Agricultural Economics Research Review
Vol. 26(No.1) January-June 2013 pp 101-108

Impact of Zero Tillage on Economics of Wheat Production in Haryana

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Abstract

The paper has compared the economics of wheat production in Haryana with zero tillage and conventional methods and assessed the contribution of technology and inputs to the increased productivity due to zero tillage (ZT). The net income has been found higher in ZT method, mainly due to lower cost of production compared to that in conventional method. The study has observed that ZT technology has potential to provide additional income to farmers and help in conservation of scarce resources. The decomposition of about 45 per cent of the difference in gross returns between ZT and CT methods has been due to ZT and the rest due to changes in input costs. Despite several economic and environmental advantages, adoption of ZT technology has been limited and one major constraint identified is the difficulty in accessing a zero-till seed drill machine during sowing period. The study has suggested that ZT technology should be disseminated on a wider scale and availability of zero-till seed drill should be ensured at least through custom-hiring basis.

Key words: Zero tillage, wheat production, economics, decomposition analysis, Haryana

JEL Classification: O33, Q16, Q5

Introduction

India is the second largest producer of wheat in the world with an average annual production of 80 Mt (million tonnes) in recent years (Anonymous, 2011a). It accounts for approximately 11.79 per cent of world's wheat production (FAO, 2011). Haryana is an important wheat-growing state in the country and produces 10.5 Mt of wheat with yield level of 4.21 tonnes per hectare (Anonymous, 2011b). The major challenge to wheat production in the state is the enhancing of its productivity and profitability. In Haryana, many farmers grow late-maturing, fine-grained basmati 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). Savings in input cost, fuel consumption and irrigation water-use have been reported due to adoption of zero tillage in wheat cultivation (Malik *et al.,* 2003; Bhushan *et al.,* 2007). Farmers prefer this technology due to farm labour shortage and rising fuel prices. Hence, the present study was undertaken with the objectives of comparing the economics of wheat production with zero tillage and conventional methods and quantifying the contribution of technology and inputs into the estimated productivity differences due to zero tillage.

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Methodology

Zero-tillage (ZT) has been interpreted here as the process of planting wheat seed after the harvest of rice directly on untilled soil which retains the rice crop residues. The conventional tillage (CT) refers to the intensive tillage with multiple passes of a tractor to accomplish land preparation for wheat sowing. Farmers in Haryana are rapidly adopting zero tillage technology for wheat cultivation. For this study, Karnal district was selected due to widespread adoption of zero tillage. From the Karnal district, three villages, namely, Ramba, Shamgarh and Taraori, were selected having larger area under ZT in wheat. A total of 35 farmers who adopted zero tillage technology for wheat production were selected randomly. From the same villages, an equal number of farmers practising conventional tillage method were selected. The characteristics and socio-economic conditions of both types of the households were almost similar. The primary data were collected during the years 2009-10 and 2010-11 from 70 farmers.

All input and output parameters pertaining to wheat production were based on average values of two years with a view to minimize seasonal fluctuations in the variables. The modern cost concept, i.e., costs A_1, A_2, B_1, B_2, C_1 and C_2, was considered for the estimation of cost of wheat production (*see* Appendix III). The cost C_1 was taken into account in this study to calculate net income and benefit-cost ratio. The cost C_1 included all direct expenses paid in cash and kind for crop production such as hired human labour, machine labour, seeds, fertilizers, irrigation, plant protection measures, overhead charges and imputed value of family labour. The overhead charges included land revenue paid to the state government, interest on working capital and fixed capital and charges paid for repairs, maintenance and depreciation of fixed assets (Central Statistical Organization, 2008).

The cost of irrigation was calculated by multiplying the time required to irrigate the farm with cost of electricity or diesel consumption per hour. The cost of electricity was taken based on per unit rate fixed by the Haryana Electricity Distribution Corporation. The cost on human labour, machine labour and diesel were taken on actual expenditure basis. Gross income included the total value of main crop and by-products. Net income was calculated as the difference between gross income and cost of production (cost C_1).

In the present study, output decomposition model, as developed by Bisaliah (1977), was used to quantify the contribution of various sources to the productivity differences between zero and conventional tillage methods. It was observed from various studies that introduction of technology has enhanced land productivity significantly (Balakrishna, 2012; Kiresur *et al.*, 2011). It is expected that the practice of zero tillage technology will result in changes in input-use pattern, which in turn will affect the land productivity. Hence, increase in land productivity in wheat is not only due to adoption of zero tillage method but also due to the changes in use of factors in production. The following output decomposition model was used in this study.

The Cobb-Douglas production function in logarithmic form for zero tillage method of wheat production is:

$$\ln Y_1 = \ln b_{01} + b_{11} \ln S_1 + b_{21} \ln H_1 + b_{31} \ln M_1 + b_{41} \ln W_1 + b_{51} \ln P_1 + b_{61} \ln F_1 + b_{71} \ln I_1 + u_i \quad \ldots(1)$$

where,

S = Seeds (kg/ha),

H = Human labour (human days/ha),

M = Machine labour (hours/ha),

W = Weedicides (g/ha),

P = Plant protection chemicals (mL/ha),

F = Fertilizers (kg/ha),

I = Irrigation (hours/ha),

b_j = Regression coefficients (j=0,1,2,…, k) (k=7), and

u_i = Error-term (i=1,2,…., n).

The per hectare production function for conventional tillage method is given in Equation (2):

$$\ln Y_2 = \ln b_{02} + b_{12} \ln S_2 + b_{22} \ln H_2 + b_{32} \ln M_2 + b_{42} \ln W_2 + b_{52} \ln P_2 + b_{62} \ln F_2 + b_{72} \ln I_2 + u_i \quad \ldots(2)$$

The difference between Equations (1) and (2) gives Equation (3):

$$\ln Y_1 - \ln Y_2 = \ln(Y_1/ Y_2) = [\ln b_{01} - \ln b_{02}] + [(b_{11} - b_{12}) \ln S_2 + (b_{21} - b_{22}) \ln H_2 + (b_{31} - b_{32}) \ln M_2 + (b_{41} - b_{42}) \ln W_2 + (b_{51} - b_{52}) \ln P_2 + (b_{61} - b_{62}) \ln F_2 + (b_{71} - b_{72}) \ln I_2] + [b_{11} \ln (S_1/ S_2) + b_{21} \ln (H_1/ H_2) + b_{31} \ln$$

$$(M_1/ M_2) + b_{41} \ln (W_1/ W_2) + b_{51} \ln (P_1/ P_2) + b_{61} \ln (F_1/ F_2) + b_{71} \ln (I_1/ I_2)] \quad \ldots(3)$$

Equation (3) gives an approximate measure of percentage change in output with the adoption of zero tillage method. The left hand side of Equation (3) indicates the difference in the per hectare productivity of zero tillage and conventional tillage methods, while the right hand side decomposes the difference in productivity into changes due to technology as well as input use. The first bracketed expression on the right hand side is a measure of percentage change in output due to shift in scale parameter of production function. The second bracketed expression is the difference between output elasticities each weighted by natural logarithms of the volume of that input used under conventional tillage method, a measure of change in output due to shift in slope parameters (output elasticities) of the production function. The third bracketed expression is the natural logarithms of the ratio of each input of zero tillage to conventional tillage methods, each weighted by output elasticity of that input. This expression is a measure of change in output due to differences in the per hectare quantities of inputs used and the given output elasticity of these inputs under zero tillage technology.

Results and Discussion

In the study area, crop production was the major activity contributing 80 per cent to the total household income (Table 1). The rice (*Oryza sativa*) crop was sown during the *kharif* season (June to November), whereas wheat (*Triticum aestivum*) and mustard (*Brassica juncea*) were the major crops grown extensively by the farmers in the *rabi* season (November to May). The vegetables and berseem (*Trifolium alexandrinum*) were also grown in a limited area. Livestock-rearing was the other important activity to supplement family income. Many farmers supplemented their household income by engaging themselves or their family members in off-farm activities. The average age of the selected respondents was 41 years. The farmers had long experience of farming, as it was their family occupation. The average size of landholdings was 6.59 ha. The average family size was 7 members per family and 85 per cent farmers were literate. About 60 per cent farmers owned tractors and 30 per cent had seed-cum-fertilizer drills. On an average, farmers owned 2 tube-wells per farm. Groundwater and canals were the main sources of irrigation. The average temperature ranges from a minimum of 2.8 °C in January to 45 °C in May. The mean annual rainfall varied from 650 mm to 950 mm, about 80 per cent of which was received during June to September (CSSRI, 2011). The soils were generally alkaline in nature, sandy loam to clay loam in texture and low to medium in organic matter content.

Table 1. Socio-economic profile of sample farmers in Haryana

Particulars	Percentage or number
General information	
Age (years)	41
(Literacy level (%)	85
Family size (No.)	7
Average farm size (ha)	6.59
Number of tube-wells per farm	2
Sources of family income (%)	
Crop production	80.38
Livestock	5.57
Service	9.60
Business	4.02
Others	0.44
Farmers owning farm assets (%)	
Tractors	60
Seed-cum-fertilizer drills	30

Resource-use and Cost and Return Structure in Wheat Production

The major farm inputs used for the production of wheat in CT and ZT methods are mentioned in Table 2. A perusal of Table 2 revealed that farmers saved 6.68 per cent human labour, 46.30 per cent machine labour and 17.65 per cent irrigation water in ZT compared to CT method of wheat production. 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). This suggests that by adopting zero tillage method, farmers can save a substantial quantity of resources which helps to overcome the

Table 2. Major farm inputs used in wheat production in Haryana

Particulars	Conventional tillage	Zero tillage	Change (%)
Human labour (human days/ha)	54.9	51.2	-6.68
Machine labour (hours/ha)	9.6	5.2*	-46.30
Seeds (kg/ha)	112	108	-3.73
Fertilizer (kg/ha)	359	361	0.55
Weedicides (g/ha)	889	1047	17.77
Plant protection chemicals (mL/ha)	1203	1272	5.74
Irrigation water (m^3/ha)	1581.7	1302.5	-17.65

Note: * On an average, 2 hours per ha were required for sowing wheat by zero till machine. The remaining machine hours were used for harvesting and threshing.

problems of human and machine (tractor) labour shortage at the time of land preparation and sowing operations.

It was observed that most of the farmers in the study area were not convinced about the superiority of ZT technology. After practising ZT technology in wheat for 2 to 3 years, several farmers had reverted back to reduced tillage (RT) or CT method. This practice is being followed to avoid weed infestation. According to the farmers, till now there are no chemical weedicides which are effective in controlling weeds in ZT. As a general practice, harvesting and threshing are done with the help of a combine harvester machine and only a few farmers harvest wheat manually and thresh wheat by power-operated threshers.

The production costs and returns of wheat production using ZT and CT methods are presented in Table 3. Gross returns were ₹ 60181/ha in ZT and ₹ 59070/ha in CT. The net return amounted to ₹ 34057/ha in ZT and ₹ 29135/ha in CT method of wheat production. The net income was higher in ZT method due to higher yield and lower cost of cultivation as compared to CT method of wheat cultivation. The cost of cultivation amounted to ₹ 26124/ha in ZT method and ₹ 29935/ha in CT method. The lower cost of cultivation was due to lower expenses on human labour (5.74%), machine labour (46.30%) and irrigation (17.65%) in ZT than in CT method. The benefit-cost ratio of 2.30 was observed in ZT as against 1.98 in CT method of wheat production.

Table 3. Cost and return in wheat production using CT and ZT methods in Haryana

(₹/ha)

Particulars	Conventional tillage	Zero tillage	Change (%)
Cost on human labour	11257	10610	-5.75
Cost on machine labour	5754	3090	-46.30
Cost on seeds	2237	2153	-3.73
Cost on fertilizer	3178	3432	8.00
Cost on weedicides	1995	2201	10.35
Cost on plant protection chemicals	1323	1393	5.28
Irrigation charges	1511	1245	-17.64
Overhead cost	2680	2000	-25.37
Total operational cost (cost C_1)	29935	26124	-12.73
Gross income	59070	60181	1.88
Net income over cost C_1	29135	34057	16.89
Benefit-cost ratio over cost C_1	1.98	2.30	16.16

Table 4. Yield, cost and return in CT and ZT methods of wheat production in Haryana

Particulars	Conventional tillage	Zero tillage	Change (%)
Yield (t/ha)	5.37	5.47	1.86
Operational cost (₹/ha)	29935	26124	-12.73
Gross income (₹/ha)	59070	60181	1.88
Net income (₹/ha)	29135	34057	16.89
Cost of grain production (₹/kg)	5.57	4.78	-14.34

There was no significant different in wheat yield with and without ZT method of cultivation (Table 4). It was only about 2 per cent more with the application of ZT than with CT method. It was also observed that among the integrated conservation and resource management technologies, ZT for wheat was most successful in terms of crop establishment (Ladha *et al*., 2009) and gain in yield ranging from 1 per cent to 12 per cent (Erenstein and Laxmi, 2008). The gross and net returns in ZT of wheat production were higher by 1.88 per cent and 16.89 per cent, respectively, as compared to in CT method. The higher net return obtained in ZT was mainly due to reduction in the total cost of cultivation by 12.73 per cent. 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 ZT than under CT method (Erenstein *et al*., 2007; Iqbal *et al*., 2002). The cost incurred to produce a kilogram of wheat was ₹ 5.57 in CT and ₹ 4.78 in ZT methods. Thus, the cost of wheat grain production was lower by 14.34 per cent in ZT as compared to in CT method. This analysis suggests that ZT technology offers ample scope to generate additional income and helps in conservation of scarce resources.

Table 5. Estimated differences in wheat output between zero and conventional tillage methods

Particulars	Contribution (%)*
Total change in measured output	1.87
Sources of change	
1. Technical change	0.84
2. Input use	
a. Seeds (kg)	-0.29
b. Human labour (human days)	-3.40
c. Machine labour (hours)	-3.48
d. Weedicides (g)	7.88
e. Plant protection chemicals (mL)	2.38
f. Fertilizers (kg)	0.15
g. Irrigation (hours)	-2.18
Total due to input change	1.04
Total due to all sources	1.88

Note: * Parametric values for computing these percentages are drawn from Appendix-I and Appendix-II.

Decomposition Analysis

Using Equation (3), the values of production parameters (Appendix-I) and input levels (Appendix-II), the total change in wheat output with the adoption of ZT technology was decomposed. The results are presented in Table 5. The per hectare production of wheat was about 1.87 per cent higher with ZT technology than with CT method. How much of this increased output was due to technological change and how much of it was due to change in input levels were also computed and are given in Table 5. The contribution of technological change to total change in output was estimated to be 0.84 per cent. This value was obtained by adding the values of the first and second bracketed expressions on the right hand side of Equation (3). Technology influences the sources of output growth by shifting the values of scale and slope parameters of the production function (Bisaliah, 1977). With the same level of per hectare inputs, 0.84 per cent more output could be obtained with ZT technology. The change in the input use under ZT technology has contributed about 1.04 per cent of the increased wheat output. The effectiveness of technology in terms of change in the input use under ZT method was timely control of weeds and diseases, which also contributed to the increase in wheat output.

Farmers' Perception on Impact of Zero Tillage Technology

Farmers who had adopted ZT method in wheat production were interested to continue with this method

of sowing in future. According to farmers, ZT method was good in terms of seed germination and yield of wheat than the CT method. Sowing of wheat crop could be accomplished 10 to 15 days earlier than in CT method. Zero tillage considerably reduced the use of tractor and saved time and diesel in field preparation. They, however, reported that weed management was a problem in ZT method of wheat production. Many farmers were deprived of wheat sowing by ZT technique because of high demand and less availability of zero-till seed drill machines in the study area.

To promote ZT technology, Department of Agriculture, Government of Haryana, distributes zero-till seed drills on 50 per cent subsidy. The Government of Haryana is also encouraging custom-hiring services through entrepreneurship development. In the study area, only a few large farmers owned zero-till seed drill machines. Small and marginal farmers accessed zero-till seed drill through custom-hiring from large farmers. Many farmers reported that during peak sowing period, accessing a zero-till seed drill machine was difficult.

Conclusions

The study has revealed that it is possible to save machine labour and irrigation water under zero tillage than under conventional method. Due to resource saving, net return has been significantly higher in zero tillage technology. Hence, this technology is an important alternative to save scarce resources and enhance the net farm income. The decomposition analysis has shown that per hectare production of wheat was 1.88 per cent higher in zero tillage than in conventional tillage method. In this improved production method, zero tillage technology contributed 0.84 per cent and inputs contributed 1.04 per cent. By adopting this technology, farmers could save scarce resources and reduce the cultivation cost. The availability of zero-till seed drill needs to be accorded more attention to foster the adoption of zero tillage technology in wheat production.

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Received: November, 2012; Accepted: February, 2013

Appendix-I

Per hectare production function estimates for zero tillage and conventional tillage methods

Variables	Output elasticity	
	Zero tillage	Conventional tillage
Intercept	1.557	8.549
a. Seeds (kg)	0.0784	0.006
b. Human labour (human days)	0.4858*	0.1297
c. Machine labour (hours)	0.0561	0.3090*
d. Weedicides (g)	0.4557*	0.0492
e. Plant protection chemicals (mL)	0.4207	0.4878*
f. Fertilizer (kg)	0.1050	0.0506
g. Irrigation (hours)	0.1376	0.0631
Number of observations	35	35
R^2	0.735	0.730
F-value	10.714	10.465

*Significant at 0.01 level of probability.

Appendix-II

Sample geometric mean levels of per hectare output and inputs in wheat production

Item	Zero tillage	Conventional tillage
Output (t)	5.462	5.361
Seeds (kg)	107.530	111.643
Human labour (human days)	51.159	54.869
Machine labour (hours)	5.127	9.536
Weedicides (g)	1.046	0.880
Plant protection chemicals (mL)	1.272	1.202
Fertilizer (kg)	358.906	353.598
Irrigation (hours)	24.651	28.226

Appendix-III

Cost concepts considered for estimation of cost of wheat production in Haryana

1. **Cost A1** included all the direct expenses made in cash and kind such as:
   i) Value of hired human labour,
   ii) Value of bullock labour (hired and owned),
   iii) Machine charges (hired and owned),
   iv) Seeds (purchased and farm produced),
   v) Cost of fertilizers,
   vi) Cost of plant protection chemicals,
   vii) Irrigation charges,
   viii) Land revenue, ceases and other taxes,
   ix) Depreciation on farm buildings, machinery and other fixed assets,
   x) Interest on working capital,
   xi) Miscellaneous charges paid to artisans, blacksmith, carpenter, etc.
2. **Cost A2** included A1 plus rent paid for leased-in land.
3. **Cost B1** included A2 plus interest on value of owned capital assets (excluding land).
4. **Cost B2** covered cost B1 plus rental value of owned land (excluding land revenue)
5. **Cost C1** included B1 plus imputed value of family labour.
6. **Cost C2** included B2 plus imputed value of family labour.

Source: Central Statistical Organization (2008)