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Efficiency of conservation agriculture: Evidences from wheat farms in Eastern Uttar Pradesh

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HIGHLIGHTS MISSING

Abstract

India is the second largest producer of wheat in the world and Uttar Pradesh is the largest wheat-growing state in the country. The major challenge to wheat production in the state is the enhancing of its productivity and profitability. Adoption of zero tillage technique is one such step in this direction. The paper has compared the economics and efficiency of wheat production in Uttar Pradesh with zero tillage (ZT) adopters and non-adopters and assessed the contribution of technology and inputs to the increased productivity due to zero tillage for the years 2013-14. For the study, CACP cost concept and Cob-Douglas production function were used to find out the economics and efficiency of wheat in zero till system. The result indicates that the net return was found 80 % higher in case of adopters than non-adopters. The study has also observed that ZT technology has potential to provide additional income to farmers and help in conservation of scarce resources. The resource use efficiency analysis showed that zero tillage adoption saved machine labour and seed than under conventional method.

Keywords: Economics, efficiency, zero till, agriculture, wheat

Agriculture in India is the primary occupation and is one of the strongholds of Indian economy from the perspective of poverty alleviation, income and employment generation. The food grain production in India which was 5.16 million tonnes in 1950-51, increased to the level of 264.77 million tonnes during 2013-14. India is one of the world's largest producer of commodities like coconuts, mangoes, banana, cashew nut, pulses, ginger, turmeric and black pepper. It is also the second largest producer of wheat in the world with an average annual production of 95.91 million tonnes in year 2013-14 (Department of Agriculture and Cooperation 2014). Uttar Pradesh is the largest wheat-growing state in the country with area 9.96 million hectares and produces 30.25 million tonnes of wheat with yield level of 27.86quintal per hectare in year 2013-14 (Department of Agriculture and Cooperation 2014).

The major challenge to wheat production in the state is the enhancing of its productivity and profitability. Adoption of zero tillage technique is one such step in this direction. As an alternative to the conventional tillage, zero tillage technology uses direct seeding of wheat crop just after harvest of rice with the help of zero-till seed drill without preparatory tillage. Rice residue management in no-till systems (surface retention) provides multiple benefits, including soil moisture conservation, suppression of weeds, improvement in soil quality (Balwinder *et al.* 2011, Ram *et al.* 2013, Kumar *et al.* 2013, Verhulst *et al.* 2011). The application of green manuring and combined use of inorganic nutrients and bio-fertilizers improves technical efficiency and profitability in long run (Thimmareddy *et al.* 2013). Thus, zero-tillage ensures early sowing of wheat, conserves irrigation water and reduces cost of cultivation (Hobbs *et al.* 2003).

Globally the total area under conservation agriculture was 45 million hectares in 1999 which increased to 95 million hectares by the year 2005. In 2008, total area under cultivation conservation agriculture was 105 million hectares. Out of this, the share of different continents was 49.58, 40.07, 12.16, 2.53, 1.15 and 0.37 million hectares for South America, North America, Australia and New Zealand, Asia, Europe and Africa Respectively (Derpsch and Friedrich 2009 as cited in Singh *et al.* 2010). In India, presently more than 2 million hectares area in Indo-Gangetic plains under rice wheat system is under resource conserving technologies (Singh *et al.* 2010). Sowing of wheat after rice in the Indo-Gangetic plains under conventional tillage involves pre-sowing irrigation, intensive land preparation and finally seeding on fine tilth soil. These operations consume time, labour, irrigation water and energy, which delay sowing of wheat and result in poor plant growth and crop yield (Fujisaka *et al.* 1994, Harrington *et al.* 1993, Hobbs *et al.* 1991). In Uttar Pradesh, many farmers grow late-maturing, fine-grained varieties of rice, causing late sowing of wheat. The delay of every successive day in planting beyond November third week decreases the grain yield progressively (Ali *et al.* 2010, Irfaq *et al.* 2005, Sharma 1992). Therefore, to avoid delay in planting and reduce the cost of production, farmers have started adopting resource conserving technologies such as zero tillage and surface seeding in wheat production (Gupta and Seth, 2007). The present study was, therefore, conducted to find out the economics and resource use efficiency of wheat under Resource Conservation Technology i.e. zero till adopters and non-adopters.

Methodology

Zero-tillage adopters has been interpreted here as the farmers adopted the process of planting wheat seed after the harvest of rice directly on untilled soil which retains the rice crop residues. The non-adopters refers to the intensive tillage with multiple passes of a tractor to accomplish land preparation for wheat sowing. Out of the 27 districts of Eastern Uttar Pradesh, Chandauli district was selected purposively for the study because of the highest adoption of zero till.The district comprises of nine development blocks out of which two blocks, viz. Barhani and Sahabganj were selected purposively. A list of farmers practicing both zero till adopters and non-adopters from 2 villages from each block (total 4 villages) was prepared and 25 farmers from each village is selected randomly which led to the sample size of 100 farmers, which were further categories in marginal and small, medium and large farmers.

Sources and period of data

The primary data was collected with help of pretested schedule by personal interview method for the crop year 2013-14. Secondary information was collected from published journal, bulletin and official records of districts and blocks.

Analytical Tools

To fulfill the objective of cost of production and return was carried out as per the cost concept of CACP. The costs were taken as:

Cost A_1 : All variable cost excluding family labors cost and including land revenue, depreciation and Interest on working capital.

Cost A_2 : Cost A_1 + Rent paid for leased in land.

Cost B_1 : Cost A_1 + Interest on value of owned capital assets (excluding Land).

Cost B_2 : Cost B_1 + imputed rental value of owned land, (net of land revenue) + Rent paid for leased in land.

Cost C_1 : Cost B_1 + Imputed value of family labour.

Cost C_2 : Cost B_2 + Imputed value of family labour.

Cost C_2* : Cost C_2* will be estimated by taking into account statutory minimum wage rate or actual wage rate whichever is higher.

Cost C_3 : Cost C_2*+ 10% of cost C_2* on account

of managerial function performed by the farmers.

Resource use efficiency: Cob-Douglas production function was used to estimate the effects of various inputs for the production of wheat in Eastern region of Ut ar Pradesh (Anene *et al.* 2010). Five independent variables namely, human labour cost, machine labour cost, seed cost, fertilizer cost and irrigation cost were taken into consideration which are likely to have an impact on production of wheat crop. All variables were expressed in monetary terms.

To determine the contribution of the most important variables in the production process, the following specification of the model is applied:

$$Y = aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} e^{u}$$

$$\text{Or } \ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + U \ldots\ldots\ldots\ldots (1)$$

The estimated coefficients of significant independent variables were used to compute the marginal value products (MVP) and the resources-use efficiency (r) was worked out using Equation (2) (Rahman and Lawal 2003):

r = MVP/MFC…… (2)

r = Efficiency ratio

MVP = marginal value product of a variable input.

MFC = Marginal factor cost (Price per unit input)

The MVP is calculated as;

MVP = bi Y /X ..... (3)

Where bi = regression co-efficient of the variables Y and X = values of log Y and log X when they assume their means. The prevailing market price of inputs was used as the marginal factor cost (MFC) since the farmers were assumed to be operating under purely competitive inputs markets. On the basis of the economic theory, a firm maximizes profits with respect to resource use when the ratio of the marginal return to opportunity cost is one, therefore, the ratio will be equal to their respective MVP (Majumder *et al.* 2009). The values were interpreted thus;

(a) If r <1, it means the resource in question was over utilized hence decreasing the quantity used of that resource increases profit.

(b) If r > 1, it shows that the resource was being underutilized and increasing the rate of use will raise profit level.

(c) If r = 1 it means resource was being efficiently utilized.

Marginal Value Product (MVP) Adjustment: The relative percentagechange in MVP of each resource required so asto obtain optimal resource allocation that is r =1 or MVP = MFC, was estimated usingequation below:

D= (1 –MFC)/MVP *100 …….. (4)

Where:

D = absolute value of percentage change in MVP of each resource.

Results and Discussion

Comparison of Cost of Cultivation of wheat in case of adopters and non-adopters:

The per hectare economics of wheat crop cultivation in Eastern Ut ar Pradesh for both adopters and non-adopters of resource conservation technology i.e. zero till is presented in table1. It is evident from the table that the average, per hectare cost of cultivation of wheat for adopters was ₹ 49199 of which ₹ 24711 (50.2%) was operational cost and ₹ 20015 (40.7%) was fixed cost while for non-adopters the total cost was ₹ 56002 of which ₹ 30649 (54.7%) was operational cost and ₹ 20261(36.2%) was fixed cost. In the case of adopters the cost of cultivation was observed higher on small farms (₹ 49805) followed by large farms (₹ 49062) and medium farms (₹ 48729) non-adopters the maximum cost of cultivation was found for large farms (₹ 56123) followed by small farms (₹ 55976) than medium farms (₹ 55906).

As per the economic theory, economies of scale operate as farm size increases operational cost per hectare increase and decrease with decrease in the farm size. The operational cost under adopter category

was ₹ 25277 in small farms, ₹ 24289 in medium farms and ₹ 24567 in large farms for adopters. Likewise in case of non-adopters operational cost was ₹ 31197, ₹ 30439 and ₹ 30311on small, medium and large farms respectively.

Table 1. Cost of cultivation of wheat on adopters and non-adopters (₹/ha.)

	ADOPTERS				NON-ADOPTERS			
Items	**Small (%)**	**Medium (%)**	**Large (%)**	**Overall average (%)**	**Small (%)**	**Medium (%)**	**Large (%)**	**Overall average (%)**
Operational Cost								
Family labour	1250 (2.5)	750 (1.5)	250 (0.5)	750 (1.5)	3000 (5.4)	1500 (2.7)	1000 (1.8)	1833 (3.3)
Hired labour	3850 (7.7)	4100 (8.4)	4550 (9.3)	4166 (8.5)	5100 (9.1)	5950 (10.6)	6550 (11.7)	5867 (10.5)
Total Human labour	5100 (10.2)	4850 (10.0)	4800 (9.8)	4917 (10.0)	8100 (14.5)	7450 (13.3)	7550 (13.5)	7700 (13.7)
Tractor charges	3450 (6.9)	3000 (6.2)	3150 (6.4)	3200 (6.5)	5400 (9.6)	5400 (9.7)	5100 (9.1)	5300 (9.5)
Seed	3445 (6.9)	3254 (6.7)	3308 (6.7)	3335 (6.8)	3540 (6.3)	3450 (6.2)	3420 (6.1)	3470 (6.2)
Irrigation	5540 (11.1)	5329 (10.9)	5484 (11.2)	5451 (11.1)	5519 (9.9)	5473 (9.8)	5528 (9.9)	5507 (9.8)
Plant protection chemical	752 (1.5)	781 (1.6)	788 (1.6)	774 (1.6)	781 (1.4)	777 (1.4)	776 (1.4)	778 (1.4)
fertilizer	6557 (13.2)	6659 (13.7)	6615 (13.5)	6610 (13.4)	7322 (13.1)	7366 (13.2)	7416 (13.2)	7368 (13.2)
Total working capital	24843 49.9	23872 49.0	24145 49.2	24287 49.4	30661 54.8	29916 53.5	29790 53.1	30123 53.8
Interest on working capital	435 (0.9)	418 (0.9)	423 (0.9)	425 (0.9)	537 (1.0)	524 (0.9)	521 (0.9)	527 (0.9)
Subtotal	25278 (50.8)	24290 (49.8)	24567 (50.1)	24712 (50.2)	31198 (55.7)	30439 (54.4)	30312 (54.0)	30650 (54.7)
Fixed capital								
Land revenue	60 (0.1)	60 (0.1)	60 (0.1)	60 (0.1)	60 (0.1)	60 (0.1)	60 (0.1)	60 (0.1)
Rental value of owned land	17690 (35.5)	16650 (34.2)	16225 (33.1)	16855 (34.3)	17380 (31.0)	16875 (30.2)	16750 (29.8)	17002 (30.4)
Depreciation	375 (0.8)	550 (1.1)	625 (1.3)	517 (1.1)	375 (0.7)	575 (1.0)	650 (1.2)	533 (1.0)
Interest on fixed capital	1875 (3.8)	2750 (5.6)	3125 (6.4)	2583 (5.3)	1875 (3.3)	2875 (5.1)	3250 (5.8)	2667 (4.8)
Sub total	20000 (40.2)	20010 (41.1)	20035 (40.8)	20015 (40.7)	19690 (35.2)	20385 (36.5)	20710 (36.9)	20262 (36.2)
10% managerial cost	4528 (9.1)	4430 (9.1)	4460 (9.1)	4473 (9.1)	5089 (9.1)	5082 (9.1)	5102 (9.1)	5091 (9.1)
TOTAL	49806 (100)	48730 (100)	49063 (100)	49199 (100)	55977 (100)	55907 (100)	56124 (100)	56002 (100)

Figures in parenthesis indicates percentage of cost of cultivation of wheat

Share of various costs in wheat cultivation as depicted in Table 1 under adopter category, fertilizer was found one of the major component in operational cost, contributing to 13.4 % (₹ 6610) of the total cost followed by irrigation charges, human labour, seed and tractor charges i.e. 11.1% (₹ 5540) , 10% (₹ 4917), 6.8% (₹ 3335) and 6.5% (₹ 3200) respectively. Cost on labour, tractor and seed constitute maximum proportion i.e. 10.2%, 6.9% and 6.9% respectively in case of small farms, fertilizer and plant protection chemicals charges found high for medium farms i.e. 13.7% and 1.6% but the use of irrigation (11.2%) was found more on large farms. Family labour contributes high on small farms followed by medium and large farms. Whereas hired labour contribution increased with increase in size of the farm. Total fixed cost per hectare was found higher ₹ 20035 on large farms as compared to other groups. Rental value of owned land was the only important component contributing 34.3% of the total cost. Rental value of leased land increased with the increase in the size of farm. Interest on average fixed capital was worked out to be ₹ 2583 (5.3%) per hectare. Several studies have also shown that ZT method of wheat production provides several benefits such as saving of irrigation water, reduction in production cost, less requirement of labour and timely establishment of crops, resulting in improved crop yield and higher net income (Laxmi *et al.* 2007, Farooq *et al.* 2006; Erenstein *et al.* 2007).

On the basis of the above results, it may be concluded that small farmers are put ing more human resources despite the use of resource conservation technology; it is because of availability of family labour, while medium farmers are paying at ention on fertilizer use and large farmers are using more irrigation facility.

In case of non-adopters there is nominal difference in the pat ern of expenses of seed, fertilizer, plant protection chemicals, irrigation and tractor use except human labour. The share of human labour expenditure was found to be higher on small farms, because of availability and use of family labour.

Table 2: Cost and returns in case of adopters and non-adopters

Items	Adopters				Non-Adopters			
	Small	Medium	Large	Overall Average	Small	Medium	Large	Overall Average
cost A_1	24462	24149	25002	24538	28632	29574	30021	29410
cost A_2	24462	24149	25002	24538	28632	29574	30021	29410
cost B_1	26337	26899	28127	27121	30507	32449	33271	32076
cost B_2	44027	43549	44352	43976	47887	49324	50021	49078
cost C_1	27587	27649	28377	27871	33507	33949	34271	33910
cost C_2	45277	44299	44602	44726	50887	50824	51021	50911
cost C_2*	45277	44299	44602	44726	50887	50824	51021	50911
cost C_3	49805	48729	49062	49199	55976	55906	56123	56002
Yield and Income								
Main product (qtl/ha)	40.7	42.5	43	42.1	37.58	37.42	37.87	38
By product (qtl/ha)	42.4	42	44.6	43	39.8	40.2	40.69	40
Price of main product	1200	1200	1200	1200	1200	1200	1200	1200
price of by product	350	350	350	350	350	350	350	350
Returns								
Return from main product	48840	51000	51600	50480	45096	44904	45444	45148

Contd.

Return from by product	14840	14700	15610	15050	13930	14070	14241	14081
Gross return	63680	65700	67210	65530.0	59026	58974	59685	59229
cost A_1	39217	41550	42207	40991	30393	29399	29663	29818
cost A_2	39217	41550	42207	40991	30393	29399	29663	29818
cost B_1	37342	38800	39082	38408	28518	26524	26413	27152
cost B_2	19652	22150	22857	21553	11138	9649	9663	10150
cost C_1	36092	38050	38832	37658	25518	25024	25413	25318
cost C_2	18402	21400	22607	20803	8138	8149	8663	8317
cost C_2*	18402	21400	22607	20803	8138	8149	8663	8317
Net return cost C_3	13874	16970	18147	16330	3049	3067	3561	3226
Farm business income	39217	41235	42743	41065	30393	29399	29663	29818
Family labour income	19652	22150	22857	21553	11138	9649	9663	10150
Farm investment income	33439	36370	37497	35768	22304	22817	23561	22894

Source: Author's own calculation

Cost and returns in case of adopters and non-adopters

Cost of cultivation for adopters and non-adopters are given in Table 2. The average total cost of cultivation i.e. cost C_3 is estimated to be ₹ 49199 and ₹ 56002 for adopters and non-adopters respectively. It was evident from table that the cost A_1 i.e. direct cost involved in wheat cultivation was ₹ 24538 for adopters and ₹ 29410 for non-adopters. In the study area there was no leased -in land so cost A_1 was equal to cost A_2. It was observed that cost B_1 was ₹ 27121and ₹ 32076 for adopters and non- adopters, respectively. Cost B_2 contributed ₹ 43976and ₹ 49078 to the cost C_3 for adopters and non- adopters, respectively. Cost C_1, C_2 and C_2* work out to be ₹ 27871, ₹ 44726 and ₹ 44726 for adopters and for non-adopters it was ₹ 33910, ₹ 50911 and ₹ 50911 per hectare, respectively.

On an average adopters and non-adopters farms, got 42.1 quintals of wheat and 43 quintal straw per hectare and 38 quintals and 40 quintals respectively, from wheat cultivation (Table 2). Zero till for wheat was most successful in terms of crop establishment (Ladha *et al.* 2009) and gain in yield ranging from 1% to 12% (Erenstein and Laxmi 2008). Overall gross income in wheat cultivation was worked out to be ₹ 65530 for adopters but for non-adopters it was ₹ 59229 per hectare. It was observed from table that net return over cost A_1 and A_2 B_1, B_2, C_1, C_2, C_2* and C3 was found to be positive which revealed that farmers had covered his all cash and kind which were incurred in the production of wheat crop, but the table also indicate that there was a huge difference in their returns i.e. in case of adopters the net return over cost C_3 found to be ₹ 16330 which was approximately 80% higher than the non-adopters returns i.e. 3226. Similar results have been reported by many other studies conducted on this aspect and explained the fact that the net revenue in wheat production was significantly higher under zero till than under conventional method (Erenstein *et al.* 2007, Iqbal *et al.* 2002, Tripathi *et al.* 2013). Overall farm business income, family income and farm investment income for adopters and non-adopters in wheat production was worked out to be ₹ 41065, 21553, 35768, 29818, 10150 and 22894 respectively.

Input outputRatio Analysis

The input output analysis was also done on the basis of cost A_1 to cost C_3 for adopters and non-adopters given in table 3. In case of adopters overall average of input output ratio varied from 1:2.671 to 1:1.332. It varied from 1:2.603 to 1:1.279 for small farms, 1:2.721 to 1:1.348 for medium farms and 1:2.688 to 1: 1.370 for large farms. In the same way non-adopter's input

Table 3: Benefit Cost Ratio Analysis

	Adopters				Non-Adopters			
	Small	Medium	Large	Overall Average	Small	Medium	Large	Overall Average
On the basis cost A_1	2.603	2.721	2.688	2.671	2.061	1.994	1.988	2.015
On the basis cost A_2	2.603	2.721	2.688	2.671	2.061	1.994	1.988	2.015
On the basis cost B_1	2.418	2.442	2.389	2.417	1.935	1.817	1.794	1.849
On the basis cost B_2	1.446	1.509	1.515	1.490	1.233	1.196	1.193	1.207
On the basis cost C_1	2.308	2.376	2.368	2.351	1.762	1.737	1.742	1.747
On the basis cost C_2	1.406	1.483	1.507	1.465	1.160	1.160	1.170	1.163
On the basis cost C_2*	1.406	1.483	1.507	1.465	1.160	1.160	1.170	1.163
On the basis cost C_3	1.279	1.348	1.370	1.332	1.054	1.055	1.063	1.058

Source: Author's own calculation

output ratio varied from 1:2.061 to 1:1.054 for small farms, 1:1.994 to 1.055 for medium farms and for large farms it found 1:1.988 to 1:1.063. The overall average of the input output ratio on the basis of various costs varies from 1:2.015 to 1:1.058.

Resource use efficiency

The estimated resource-use efficiency of adopters and non-adopters in wheat production is furnished in Table 4. The result of Cobb-Douglas production function shows that the values of the multiple determination (R^2) in adopters and non-adopters is 0.93 and 0.94, respectively. This implies that 93% and 94% of the total variation in the dependent variable is explained by variation in the independent variables included in the model.

Table 4: Production elasticity of wheat crop in case of adopters and non-adopters

	Adopters			Non-Adopters		
Particular	Regression coefficient	Standard error	t-value	Regression coefficient	Standard error	t-value
Intercept	38.40754	0.39920	9.13879	0.643386	0.44964	-0.9807
Human Labour	0.02929	0.14039	0.21885	0.0016323	0.044621	0.03658
Tractor Charges	0.39994*	0.1521	2.62794	-0.023939	0.040023	-0.59815
Seed	0.51714**	0.21712	2.38177	0.917872*	0.13991	6.56039
Fertilizer	-0.03977	0.02933	-1.35598	-0.008130	0.09058	-0.08976
Irrigation	0.013392	0.36437	0.03920	0.473472*	0.09717	4.87233
$\sum bi$	0.92			1.36		
R^2	.93			.95		

Note: *Significant at 1% level
** Significant at 5% level

In case of adopters the coefficient of elasticity of production (regression coefficient) at ached to the tractor used and seed turn out to be positive for adopters. The coefficients for these resources were significant at 1% and 5% level respectively. The significant and positive coefficient of tractor and seed used indicates that a unit increase in tractor and seed used (value term), would bring about an increase in the gross return by 0.399% and 0.517%. Jimjel *et al.* (2014) applied frontier production function and also found seed variable significant at 1% level in case of tomato efficiency. Seed and irrigation were found significant at 1% level in case of non-adopters indicating that a unit increase in these variables would enhance the gross return by 0.91 and 0.47% respectively. Keeping the variable resources considered in the equation constant at their geometric mean levels. The regression coefficient of fertilizer was negative and insignificant in both cases and coefficient of tractor used was also found negative and insignificant in case of non-adopters indicated no impact of this resource was visible on the gross return in both categories. Human labor showed positive magnitude but found to be insignificant in both the categories. In case of adopters the elasticity

of production of all the variables summed up to 0.92 meaning decreasing return to scale, implying that, if these resources are increase by 1%, the output would increases by less than 1%. On the contrary, for non-adopters category the elasticity of production of all the variables summed up to 1.30 meaning increasing return to scale, implying that, if these resources are increase by 1%, the output would increases by more than 1%.

for optimum allocation of resources more than 88% increase in tractor charges and 90% increase in seed in case of adopters while 94% increase in seed and 74% increase in fertilizer use in case of non- adopters were needed, respectively. In case of adopters the human labour and irrigations were over-utilized, which required approximately 156% and 498% reduction, respectively but in case of non-adopters 7803% reduction in human labour, 470% reduction

Table 5: Estimates of measures of resource use efficiency of inputs used in wheat production

Input	MVP	MIC	MVP/MIC	efficiency	Percent adjustment	MVP	MIC	MVP/MIC	efficiency	Percent adjustment
Human Labour	0.39	1	0.39	Over utilized	-156.14	0.01	1	0.012	Over utilized	-7803.34
Tractor Charges	8.18	1	8.19	Underutilized	87.79	-0.26	1	-0.26	Grossly Inefficient and Over utilized	470.94
Seed	10.16	1	10.16	Underutilized	90.15	15.78	1	15.78	Underutilized	93.66
Fertilizer	-0.39	1	-0.39	Grossly inefficient and Over utilized	353.64	3.83	1	3.83	Underutilized	73.92
Irrigation	0.16	1	0.16	Over utilized	-497.53	-0.08	1	-0.08	Grossly inefficient and Over utilized	1234.88

Source: Author's own calculation

Table 5 further revealed that the ratio of the MVP to the MFC was to be greater than unity for seeds and tractor charges in case of adopters but on the contrary in case of non-adopters seed and fertilizer showed greater than unity ratios indicating that a unit increase in each input would increases the value of output, indicating that all the inputs are underutilized. Less than unity values of irrigation in case of adopters and human labour in both cases indicated that they were over utilized. While the negative values of the ratio inputs in both the cases demonstrated that they were inefficient and over-utilized.

The adjustment in the MVPs for optimal resource-use (per cent adjustment) in Table 5 indicates that in tractor charges and 1234% reduction in irrigation were required respectively.

Conclusion

Farming community is in looking for yield increasing and cost reducing technologies for improving farm profitability. The present study compared the resource use efficiency of adopter and non adopter of zero till in wheat crop. The findings of study have revealed that it is possible to save machine labour and seed under zero tillage than under the conventional method. Due to resource saving, net return had been significantly higher i.e. 80% who adopted zero tillage technology as compared to non-adopters. It was also

evident from the study that reduced costs in fuel and labour, and timely sowing of wheat, produce higher yields, reduce weed density, help in saving of irrigation water, improve input use efficiency because of bet er crop stands due to good seed and fertilizer. The adoption of the technology not only beneficial in case of large farmer but also for small and medium farms. Hence, this technology is an important alternative to save scarce resources and enhance the net farm income.

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