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Contribution of Improved Rain-fed Wheat Productivity towards Food Security in Pakistan

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1 INTRODUCTION

Agriculture is the largest sector of Pakistan's economy contributing 21 percent to its GDP and 45 percent of labor force employment (GoP 2010). It is characterized by low productivity and instability as compared to developed countries due to non availability of improved seeds, inefficient fertilizer use, weed infestation, shortage of irrigation water, drought in rain-fed area, soil degradation, lack of finance and proper credit availability and insufficient extension services. The population (170 million) of Pakistan has increased more than 3 times since 1960 and it is estimated that will double by the year 2025, which is posing a serious threat to food. A little expansion of the agricultural area in the Pakistan took place since its creation. The water resources are not consistent with increased cropped area due to increased cropping intensity. Resultantly between 1991 and 2010 per capita agricultural land availability has dropped form 0.18 to 0.12 hectares and per capita water availability from 1565 m^3 to 1,066 m^3 in this time span (GoP 2007, GoP 2010). The present situation has resulted in the gap in the agricultural food items demand and supply. To meet the food requirements of the growing population, it is imperative to develop strategies for crop, land and water productivity improvement and resource conservation. In this scenario the improved crop productivity in less intensively cropped and land degraded rainfed areas may play vital role to meet the ever increasing food demand of Pakistan's population.

Wheat being the leading food grain of Pakistan and the staple diet of masses is the most important crop. It is cultivated on the largest area (9.042 million hectares during the growing season 2009-10) in almost every part of the country with 23.864 million tonnes of production. It contributes 14.4 per cent to the value added in agriculture and 3.1 per cent to GDP (GoP 2010). The wheat yield on progressive farms of irrigated area ranges from 6000 to 7000 kgs per hectare. However, wheat yield at rain-fed farms ranges from 500 to 1300 kgs per hectare depending upon the amount of rainfall. In irrigated area wheat yield ranges from 2500 to 2800 kgs per hectare depending upon the irrigation water availability and other factors. There is around 60 per cent yield gap in wheat, which needs to be narrowed. Food security in Pakistan would be ensured if this gap could be closed (Anonymous 2000, Arif, M 2000). The present study is under taken to find out the determinants of wheat productivity under rain-fed conditions in Pothowar region and to give recommendations for improving wheat yield.

The rest of paper is organized as follows. The discussion of the data and variables used in the analysis is undertaken in section 2 Materials and methods. This is followed by results and discussions in third section. In fourth section some conclusion and policy implication will be drawn.

2 MATERIALS AND METHODS

The purposive and stratified random sampling technique was applied to select the sample farmers. At first stage two districts Rawalpindi and Chakwal out of four were selected for the study purposes. At the second stage one sub-district Gujar Khan from Rawalpindi district (high rainfall) and two sub-districts i.e Chakwal (medium rainfall) and Talagang (low rainfall) were selected from District Chakwal. At third stage 10 villages were randomly selected from each of the 3 sub-districts. Finally at the fourth stage 7 farm households were selected for interview by chance meeting for final sample of the study. The data were collected through personal interviewing, using well-defined questionnaire. Overall 210 farmers from 30 villages of 3 representative sub-districts of rain-fed Punjab were interviewed during the cropping year 2009-10. Secondary data regarding agricultural policy and farm sector development were gathered from various government publications. For initial data analysis, based on farm operational holding, the sample farmers were classified into small (≤ 5 hectares),

medium (>5 to 10 hectares) and large (> 10 hectares) farmers categories. The data was processed and analyzed by employing descriptive statistics and different econometric techniques.

Translog functional form is employed to estimate the production function. This is a flexible functional form that places no a priori restrictions on the elasticity of substitution and allows the economies of scale to vary with the output level (Ali and Flinn, 1989). The normalized translog stochastic profit function, which is assumed to be "well behaved", is specified as:

$$InY_i = \beta_0^* D_i + \sum_{j=1}^{4} \beta_j \ln X_{ij} + \frac{1}{2}\beta_{jj}(\ln Xi)^2 + \sum_{k=1}^{4}\sum_{j=1}^{4} \beta_{jk} \ln X_{ji}.\ln X_{ki} + \boldsymbol{\varepsilon_i} \quad (1) \qquad \text{where } \varepsilon_i = V_i - U_i$$

i subscript is indicator for the ith farmer in the sample, ln is the natural logarithm, Yi is the normalized yield kgs per hectare of wheat on a given farm, D_i is the regional dummy variable (representing sub districts effects) which has value one for farmers in region I and zero otherwise, β_{jk} (j,k= 1,2,…,4 with j ≤ k) are the unknown parameters associated with the explanatory variables in the production function , Xi,s (i=1,2,..,4) = total amount of land owned in ha, seed used for wheat sowing in kilogram, fertilizer used for wheat production in kilogram and total amount of hired labor spent for farming operations. The $v_i's$ are assumed to be independent and identically distributed random errors having $N(0,\sigma_v^2)$ distribution, while the $u_i's$ reflect non-negative random variables associated with technical inefficiency of production. Where μi is defined by:

$$u_i = \alpha_0 + \alpha_1 AGE + \alpha_2 EDU + \alpha_3 CD + \alpha_4 CI + \alpha_5 OFFINC + \alpha_6 FS + \alpha_7 MF + \alpha_8 LF + \alpha_9 TOWN + \alpha_{10} SQ + \alpha_{11} EXT + \alpha_{12} CREDIT$$

Where as α_{is} are parameters to be estimated, AGE is the age of farmers, EDU is number of years of schooling achieved by household head, CD is the crop diversity index, CI is the cropping intensity, OFFINC is the annual off-farm income, FS is the family size, MF, LF, TOWN, SQ, EXT and CREDIT are dummies for medium farmers, large farmers, tractor ownership, soil quality, farmers contact with extension agents and credit facility availed respectively.

3 RESULTS AND DISCUSSIONS

Overall more than two third farmers are small and one forth are of medium size. The large farmers in study area constitute less than the ten percent of sample size. Tallagng sub-district has more large farmers and lesser small farmers as compared to other sub-districts. Guar khan has the largest number of small farmer and lowest number of large farmers. The average farm size of large farmers (20.12 ha) is far high as compared to that of medium (7.12 ha) and small (2.73) farmers. Overall almost 10 percent area is irrigated.

Table 1: Farm and Farmers Characteristics by Farm Size Categories in the Study Area

Variables	*Farm Size*			*All*	*Sig.*
	Small	**Medium**	**Large**		***(p value)***
Age (yrs)	53.84 (14.10)	50.89 (14.48)	51.44 (9.75)	52.91 (13.93)	.383
Education (yrs)	7.37 (3.78)	7.85 (3.36)	7.69 (2.82)	7.51 (3.61)	.699
Experience (yrs)	29.13 (15.78)	30.64 (15.86)	35.88 (11.16)	30.03 (15.54)	.246
Area owned (ha)	3.99 (4.25)	8.31 (8.57)	25.62 (18.55)	6.73 (9.39)	.000
Oper. holding (ha)	2.73 (1.39)	7.12 (1.36)	20.12 (8.29)	5.16 (5.37)	.000
Irrigated (%)	10.64 (25.85)	3.06 (11.78)	20.59 (28.12)	9.49 (23.65)	.020
Rain-fed (%)	89.36 (25.85)	96.94 (11.78)	79.41 (28.12)	90.51 (23.65)	.020
Wheat area	55.73 (22.26)	46.80 (16.49)	41.50 (21.20)	52.39 (21.37)	.003
Crop Diversity Index	3.10 (0.97)	2.95 (0.76)	3.07 (1.84)	3.06 (1.01)	.630
Cropping Intensity (%)	123.38 (31.29)	113.17 (23.13)	110.96 (19.57)	119.85 (29.02)	.040

**The figures in parenthesis are standard deviation* *Source: Field Survey Data 2009*

First descriptive results of the survey reveal that the average age of the sample respondents is above 50 years (52.91 yrs) having 7.5 years of schooling and 30 years farming experience. This shows that farmers practicing agriculture are mostly aged with good farming experience and lesser education. Mostly farmers prefer their children to have education and get off-farm jobs. Land owned in the study area is 6.73 ha while the operation land holding of the study area is 5.16 hectares.

Efficiency Analysis in Wheat Production

The maximum-likelihood (ML) estimates of the normalized production frontier subject to the restrictions of homogeneity and symmetry are given in table 2. The equation was estimated by the LIMDEP econometric package. The results indicate that the extent of land, seed and labour input are positively related to efficiency while the coefficient for the fertilizer has the negative signs. The land and seed affect on productivity is significant at one percent significance level. The positive affect of chemical fertilizers is linked with the availability of sufficient water availability. The negative sign of fertilizer shows that there is severe water shortage in the study area which results in to negative impact of fertilizer on productivity.

Table 2: Maximum Likelihood Estimates of Translog Production Frontier

Dependent Variable= Wheat Yield (Kgs/ha)

Parameter	Variable	Coefficient	t-ratio
β_1	ln (land)	2.06065994	3.957***
β_2	ln (seed)	3.88922904	7.933***
β_3	ln (fertilizer)	-.02439718	-.065
β_4	ln (labour)	.10760429	.221
β_{11}	ln (land) x ln (land)	.60788004	1.931**
β_{22}	ln (seed) x ln (seed)	-1.23019791	-4.058***
β_{33}	ln (fertilizer) x ln (fertilizer)	.11933835	2.284**
β_{44}	ln (labour) x ln (labour)	.05493737	.371
β_{12}	ln (land) x ln (seed)	-.88722093	-4.063***
β_{13}	ln (land) x ln (fertilizer)	.07958108	1.044
β_{14}	ln (land) x ln (labour)	-.18376999	-2.118**
β_{23}	ln (seed) x ln (fertilizer)	-.10962531	-.382
β_{24}	ln (seed) x ln (labour)	.04474317	.126
β_{34}	ln (fertilizer) x ln (labour)	-.05267424	-.947
β_0	Talagang (Dummy)	-.24426675	-1.570
β_0^*	Gujar Khan (Dummy)	-.33491517	-2.186**
Variance parameters			
σ^2	$(\sigma^2 = \sigma_u^2 + \sigma_v^2)$	.78509289	12.924***
γ	$(\gamma = \sigma_u^2 / \sigma_u^2 + \sigma_v^2))$	1538.35128	.020
Inefficiency effects			
α_1	Age	.00691299	1.774*
α_2	Education	.00997050	.592
α_3	Crop Diversity	.12225305	2.086**
α_4	Cropping Intensity	.00096273	.549
α_5	Off-farm income	.477356D-05	1.398
α_6	Family size	-.00102933	-.049
α_7	Medium farmers	.00221831	.021
α_8	Large farmers	-.25808269	-1.158
α_9	Tractor ownership	.11947032	1.061
α_{10}	Soil quality	-.19406376	-.687
α_{11}	Extension agent's visit	-.16000477	-.725
α_{12}	Credit facility availed	.49126332	1.952**

The age of the farmer, crop diversity and credit availability with positive sign tend to have a negative and significant impact on wheat production efficiency. As the average age of the sample farmers is above fifty years therefore the aged farmers are reducing the farm efficiency. The farm efficiency of wheat producing farmers decreases with the diversification of farm activities. The farmers who availed the credit facility experienced more farm inefficiency. This unexpected sign may be due to two reasons first the improper use of credit, particularly on daily household consumption and marriages of children and secondly excessive use of fertilizers in water stressed conditions of rain-fed agriculture. Education of the farmers, household family size, cropping intensity, tractor ownership, off-farm income, farm size, contacts to extension services and soil quality are statistically insignificant with small coefficient.

4 CONCLUSION and POLICY IMPLICATIONS

This paper has examined technical efficiency of farmers of rain-fed Punjab of Pakistan using Translog Stochastic Frontier Model. The results reveal that land and seed contribute positively and significantly with high coefficients to farm technical efficiency in wheat production. This shows that by increasing the land and seed quantity the farm efficiency increases significantly. The land holding in the study area is very small. This is the major cause of farm inefficiency. The improvement in landholding and farm size through land consolidation and fixing the minimum limit of land holding can improve the farm efficiency and wheat yield. The practice of renting out and renting in of the land in the study area may be improved to gain the economies of scale. The agriculture of the area is characterized by use of poor quality and uncertified seed. There is great opportunity to increase the wheat productivity under rainfed conditions by improving the farm technical efficiency through increasing the farm size, seed quality and quantity. The improved extension services can play effective role in this regard.

The farmers of the study area involved in agriculture are aged. They have good farming experience but they are resistant to adopt the innovative and improved agricultural production technologies. The young and educated members of the households may be encouraged to adopt the farming as full time job by crop insurance schemes. The inclusion of minor crops in cropping pattern reduces the farm efficiency. The management of the household head is diverted to different farm activities hence farm efficiency for particular individual crops is reduced. Credit availability is the major problem of the study area. The respondent farmers are unwilling to take the credit from institutional sources. The main reason is the fear of failure of default due to the risky nature of rain-fed agriculture and high interest rate charged on agricultural production loan. This negative contribution of agricultural credit to farm efficiency may be due to two reasons first the improper use of credit, particularly on daily household consumption and marriages of children and secondly excessive use of fertilizers in water stressed conditions of rain-fed agriculture. Farm efficiency may be increased significantly increased if cheap credit along with the crop insurance scheme is introduced in rain-fed agriculture.
The water conservation and management techniques can improve the impact of education, cropping intensity, off-farm income, tractor ownership and soil quality on farm efficiency. This improved farm efficiency and increased wheat productivity can ensure the food security in the country in general and in the study area in particular.

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