PROFIT EFFICIENCY OF ORGANIC VS CONVENTIONAL WHEAT PRODUCTION IN RICE-WHEAT ZONE OF PUNJAB, PAKISTAN

*Muhammad Asim Yasin, Muhammad Ashfaq, Sultan Ali Adil and Khuda Bakhsh**

ABSTRACT

The present study was conducted at Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan during the year 2011-12. In this study profit efficiency of organic and conventional wheat production was compared by collecting primary data of crop year 2011-12 from districts Sheikhupura, Nankana Sahib and Gujranwalla. Profit efficiency of organic and conventional wheat farmers was calculated by stochastic profit function. Maximum Likelihood estimates (MLE) results of Cobb Douglas frontier profit function show that average profit efficiency of organic wheat farmers is 0.915 relatively higher than that of conventional wheat farmers (0.911). It indicated that organic wheat farmers are more profit efficient than conventional farmers. The results revealed that normalized price of other inputs caused significantly to lower the profit in both organic and conventional wheat farming with elasticities -0.238 and -0.327 respectively. The normalized price of irrigation contributes significantly to lower the profit in organic wheat farming with elasticity of -0.176, while, normalized price of labour lower the profit significantly in conventional wheat farming with elasticity of 0.349. The fixed factors play an important role in increasing profit but pest breakouts affect the profit negatively in both organic and conventional wheat farming. The results of inefficiency model indicated that education and experience in wheat farming significantly reduced the profit inefficiency in both organic and conventional wheat farming. The study suggests that profitability of both organic and conventional wheat farming can be enhanced by investing in education and strengthening the role of extension department.

KEYWORDS: ***Triticum aestivum;*** **organic farming; conventional farming; profit efficiency; Punjab, Pakistan.**

INTRODUCTION

Wheat is one of the major crops of Pakistan that ensures not only food security but also brings valuable returns to the farming community. High yielding varieties of wheat were introduced first in rice-wheat belt of Punjab.

***Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan.**

However, use of chemical fertilizers and pesticides was considered necessary to harvest better yield. Since last few years, the production increased considerably but became stagnant and the use of fertilizers and pesticides continued to increase which resulted in high cost of production. Wheat yield ranged from 2500 to 2800 kg per hectare during the last ten years (4). The Green Revolution brought increase in yields for a while, but with poisoning of people and animals, loss of local biodiversity, loss of natural fertility of soil, loss of genetic diversity, loss of indigenous knowledge and practices, farmer dependency on external inputs, and finally an increase in the number of people living in extreme poverty in many countries (5).

In this scenario, organic agriculture provided an opportunity to combat the post effects of Green Revolution by boosting the eco-friendly techniques, promoting agro-diversity and using indigenous knowledge. Many farmer's organizations, NGOs and other institutions started working with farmers to transform their farming systems from conventional to organic. According to FAO (3), organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account the regional conditions and locally adapted systems.

The organic farming has an enormous potential to generate both socially and environmentally beneficial effects. However, it seems essential to assess the economic performance of organic farming that ultimately affects the adoption of any technology. Ramesh *et al.* (19) found that yield of organic farming could be compared to chemical farming after an initial period of three years. In the transition period of three years, soils develop adequate biological activity that follows a yield increase. Thakur and Sharma (22) also favoured the organic farming in terms of both higher yield as well as profitability while, comparing economics of organic and conventional farming systems. Singh and Grover (21) compared the economic viability of organic wheat farming in comparison with conventional wheat farming in Punjab, India and computed that net return over variable cost for organic wheat was Rs. 21985 per acre, much better than that of conventional wheat which remained Rs. 16700 per acre. McBride *et al*. (17) concluded that similar yield of wheat with lower cost of production was possible by organic method as compared to conventional. However, limited knowledge is available on various economic benefits of organic farming especially with regards to input-use pattern and profit efficiency. Therefore, present study was taken up with the following specific objectives:

- To analyze and compare the profit efficiency of organic and conventional wheat.
- To determine the factors affecting the profit efficiency of organic and conventional wheat.
- To devise suggestions and recommendations for future policy options.

MATERIALS AND METHODS

This study was conducted at Institute of Agriculture and Resource Economics, University of Agriculture, Faisalabad, Pakistan during the year 2011-12.

Description of study area: Area selected for this study was districts Sheikhupura, Nankana Sahib and Gujranwala. These districts lie in "kalar" tract which is famous for producing world's finest Basmati rice. The climate is sub-humid and sub-tropical type with monsoon rainfall mostly in July-August. Wheat and rice are the most important cereal crops of the region and being both cash and staple food crops are central to cropping patterns and occupy significant acreage. The rice-wheat farming system of this area is mainly characterized by a winter wheat crop followed by summer rice crop and sometimes also a short spring vegetable crop.

Measuring efficiency: Number of studies have been conducted to measure the efficiency by using two stage procedure but this procedure has been found inconsistent with its assumptions regarding independency of inefficiency effects (9). So, the extension in production frontier model was made by Battesse and Coelli (7). They suggested that inefficiency effects could be expressed as a linear function of explanatory variables explaining the farm-specific characteristics. The extended Battesse and Coelli (7) model has been quite useful in determining the farm specific efficiency and factors affecting the efficiency in a single stage estimation procedure. So, in present study, Battesse and Coelli model is used by formulating a profit function to measure the economic efficiencies of organic and conventional farmers. The stochastic profit frontier for j*th* farmer is written as:

$$\Pi_j = f\,(P_{ij}, X_{Kj}, D_{nj}).\ exp\,(\varepsilon_j) \text{ ---------(1)}$$

where,

Π_j - is the normalized profit of *jth* farm which can be calculated by subtracting variable cost from gross revenue divided by farm specific price of output

P_{ij} - can be estimated by dividing price of *jth* variable input by output price

X_{kj} - is the *kth* fixed factors on *jth* farm

D_{nj} - is the dummy variables that affect the profitability of the *jth* farm.

ε_j - is the error term which is assumed to behave consistent with the frontier concept of Ali and Flinn, (2).

$$\varepsilon_j = v_j - u_j \text{ --------(2)}$$

where,
V_j - is a two sided error term assumed to be normally distributed $N(0,\sigma^2_v)$
U_j - is a non-negative random variable ($u_j > 0$) associated with inefficiency

If ($u_j = 0$), the firm will be on profit frontier, taking maximum profit. The inefficiency parameters are measured by farmer's managerial abilities and house hold characteristics subject to statistical error, such that

$$u_j = Z_{ij}\delta + \zeta_j \geq 0$$

where, Zi are the farmer's managerial abilities and household characteristics which impact the inefficiencies of *jth* farm. ζ_j is the error term that is assumed to be normally distributed as $\zeta_j \sim N(0,\sigma_\zeta^2)$. The profit efficiency equation of *jth* farm is

$$EFF_j = E[exp(-u_j) \mid \varepsilon_j]$$

If the equation 1 is estimated by OLS, an average, as opposed to best-practice frontier is derived. Therefore, frontier function must be estimated to provide an estimate of industry's best-practice profit (2). So, the unknown parameters of stochastic frontier and inefficiency is estimated by the method of maximum likelihood.

The likelihood function is:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2$$

and

$$\gamma = \sigma_u^2 / \sigma^2$$

The value of parameter γ ranges from 0 to 1.

Data collection: A multistage sampling technique was adopted to select the sample farmers. At first stage, three districts from Punjab province were selected with priority of presence of organic farms. In second stage, 50 farmers from each district; 25 organic and 25 conventional were selected randomly for data collection. Thus the total sample size from three districts was 150 farmers comprising 75 organic and 75 conventional farmers. A detailed questionnaire was developed to seek information from organic and conventional wheat farmers of crop year 2011-12. The questionnaire also covered the information regarding socio-economic variables like education, farming experience, access to credit, linkages with extension services, off-farm employment and area under wheat crop. The input and output oriented data were collected on per acre basis in the survey.

Empirical model: In the literature, profit function has been estimated by different functional forms such as Cobb Douglas (C-D), normalized quadratic, translog and generalized Leontif. The C-D model is the most popular and has been used widely to estimate the farm efficiencies (6, 10, 20).

The Cobb Douglas profit equation and inefficiency equation are following:

$$ln\pi_j = \beta_o + \beta_1 lnP_{1j} + \beta_2\, lnP_{2j} + \beta_3\, lnP_{3j} + \beta_4\, lnP_{4j} + \beta_5\, lnZ_{1j} + \beta_6\, lnD_{1j} + \beta_7\, lnD_{2j} + (V_j - U_j) \quad \ldots\ldots(3)$$

where,

π_j = normalized profit for jth farm, is defined as gross revenue less variable costs divided by farm specific price of wheat crop (P_y)

In = natural log

P_i = prices of variable inputs normalized by price of output where (for*I*1, 2,..4)

so that:

P_1 = price of land preparation normalized by price of output (p_y)

P_2 = Prices of other inputs (fertilizers/compost, pesticides/ bio-pesticides and seed) normalized by price of output (p_y)

P_3 = price of irrigation normalized by the price of output (p_y)

P_4 = price of labour normalized by the price of output (p_y)

Z_k = are the fixed inputs

where,

Z_1 = capital used in farm *j* (hand tools and light machinery)

and

D_q = are dummy variables for environmental factors

where,

D_1 = dummy variable for soil fertility

D_2 = dummy variable for pest breakout β's are unknown parameters to be estimated and V_j and U_j has been defined earlier. The inefficiency effects model is defined as;

$$U_j = \delta_0 + \sum_{d=1}^{6} \delta_d \omega_d + \vartheta \quad \text{.......}(4)$$

U_j = inefficiency effects
ϑ = truncated random variable
δ_0 = constant
ω_d = variables explaining inefficiency effects and are defined as follows:

ω_1 = education (schooling years)
ω_2 = experience of rice and wheat farming (years)
ω_3 = access to credit (if yes = 1 otherwise = 0)
ω_4 = linkages with extension services (if yes = 1 otherwise = 0)
ω_5 = off-farm employment (if yes = 1 otherwise = 0)
ω_6 = area under wheat crop in acres for each farm *j*

If equation-3 is estimated by OLS, an average frontier is derived. Therefore, frontier function should be estimated to provide an estimate of industry's best-practice profit (2). So, unknown parameters of stochastic frontier and inefficiency were estimated by the method of Maximum Likelihood. Frontier 4.1 developed by Coelli (8) was employed for analysis.

RESULTS AND DISCUSSION

Summary statistics for different variables of wheat farmers

All variables are expressed in terms of means while access to credit and linkages with extension services are presented in percentages (Table 1). The organic and conventional farmers lie in similar age category with mean of 46 and 45 years, respectively. Education level of organic farmers is better than conventional farmers with number of schooling years 6 as compared to 5. Organic and conventional farmers in the study areas have approximately the same level of farming experience.

Organic farmers have relatively better access to credit (52%) as compared to conventional farmers (46%). Similarly, organic farmers have better linkages with extension services as most of organic farmers are working closely with NGOs and farmer groups which are working to promote organic agriculture. The average landholding for organic farmers is relatively less as compared to conventional farmers.

Table 1. Summary statistics for different variables of wheat farmers in Punjab.

Characteristics	Organic farmers (Mean/%age)	Conventional farmers (Mean/%age)
Age of household head (years)	45.76	44.93
Education (schooling years)	5.84	4.77
Experience (years)	23.70	24.09
Credit access (%age)	52	46
Linkages with extension services (%age)	72	52
Total Area (acres)	5.32	6.05
Area under wheat (acres)	3.55	3.78
Cost of land preparation per acre (Rs.)	3785.3	3676
Cost of other inputs per acre (Rs.)	4494.4	7220.6
Cost of irrigation per acre (Rs.)	1586.2	1720.05
Cost of labour per acre (Rs.)	4183.3	4048.5
Yield (kg)	1568.8	1650
Wheat price per maund (40 kg) (Rs.)	992.33	978.73
Gross revenue per acre (Rs.)	38921	40377.1
Profit per acre (Rs.)	24872.5	23712

It can be noticed that cost of other inputs is lower in organic farming (Rs. 4494/acre) than conventional farming (Rs. 7220.6/acre) because organic farmers are more dependent on on-farm resources and use different types of composts and bio-pesticides instead of external inputs like chemical fertilizers and pesticides. The cost of irrigation is also lower for organic farmers (Rs. 1586.2/acre) as compared to conventional farmers (Rs. 1720.05) due to more water holding capacity of organic soils. Due to labour intensive nature of organic farming, labour cost exceeds in organic farming than conventional farming. Average yield of conventional wheat farmers(1650kg/acre) is better than organic wheat farmers (1568.8kg/acre). The data showed that organic farmers get better price for wheat as compared to conventional farmers.

As far as profit is concerned, organic farmers get more profit per acre (Rs. 24872.5) in wheat farming as compared to conventional farmers (Rs. 23712).

Tests of hypotheses

The first hypothesis tests whether the farmers are operating on the frontier by imposing the restrictions on the original model expressed by equations 3 and 4. To reject the null hypothesis difference between LL_U and LL_R should be greater than critical value taken from Kodde and Palm (15). The null hypothesis is:

$$H_0 : \gamma = \delta_0 = \delta_1 = \delta_2 = \delta_d = 0$$

The first null hypothesis is rejected at 5% confidence level confirming that all farms are not operating on the frontier. The second hypothesis has been designed to test the influence of farmer specific factors on the level of inefficiency at 5% confidence level with the imposition of restrictions on original model.

$$H_{0:}\ \delta_0 = \delta_1 = \delta_2 = \delta_d = 0$$

The second null hypothesis is also rejected concluding that variables included in inefficiency model significantly affect the level of profit inefficiency.

Table 2. Hypotheses testing for organic and conventional wheat farmers.

Hypotheses	**Likelihood values**		
		Organic	**Conventional**
$H_{0:}\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_d = 0, \nabla_d$ Each farm is operating on profit frontier	**LL_U**	101.68	103.46
	LL_R	80.36	74.50
	LL	41.28	57.92
	Critical Value	14.85	14.85
	Decision	**Reject H_0**	**Reject H_0**
$H_{0:}\ \delta_0 = \delta_1 = \delta_2 = \delta_d = 0, \nabla_d$ Variables included in the inefficiency effects model have no effect	**LL_U**	101.68	103.46
	LL_R	67.24	74.14
	LL	68.89	58.64
	Critical Value	13.40	13.40
	Decision	**Reject H_0**	**Reject H_0**

Frontier profit function among wheat farmers in Punjab

The results of Maximum Likelihood Estimates (MLE) of Cobb Douglas frontier profit function are reported in Table 3. The parameters of Cobb Douglas profit function can be directly illustrated as production elasticities of inputs in the production process. For organic wheat, the coefficient of land preparation and labour are non significant but with negative sign. The estimated coefficient of other inputs (seed, fertilization and pesticides) is significant at 1 percent level of confidence with negative sign implying that these variables are contributing to lower the profit. This result is in line with Hyuha (13). Madau (16) also computed a negative impact of fertilizers on technical efficiency of organic cereal farms in Italy. The coefficient of irrigation is also significant at 1 percent level of confidence with negative sign indicating that farmers are overusing irrigation. Capital is significant at 1 percent and positive sign shows that it is affecting profit positively. This finding is in line with Rahman (18). Soil fertility has positive sign and significant at 5 percent level. The pest breakout is also affecting the profit negatively at 1 percent significance level.

Table 3. Frontier profit function among organic and conventional wheat farmers.

Variables	Wheat	
	Organic (coefficients)	**Conventional (coefficients)**
Constant	6.106* (0.786)	7.502* (0.601)
P_1 (Normalized price of land preparation)	-0.039 ^{ns} (0.115)	-0.162 ^{ns} (0.145)
P_2 (Normalized price of other inputs)	-0.238* (0.086)	-0.327*** (0.196)
P_3 (Normalized price of irrigation)	-0.176* (0.058)	-0.067 ^{ns} (0.073)
P_4 (Normalized price of labour)	-0.040 ^{ns} (0.111)	-0.394*** (0.235)
Z_1 (Capital)	0.320* (0.078)	0.247* (0.073)
D_1 (Soil fertility)	0.044** (0.019)	0.006 ^{ns} (0.030)
D_2 (Pest breakouts)	-0.059* (0.023)	-0.035*** (0.024)
Sigma square	0.030* (0.006)	0.006* (0.002)
Gamma	0.981* (0.009)	0.550* (0.156)
Log likelihood	101.69	103.469
Average profit efficiency	0.915	0.911

*, ** and *** indicate that coefficients are significant at 1, 5 and 10 percent level of significance, respectively and ns stands for non-significant.
Figures in the parentheses are standard errors.

For conventional wheat farmers, the estimated coefficients of other inputs and labour are significant at 10 percent level of confidence with negative signs indicating that these costs are contributing significantly in lowering the profit. Similar results have been reported earlier (2, 13, 18). The coefficient of land preparation and irrigation are non-significant. The capital is significant at 1 percent level of confidence with positive sign. The soil fertility has expected positive sign but non-significant. The pest breakout is contributing to lower the profit with negative sign and significant at 10 percent level of significance. The average profit efficiency of organic wheat farmers is found to be 0.915 which is slightly higher than the conventional farmers to conclude that organic wheat farmers are more profit efficient than conventional farmers.

Determinants of farm specific profit inefficiency among wheat farmers

The estimated coefficient of education is significant at 1 percent level of confidence in both organic and conventional wheat farming with negative sign (Table 4). It indicated that education is contributing to reduce the profit inefficiency in both organic and conventional wheat farming. It implies that investment on human capital is a powerful tool to improve efficiency. Similar results were reported by Kaur *et al*. (14) and Hassan and Ahmad (12).

Table 4. Determinants of farm specific profit inefficiency among organic and conventional wheat farmers.

Variables	Wheat	
	Organic (coefficients)	Conventional (coefficients)
Constant	0.268*** (0.148)	0.462* (0.111)
Education(number of schooling years)	-0.052* (0.018)	-0.028* (0.010)
Experience of wheat farming	-0.013 ** (0.006)	-0.015* (0.004)
Access to credit	-0.041^{ns} (0.130)	-0.057^{ns} (0.064)
Linkages with extension services	-0.667*** (0.369)	-0.033^{ns} (0.061)
Off-farm employment	0.144*** (0.100)	0.017^{ns} (0.030)
Area under wheat	-0.009^{ns} (0.027)	-0.004^{ns}(0.017)
*, **and ***indicate that coefficients are significant at 1, 5 and 10 percent level of significance, respectively and ns stands for non-significant. Figures in the parentheses are standard errors.		

Experience of head of household was included in the model to assess the impact of experience on profit efficiency. The coefficient of experience is significant at 5 and 1 percent level of confidence in organic and conventional wheat farming, respectively. The negative sign in both organic and conventional wheat farming indicates that experience contributed to reduce the profit inefficiency. These results agree to those of Kaur *et al*. (14) and Hasan and Islam (11). The access to credit is non-significant in both organic and conventional wheat farming.

Linkages with extension services are important and expected to affect the inefficiency negatively by enhancing the managerial ability of farmers to use resources in an efficient manner. The linkages with extension service is significant at 10 percent level of confidence in organic wheat farming because most of organic farmers are working closely with NGOs and other institutions which are promoting organic farming but it is non-significant in conventional wheat farming. Off-farm employment can affect the profit inefficiency in both positive and negative manners because it is the source of extra income which makes more funds available to purchase inputs and on the other hand it consumes valuable time of the farmers that affects the inefficiency positively. For organic wheat production, the estimated coefficient of off-farm employment is significant at 10 percent level of confidence. These results confirm the findings of some earlier workers (1, 2, 18). The coefficient of off-farm employment is non-significant in conventional wheat.

Key policy variables and profit loss in wheat production

Contribution of key policy variables to profit inefficiency in terms of profit loss was also evaluated. The experience, off-farm income and area under wheat are ignored in the analysis because these variables cannot be affected directly by policy interventions. So, the education, access to credit and linkages with extension services are included as key policy variables in the analysis.

Profit loss can be defined as the amount that has been lost due to inefficiency in production at given prices and fixed factor endowments. It is calculated by multiplying maximum profit by 1-PE. PE stands for profit efficiency. Maximum profit per acre is computed by dividing the actual profit per acre of individual farm by its efficiency score (18).

The analysis of profit loss due to key policy variables in wheat production in organic and conventional farming in Punjab (Table. 5) indicated a significant difference between actual profit, profit loss and efficiency of the farmers who have education above primary level compared to the farmers having education up to primary level. By raising the education of farmers beyond primary level,will increase the efficiency from 87 to 96 percent in organic wheat and 86 to 98 percent in conventional wheat production. This implies that education is an effective tool to capacitate the farmers for better utilization of resources and opportunities to improve revenue and profit.

Table 5. Profit-loss in organic and conventional wheat farming in Punjab.

Selected policy variables	Organic				Conventional			
	N	Actual profit	Profit loss	Efficiency	N	Actual profit	Profit loss	Efficiency
		Mean				Mean		
Education								
Above primary	37	25972.08	999.56	0.962	32	29814.06	496.47	0.983
Up to primary	38	18867.66	2635.34	0.869	43	20924	3153.72	0.860
t-ratio		8.07	-4.56	4.69		9.11	-9.18	8.34
Access to credit								
Yes	39	25269	1106.09	0.957	35	29412.94	655.83	0.976
No	36	19234.64	2610.82	0.870	40	20608.23	3213.55	0.857
t-ratio		6.00	-3.95	4.13		9.02	-7.94	7.45
Linkages with extension services								
Yes	54	28411.81	649.86	0.978	39	29154.92	641.81	0.977
No	21	20023.89	2286.66	0.890	36	19909.44	3512.95	0.843
t-ratio		10.89	-5.75	5.95		8.25	-9.17	8.44

The farmers who have access to credit experienced better profit, less profit loss and better efficiency score as compared to those who don't have any access to credit in both farmings. The results on access to credit showed that farmers can improve profit efficiency from 87 to 96 percent in organic wheat and 86 to 98 percent in conventional wheat production. These results are statistically significant at 1 percent level clearly indicating that access to credit would improve profit efficiency in wheat farming.

The results for linkages with extension services are also similar. The farmers who have linkages with extension services are better off than those who don't have any links with extension services in both organic and conventional farming. The results indicate that linkages with extension services significantly contribute to improve the profit efficiency from 89 to 98 percent in organic wheat and 84 to 98 percent in conventional wheat production. All results are significant at 1 percent level of confidence.

CONCLUSION AND RECOMMENDATIONS

The results of stochastic frontier profit function show that average profit efficiency of organic wheat farmers is found to be 0.915 slightly higher than the conventional farmers. It concludes that organic wheat farmers are more profit efficient than conventional farmers. The variable inputs effect differently in both organic and conventional farming but their overall impact is found to lower the profit. The results indicated that both organic and conventional farmers are not making optimum use of these inputs. The results revealed that normalized price of other inputs affects significantly to lower the profit in both organic and conventional wheat farming with elasticities of -0.238 and -0.327, respectively. The normalized price of irrigation contributes significantly to lower the profit in organic wheat farming with elasticity of -0.176 while normalized price of labour is found to lower the profit significantly in conventional wheat farming with elasticity of -0.349. The fixed factors are also observed to play an important role in increasing profit. The pest breakout significantly affects the profit negatively and requires timely application of plant protection measures.

On an average, farmers are 91 percent efficient implying that little potential exists that can be explored to improve resource use efficiency in wheat production. Therefore, to improve wheat productivity and profit in the long run, profit function needs to be shifted upward by key determinants of profit efficiency. The capital in the form of modern technology should be increased for the improvement in profit efficiency in both conventional and organic wheat farming. Education is found to have a positive impact on profit efficiency of both organic and conventional wheat farmers. The significant differences in profit are observed between farmers who are illiterate or having education upto primary and also who have above primary education. The implications are very clear that primary level of education is absolutely necessary to improve efficiency in wheat farming.

To improve the efficiency, extension departments needs to play a positive role in increasing their access and facilitate each and every farmer. The Government should also take concrete steps to strengthen extension services in qualitatively and quantitatively manner to improve the efficiency of the farmers. Today, agriculture starts with capital and provision of quick, easy and adequate credit should be the top priority of policy makers to improve the profit efficiency.

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