12	3650.95	7.17
c. Potassic	31.95	115.02	0.24	6.11	19.54	0.04
d. Zn	8.24	82.03	0.17	2.34	9.23	0.02
e. Sulpher	0.24	0.20	-	-	-	-
f. Others	3.66	3.29	0.01	-	-	-
6. Insecticides & Pesticides	-	70.00	0.14	-	70.00	0.14
7. Irrigation (Hrs)	49.61	3621.77	7.46	62.07	5462.00	10.73
8. Harvesting and Threshing		11285.06	23.23		11353.17	22.31
Sub-Total		36766.37	75.68		39957.11	78.52
9. Interest on working capital		1286.82	2.65		1398.50	2.75
10. Total Working Capital		38053.19	78.33		41355.61	81.26
11. Rental value of own land		5627.42	11.58		4488.76	8.82
12. Rental value of leased-in land		484.51	1.00		419.87	0.83
13. Cost of Cultivation		44165.11	90.91		46264.24	90.91
14. Cost A1		36585.75	75.31		40240.05	79.07
15. Cost B1		36585.75	75.31		40240.05	79.07
16. Cost C1		42697.67	87.89		45148.69	88.72
17. Cost C2		44165.11	90.91		46264.24	90.91
18. Cost of Cultivation(C3)		48581.62	100.00		50890.66	100.00

of wheat crop. Per hectare wheat grain and *Bhusa* obtained by rotavator adopters was estimated to be 45.36 and 44.20 quintal respectively, whereas in case of non-adopters it was found to be 37.21 and 35.83 quintal of wheat grain and *Bhusa* respectively (Table 4). Per hectare incremental grain yield benefit due to adoption of rotavator was estimated to be 8.15 quintal over conventional method of wheat cultivation. Per hectare incremental yield of by-product of wheat crop was found to be 8.36 quintal.

The current price of labour was Rs 225 per day, tractor charges was Rs 600.00 per hour, cost of seed was Rs 30.51 per kg and market price of main and by-product was Rs 1565.00 and Rs 527.50 per quintal. Per hectare economic benefits due to adoption of rotavator was estimated to be Rs 20732.76 (Table 4). This economic benefit of rotavator was due to reduction in cost of machine labour, cost of seed, irrigation cost, cost of harvesting, increase in crop yield (both main and by-products) and saving of diesel for land preparation and sowing of wheat crop.

Reduction in Carbon Emission

Per hectare environmental benefits due to adoption of rotavator per hectare is given in Table 5. The one litre diesel burning is generating 2.6 kg of CO_2 (Jat *et al*., 2006) and one kg CO_2 is equal to 0.27 kg of carbon (Paustian *et al*., 2006). Per hectare total diesel used for land preparation and sowing of wheat crop was estimated to be 55.40 and 65.15 litres for rotavator adopters and non-adopter respectively. Per hectare CO_2 emission from rotavator adopters and non-adopters from wheat cultivation was estimated to be 144.04 and 169.38 kg respectively and carbon emission was 38.89 and 45.73 kg respectively. After adoption of rotavator, per hectare carbon emission was reduced by 6.84 kg (Table 5).

Farmers of the study area also using diesel pump for pumping groundwater to irrigated wheat crop. Per hectare diesel used to irrigate wheat crop was estimated to be 49.61 and 62.07 litres for rotavator adopters and non-adopters respectively. Per hectare carbon emission was estimated to be 34.83 and 43.57 kg for rotavator adopters and non-

Table 2. Income from Wheat Production (Rs/Ha)

S. No.	Particulars	Rotavator adopters	Rotavator Non-adopters
1.	Gross Income	94300.95	77139.91
2.	Net Income Over		
	a. Cost A1	57715.20	36899.86
	b. Cost B1	57715.20	36899.86
	c. Cost C1	51603.27	31991.22
	d. Cost C2	50135.83	30875.67
	e. Cost C3	45719.32	26249.25
3.	Cost of Production (Rs/Qt)		
	a. Cost A1	806.57	1081.32
	b. Cost B1	806.57	1081.32
	c. Cost C1	941.31	1213.23
	d. Cost C2	973.66	1243.20
	e. Cost C3	1071.03	1367.52
4.	Input-Output Ratio Over		
	a. Cost A1	2.58	1.92
	b. Cost B1	2.58	1.92
	c. Cost C1	2.21	1.71
	d. Cost C2	2.14	1.67
	e. Cost C3	1.94	1.52

adopters respectively. After adoption of rotavator, carbon emission was reduced by 8.74 kg as compared to non-adopter from irrigation. Therefore, total carbon emission was reduced from wheat cultivation and estimated to be 15.58 kg per hectare.

Irrigation Water Saving and Water Productivity

Sample farmers of the study area were using groundwater to irrigate their wheat crop. Total water used for irrigating wheat crop by rotavator adopters and non-adopters were estimated to be 3769.88 and 4716.27 m^3 per hectare respectively (Table 6). After adoption of rotavator, sample farmers were using less groundwater for irrigating their wheat crop. Reduction in irrigation water was estimated to be 946.39 m^3 per hectare. Per hectare average crop yield was obtained by the rotavator adopters and non-adopters were estimated to be 45.36 and 37.21 quintal respectively. Per hectare net income received by the sample farmers were estimated to be Rs 45719.32 and Rs 26249.25 for rotavator adopters and non-adopters respectively. The agronomic water productivity for rotavator adopters and non-adopters were workout to be 1.20 and 0.79 kg per m^3 respectively. The net economic water productivity for wheat crop was found to be Rs 12.13 and Rs 5.57 per m^3 for rotavator adopters and non-adopters respectively.

Reason for Adoption of Rotavator

The reasons for adoption of rotavator in the study area, Garrett ranking was used to rank the most important influencing factors for adoption of rotavator and it is presented in Table 7. The most important reason for adoption of rotavator in the study area was reduction in weed problem. During the field visit sample farmers told that after adoption of rotavator, the weed problem in the agricultural field was reduced. The second most important reason for adoption of rotavator was improvement in soil health due to incorporation of weed into soil. Third and fourth reason for adoption of rotavator in the study area were as it reduces the ploughing cost which leads to overall reduction in cost of cultivation of wheat crop. After adoption of rotavator, the crop yield was increased and farmers were getting higher net income from the wheat crop and rank was fifth and sixth. The least important reason for adoption of rotavator in the study area was reduction in irrigation water use, reduction in fertiliser use early sowing of wheat crop etc.

Table 3. Factors Influencing Adoption of Rotavator

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
a. Constant "a"	-6.278	4.225	2.207	1	.137	.002
c. Farming experience (Year)	0.013	.062	.046	1	.830	1.013
d. Land holding size (Ha)	1.077**	.586	3.383	1	.066	2.936
e. Age of respondents (Year)	-.107**	.059	3.270	1	.071	.899
f. Family size (No.)	0.018	.146	.016	1	.900	1.019
g. Education level of respondents (Year)	0.639*	.291	4.828	1	.028	1.895
	Model Summery					
-2 Log likelihood	24.663					
Cox & Snell R Square	0.537					
Nagelkerke R Square	0.716					

*: Significant at 5 per cent level of significance
**: Significant at 10 per cent level of significance

Table 4. Economic Benefit of Rotavator (Rs/Ha)

Sl. No.	Particulars	Amount (Rs)
1.	Due to reduction in cost of labour	-32.56
2.	Due to reduction in cost of machine labour	1461.95
3	Due to reduction in cost of seed	82.14
4	Due to reduction in cost of fertilizer	-384.19
5	Due to reduction in cost of pesticide	0.00
6	Due to save in irrigation cost	1840.23
7	Due to reduction in cost of harvesting	68.11
8	Due to yield benefits (main & by-product)	17161.04
9	Due to diesel saving (@ Rs. 55/Lt)	536.05
	Total	**20732.76**

Table 5. Environmental Benefit per hectare

Sl. No.		Rotavator adopters	Rotavator non-adopters
A.	**From Land preparation and Sowing**		
	1. Diesel consumption (Lts)	55.40	65.15
	2. CO_2 emission (Kg)	144.04	169.38
	3. Carbon emission (Kg)	38.89	45.73
	4. Reduction in carbon emission (Kg)	6.84	
B.	**From Irrigation**		
	1. Diesel consumption (Lts)	49.61	62.07
	2. CO_2 emission (Kg)	128.99	161.38
	3. Carbon emission (Kg)	34.83	43.57
	4. Reduction in carbon emission (Kg)	8.74	

Table 6. Irrigation Water Productivity for Wheat Crop

Sl. No.	Particulars	RCTs Adopter	RCTs Non-Adopter
1.	Wheat yield (Qt/Ha)	45.36	37.21
2.	Gross Income (Rs/Ha)	94300.95	77139.91
3.	Cost of cultivation (Rs/Ha)	48581.62	50890.66
4.	Net Income (Rs/Ha)	45719.32	26249.25
5.	Irrigation water use (m^3/Ha)	3769.88	4716.27
6.	Agronomic water productivity (Kg/m^3)	1.20	0.79
7.	Net economic water productivity (Rs/m^3)	12.13	5.57

Table 7. Reason for Adoption of Rotavator

Sl. No.	Reasons for adoption of Rotavator	Garrett Score	Rank
1.	Reduction in weed problem	70.75	I
2.	Improve in soil health	70.15	II
3.	Reduction in ploughing cost	61.35	III
4.	Reduction in cost of cultivation	56.10	IV
5.	Increase in crop yield	52.50	V
6.	Increase in net income	51.85	VI
7.	Increase in insect attack	46.25	VII
8.	Increase in cost of Insecticide	40.75	VIII
9.	Early sowing of wheat	39.00	IX
10.	Reduction in fertilizer use	34.05	X
11.	Reduction in irrigation water use	25.65	XI

Reason for Non-adoption of Rotavator

The most important factor that influenced farmers for non-adoption of rotavator in the study area was high cost of the rotavator (Table 8). For operating rotavator, farmers need to purchase high power tractor. The second and third most important influencing factor for adoption of rotavator in the study area were as sample farmers not very sure about the profit they received after adoption of rotavator and they also not sure about the technology. Other important reasons for not adoption of rotavator in the study area were high density of weed in agricultural field, non-

Table 8. Reason for Non-adoption of Rotavator

Sl. No.	Reasons for Non-adoption of Rotavator	Garret t Score	Rank
1.	High cost of Machine	66.10	I
2.	Not sure of profit	64.80	II
3.	Not sure about technology	60.85	III
4.	Does not own Machine	60.30	IV
5.	Weed problem	54.10	V
6.	Non-availability on hire basis	51.85	VI
7.	Non-availability of machine on time	51.00	VII
8.	Custom hiring of machine is high	47.05	VIII
9.	Poor soil quality	45.80	IX
10.	Lack of financial support	45.80	IX
11.	Uncertainty of irrigation	44.70	X
12.	Labour issues	41.90	XI
13.	Upland field	40.50	XII
14.	Credit unavailability	39.55	XIII
15.	Less yield under rotavator	38.40	XIV

availability of rotavator on hire basis when it was required. The less important reason for non-adoption of rotavator in the study area were uncertainty of irrigation water, non-availability of trained labour, upland field, credit unavailability and less yield under rotavator.

Conditions for Adoption of Rotavator in Future

The most important condition for adoption of rotavator by farmers in the study area was if custom hiring rate for rotavator is low (Table 9). Second most important condition for adoption of rotavator in future was if they convinced on the yield benefit. Third and fourth conditions for adoption of rotavator in the study area in future were if rotavator is available on subsidy basis and more observation on other field respectively. Least important conditions for adoption of rotavator were availability of skilled labour for using machine and if better repair service for rotavator machine is available.

Table 9. Condition for Adoption of Rotavator in Future

Sl. No.	Condition for adoption of Rotavator	Garrett Score	Rank
1.	If custom hiring rate is low	62.50	I
2.	If convinced of yield benefit	60.60	II
3.	If rotavator is available on subsidy	55.05	III
4.	More observation on other field	51.15	IV
5.	Availability of skilled labour	36.70	V
6.	If better repair service is available	34.00	VI

CONCLUSION AND POLICY IMPLICATION

Farm mechanisation helped farmers to enhance their cropping intensity which triggered to improvement in socio-economic conditions of the farmers. The negative impact of intensive tillage based agriculture and imbalance use of inputs of crop production is loss of organic matter in the soil which leads to reduction in crop productivity. Out of several options of resource conservation technologies, rotavator is playing an important role in the improvement in crop production. It helps farmers to prepare land for sowing of wheat crop with less tillage and less cost. Average cost of wheat cultivation for rotavator adopters was lower than the non-adopter. After adoption of rotavator for wheat crop, per hectare average wheat yield and net income was higher as compared to non-adopters. Land holding size, age and education level of the respondents were playing important role in adoption of rotavator in the study area.

Per hectare economic benefits due to adoption of rotavator was estimated to be Rs 20732.76. Total carbon emission was reduced from wheat cultivation was estimated to be 15.58 kg per hectare. After adoption of rotavator in the study area, farmers were using less irrigation water for wheat production as compared to non-adopters. The agronomic and net economic water productivity for rotavator adopters was higher as compared to non-adopters. Out of several reasons for adoption of rotavator in the study area, most important reason was reduction in weed problem. The most important factor that influenced farmers for non-adoption of rotavator in the study area was high cost of the rotavator. The most important condition for adoption of rotavator by sample farmers in the study area was if custom hiring rate for rotavator is low. As farmers in the study area was largely marginal and small farmers with resource and economically poor, government should provide more subsidy on purchase of rotavator and tractor. It will help to enhance the availability of rotavator in the study area, which leads to reduce the hiring cost of rotavator and it will trigger the large scale adoption of rotavator in the study area.

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