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Factors affecting yield gap in different wheat varieties in Southern Punjab

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Abstract: Despite the significant attention given to cereal production in the country, the productivity of wheat crop is still substantially lower both on regional and global level. What makes the situation even worse is that there exist wide productivity gaps within the country as well. Within this context, the present study examines the wheat yield gap in the two different districts of Punjab for two major wheat varieties and the constraints that lead to such yield gaps. A purposive sampling technique was applied, total sample size was 120. The yields gaps were calculated for all these farmer groups and it was found that high yield farmer group had 17.84% yield gap when compared with medium and low yield farmers group. Benefit cost ratio with opportunity cost of land and family labor was 1.24, 1.36 and 1.55Rs. Against their Rs. one cost for low, medium and high yield groups. The constraints analysis showed that adulterated pesticides, lack of extension services, lack of credit, shortage of canal and tube well water, high input and oil prices were the main constraints being faced by the wheat farmers. By effectively addressing the problems identified in the study, government should take part in the improvement of input-output price relationship. And develop new and high yielding wheat varieties to reduce yield gap.

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1. Introduction

The term yield gap has been widely used in the literature for at least the past few decadesYield gaps are estimated by the difference between yield potential and average farmers' yields over some specified spatial and temporal scale of interest. Yield potential, in turn, can be defined and measured in a variety of ways, which has resulted in lack of consistency in yield gap analysis in the literature. Yield gap in wheat production can be explained in two ways. First, at the research station (experimental yield) and Second, the yields obtained by farmers under the condition of actual field (Yadav, 2008).

World cereal production has increased significantly over the last 50 years, mainly as a result of poor land management and introduction of new technologies. In the future, a strong increase in demand for grain is expected, which may be filled with further intensification of agriculture rather than expansion of agricultural land (Neumann et al., 2010).

Economic factors, namely farm type (tenure or ownership), farm size, farm machinery and socioenvironmentalfactors, namely infrastructure, markets, government policies and international trade contribute directly or indirectly in efficient wheat production. The existence of a large difference in yield gap has been demonstrated in several studies. In Pakistan, there are as many as 40-50% of yield gap in wheat production and is believed to exist (Hussain et al., 2011). In addition to wheat, there is a yield gap at the national level in other major crops in the country.

Pathak et al. (2003) concluded that the potential and on-farm yields of rice were declining over time. The decrease in radiation and increase in minimum temperature were the main reasons for yield declines. The way for the rice sector to thrive is to restructure it. Land, labour and capital must be reallocated to raise productivity and total value product of the sector (Ti, 2003).

Yield gaps are also classified in accordance with the restrictions as agronomic gap is mainly due to the physical and biological limitations, socio-economic gap is mainly due to the socio-economic constraints, institutional gap is due to institutional constraints and limitations are mixed because of the above mentioned gaps (Tran, 2005).

Villano and Fleming (2006) studied the several characteristics of farm operators, such as age and educational attainment, ratio of adults in the farm

households and income from non-farm activities, were found to have significant effects on rice production. The coefficient associated with the ratio of adult members of the household was expected to have a negative sign.

Hassan (2010) conducted a study on technical inefficiency and yield gap of wheat production in Bangladesh. He argued that this gap can be minimized by focusing on better formal education, technologies related to wheat production, and farming experience of growers.

Objectives of the study were i) to estimate the yield gaps in wheat production for various districts of Punjab, ii) to conduct economic analysis of each productivity level, iii) to identify the constraints in wheat production, and iv) to suggest policy recommendation for closing yield gap.

2. Methodology

2.1 Data Collection

In this study we used the cross-sectional data collected with the help of a well-structured questionnaire in one of the most important wheat growing areas of Pakistan located in District Gujarat and Khanewal districts of Punjab. Information on wheat yield gap and farm inputs including land, fertilizer, pesticides, and weedicides and constraints involved in low yield production were collected from 120 farmer's .The data was also collected from research stations to account for the potential wheat yield of selected varieties.

The farmers were divided into three groups on the basis of their per acre wheat yield. (i) Low yield group obtaining yield less than 30 mounds per acre. (ii) Medium yield group obtaining yield 30 to 35 mounds per acre. (iii) High yield group obtaining yield more than 35 mounds per acre.

2.2 Data Analysis

For data analysis Microsoft Office Excel software package and SPSS 17 package were used. The same packages were used by (Ghafoor et al, 2010) in their studies. Following statistical techniques were used to analyze and interpret data.

2.3 Cost of production estimation

Following methodology was adopted to estimate cost of various farm inputs and their allocation to wheat crop and to estimate the economics of wheat production and variation in yield benefit cost ratio (BCR) was used (Chaudhry and Ahmad, 1986) as described in equation 1.

$$\Pi = PY - TC \quad [1]$$

2.4 Analysis of Primary Data

The respondents were categories into three groups on the basis of their yield to find the yield variability across the farmers.

Forms of production function fitted to the data of three yielding groups include both Cobb – Douglas type production function and linear multiple regression function.

2.5 Mathematical form of the Model

As described above, Cobb-Douglas type of production function was found to be the best for analysis. Function was estimated by using stepwise regression procedure. The equation which is used for analysis is as given in equation 2.

$$\mathbf{Ln\ Y = \beta_0 + \beta_1 Ln + \beta_2 Ln + \beta_3 Ln + \beta_4 Ln + \beta_5 Ln + \beta_6 Ln + \beta_7 Ln + \mu_i} \quad [2]$$

Where Ln is natural log of variables; β_0 is intercept and β_1- β_7 is the unknown parameters to be estimated. β_1Ln is area under wheat, β_2Ln is wheat sowing time, β_3Ln is number of cultivations, β_4Ln is seed, β_5Ln is number of irrigations, β_6Ln is amount of fertilizer applied, β_7Ln is amount of chemicals applied and μi is an error.

3. Results and Discussion

The yields gaps were calculated for all these farmer groups and it was found that high yield farmer group had 17.84% yield gap when compared with research station yield. The yield gap between high and medium farmers was 8.02% while between medium and low farmers it was 5.93%.

Table 1. Crops Yield Gaps in Pakistan

Crops	Progressive Farmers' yield (mounds/acre)	National average yield (last three years) (mounds/acre)	Yield Gap (%)
Wheat	47	26	43.5
Cotton	26	18	30.8
Maize	69	29	58.5
Rice	38	21	45.6
Potato	253	176	41.0
Sugarcane (Punjab)	2024	554	72.8
Sugarcane (Sindh)	1315	505	61.6

Adapted from Khan et al., (2003)

Table 2: Yield groups and gap (mound/acre)

Yield Group	Frequency	Percent	Average Yield	Yield gap
Research station	……..	……	58	…….
High ≥ 35 m/acre	63	52.5	40.16	17.84
Medium ≥ 30≤ 35 m/acre	38	31.68	32.14	8.02
Low <30 m/acre	19	15.83	26.21	5.93
Total	120	100		

The benefit cost ratio was without opportunity cost and with opportunity cost were 2.07, 2.34 and 2.65 Rs. against their Rs. one cost, for low, medium and high yield groups. And with opportunity cost were1.24, 1.36 and 1.55 against their Rs. one cost, for low, medium and high yield groups. Net income simply obtained by subtracting total costs from gross income, the net income without opportunity costs were Rs. 22370.65, Rs. 29918.14 and Rs 41017.25. And including opportunity costs were Rs.8420.65, Rs.13817.89 and Rs.23627.25 respectively for low, medium and high yield groups.

Among the input use, the area under wheat crop had a significant impact on per acre yield of wheat for low, medium and high yielding groups. This indicated that if more area comes under wheat crop, the yield will raise significantly. Timely sowing of wheat had a positive impact. Another thing was also realized during the collection of data that the climate change (temperature) highly affects the wheat yield. The farmers sowing at proper time getting good results. The variable for cultivation of land was slightly significant for high yield group but it was not significant for low and medium yield groups.

Table 3: Cost of Production among Farmer Groups (Rs/acre.)

		Productivity Level		
Variable		**Low**	**Medium**	**High**
Land Preparation		2892.1	3226.00	3023.02
Sowing		202.6	215.79	292.06
Seed		1335.4	1491.29	1576.19
Fertilizers		6046.0	6644.08	8986.83
Chemicals		528.9	1165.00	1175.87
Irrigation		5585.9	4256.18	3919.70
Harvesting (ripper+manualcutting+harvester+thresher)		2992.18	3514.44	3773.77
Labor (Wages Rs)		2824.61	3277.89	3000.78
Total Cost without Opportunity Cost (OC)		20729.35	22281.86	24832.75
Opportunity Cost of Land Rent (Cost Rs)		13000	15000	16000
Opportunity Cost of Family Labor (Wages Rs)		950.00	1100.25	1390.00
Total Cost With OC (Cost Rs)		34679.35	38382.11	42222.75
Yield per acre (Mound)		25.13	33.32	46.50
Price per 40 Kgs.		1050	1050	1050
Income	Grains	34800	42000	53400
	Straw	8300	10200	12450
Gross Income		43100	52200	65850
Net Income without OC		22370.65	29918.14	41017.25
Net Income with OC		8420.65	13817.89	23627.25
Benefit Cost Ratio without OC		**2.07**	**2.34**	**2.65**
Benefit Cost Ratio with OC		**1.24**	**1.36**	**1.55**

Table 4. Regression coefficients & estimated equation

	Coefficient (βs)		
Variables	**High Yield Group**	**Medium Yield Group**	**Low Yield Group**
Constant	3.114	3.630	3.006
Area Under Wheat Crop	0.019	0.0028	0.0029
Sowing time	0.014	0.00567	0.0161
No. of cultivations	0.090	0.0585	0.0656
No. of irrigation	0.024	0.0532	0.0765
Fertilizer nutrients	0.019	0.0427	0.185
Chemical	0.00215	0.0053	0.0124
	High Yield Group	**Medium Yield Group**	**Low Yield Group**
R^2	0.698	0.586	0.514
F. Ratio.	5.276	4.453	3.237

Cultivation of land had highly significant results for overall productivity. Irrigation was significant at low and medium yield groups but it not significant for high yield group. But overall irrigation number slightly affects the yield but irrigation at required time is more important factor in yield variation. High yield farmers have timely access to tube well water as compared to the medium and low yield group in the study area. Fertilizer also plays an important role to increase per acre yield of wheat crop. Fertilizer application had positive impact on wheat yield and it was highly significant for medium and high yield groups but it was significant for low yield group. As wheat is a staple food, so farmer mostly using less chemical for wheat. The chemical cost for wheat was not significant for low, medium and high yield groups These result are justified by the result of Haq et al., (2002), Hussain et al.,(2003), Panhwar (2005), Iqbal et al., (2001).

4. Constraints Faced by the Farmers

The main constraints confronted by the farmers are discussed below one by one.

4.1. Problems in the availability of inputs

There are different problems faced by the farmers in the availability of inputs. Some major problems discussed below:

4.2. Adulteration of pesticides and inputs

The most and big problem was adulteration of pesticides and fertilizers. The Table shows that about 40.83 percent farmers claimed that the pesticides and fertilizers sold in market were impure. They had no effect on insects and crop but only cause of increasing the cost of production

4.3. Lack of extension services

An extension service plays important role in the training of farmers about the cultural practices of any crop. About 54.17 percent farmers claimed that due to lack of extension services productivity of wheat decreased. In both districts no member from agriculture department had visited the field.

4.4. Distant market

Distant market also one of the main problems and about 14 percent framers in the study area said that input market is far away from them and there were problem to bring them at farm gate.

4.5. Less canal water for irrigation

Among different constraints faced by the farmers less canal water for irrigation is the most important. As water is major requirement raising the wheat crop and in some areas ground water quality was not very good to apply it to field for irrigation alone. About 61 percent farmers were facing the problem of less canal water for irrigation. This percentage is so high because in Gujarat district no canal water is available.

4.6. High input prices

About 47 percent farmers in the study area said that prices of inputs were very high. Farmers had used the less inputs due to high inputs prices.

4.7. Insect/disease attacks

About 17 percent farmers in the study area said that insect/ disease attack was the major problem faced by the farmers in getting high wheat yield. They said that pesticides available in the market were impure and had no effect on insects.

Table 5. Constraints Faced by the Farmers

Constraints	**No. Respondents**	**Percentage (%)**
Adulteration in pesticides and fertilizers	49	40.83
Lack of extension services	65	54.17
Distant input market	17	14.17
Less canal water	74	61.67
High input prices	57	47.50
Insect/ diseases attack	21	17.50
High oil prices	59	49.17
Any other	15	12.50

4.8. High oil prices

Most if the machinery was oil based like tractors, peter engine for irrigation etc. the prices of oil were high and farmers use the less machinery in fear of increasing the cost production. About 49 percent farmers in the study area claimed that high oil prices are one of the main constraints in high wheat yield.

4.9. Any other

Only 12 percent farmers in the study area said that there were some other problems like sowing time, timely visit to crop and improper cultivation of land.

5. Conclusion

The yields gaps were calculated for all these farmer groups and it was found that high yield farmer group had 17.84% yield gap when compared with research station yield.The farmers of high yield group used the inputs more efficiently in quantity, quality and timely. Economics of wheat production was also calculated. Total cost of production of wheat crop was different for the three levels of productivity. The BCR for high, medium and low yield groups are 1.55, 1.36 and 1.24 respectively. The Cobb-Douglas production function was used to explain the yield variation, which was contributed by different explanatory variable incorporated in the model. There were many inputs which affected the yield of wheat such as, the area under wheat crop, the sowing time, and cultivation of land, irrigation, fertilizer and chemical use.

6. Policy Implications

It is evident from results that farmers in study area were paying high input prices and getting low output price. Therefore government should take part in the improvement of input-output price relationship. Government should check the proper management of input supply to avoid shortage and black marketing of different farm inputs.

It is evident from regression results that farm machinery had positive impact on farm diversification. Therefore, government should initiate different schemes to provide tractors and other farm implements to farmers at cheaper rates.

Task for researchers to evolve improved varieties of wheat with more yield potential. The results show that only 35 percent farmers of the study area had contact with agriculture officer. There should be the proper functioning of Extension Department to create a link between farmers and research station. The government should take part in the motivation of farmers towards the adoption of modern agricultural technologies.

It is evident from the survey that the quality of canal water available for irrigation in study area was very less and timely availability was also a problem. Government should improve the canal system and assure the timely supply of canal water. There is a need to develop new and high yielding wheat varieties to reduce yield gap and government should check the performance of breeding departments and also ensure the access of these varieties to farmers.

Competing Interests: The authors declare that there is no potential conflict of interest.

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