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A Comparative Economic Analysis of Maize Production Using Traditional and Hybrid Varieties of Seed: An Empirical Analysis

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ABSTRACT

Aim of the Study: Agriculture is the pillar of Pakistan's economy. It encourages the development of other sectors and serves as a significant source of foreign exchange. The aim of this study is to explore a comparative economic analysis of maize production in District Swabi utilizing both traditional and hybrid seed varieties.

Method: A questionnaire was designed and used to collect primary data from 100 respondents who were traditional and hybrid maize growers in the three villages of Dagi, Maneri, and Lahor. For estimation using Cobb-Douglas production function.

Key Results: The findings show that traditional seeds cost Rs. 27905 per acre, whereas hybrid varieties cost Rs. 33705 per acre. The total revenues for both types of seeds are Rs. 29100 and Rs. 42600, respectively.

Conclusion: The R^2 is 0.93, which means that Area, Seed application, Irrigation, Fertilizers, Plough, and Herbicides account for 93% of the variation in Maize production. When compared to maize production using certified and uncertified seeds, certified seed farming generates a net profit per acre that is 154.20 percent higher. The yield of certified seeds used in maize farming is 44 percent greater for the straw and 45.45 percent higher for the grain compared to non-certified seed production. It demonstrates that hybrid maize cultivation is much more profitable than traditional maize production.

Implication: Growing maize using certified seeds is more beneficial to the producer's welfare than growing maize with conventional seeds.

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Introduction

Background of the study

Agriculture sectors play a key role in the prosperity of the economy. It encourages the development of other sectors and serves as a significant source of foreign exchange. Pakistan's national economy heavily depends on agriculture. About 70% of people in our country reside in rural areas, where 45% of people work in agriculture, poultry, livestock, and industries based on agriculture. Small- and large-scale farmers are the foundation of Pakistan's economy. The majority of them cultivate crops including maize, wheat, sugarcane, tobacco, sugar beans, medium vegetables, etc. using outdated technology. Due to their biodiversity, climatic conditions, geographic position, and environment, specific agricultural product categories are sought locations of Pakistan. Physical characteristics, water accessibility, and other natural resources. The study region is pertinent to this goal since maize is the area's leading crop and because most landowners in the research area also produce maize. Alongside it, many additional crops are also cultivated, such as wheat, tobacco, sugarcane, beets, etc. A large amount of the food for millions of the world's poorest families comes from the key staple crop known as maize. Around 100 million hectares of conventional maize are grown by farmers throughout all developing nations (Abideen et al., 2014). Maize is one of the leading food crops in the world (Zea mays L.). In Pakistan out of total production, 99.81% is produced by two provinces Punjab and Khyber Pakhtunkhwa. Maize crops contribute 2.2 % of total Agriculture products and 0.4 % to GDP. The total area cultivated under maize during 2015-16 has increased to 1.14 million hectares while maize production was 5.2 million tons. (Economic survey of Pakistan, 2015-16). The "king of grain crops" is another name for him. In Pakistan, there are 896,000 hectares of land planted with maize, with a mean grain yield of 3097 kg per hec and annual production of 2775,000 tones. (Aurangzeb, 2007). Starch, protein, oil, fibre, and sugar content in corn kernels is substantial (72 percent, 10 percent, 4.8 percent, and 3 percent, respectively) (Chaudry., 1983). About 56 percent of Pakistan's total production of maize, or 63 percent of all production, is produced in KPK and Sindh, while Punjab comes in third with 39 and 30 percent of production, respectively. When compared to other regions or nations, Pakistan's average maize production is quite low at 3672 kg per hec (Anonymous, 2012). Only a handful of the research that have has been conducted in and outside of Pakistan are used to review the literature for the study. According to Mayer et al., (2006) there are two distinct ways of producing maize white and yellow maize across the world. Genetically both types of maize are similar, however there is a slight visual distinction of yellow colour which shows presence of carotene oil in yellow maize. Both categories use the same cultivation techniques and production circumstances. Early-season droughts have a deleterious impact on maize growth in several regions of Southern Africa and Central Indonesia, and farmers replant more or less as a result (CIMMYT., 1990). The current estimate of the world's white maize production is 65–70 million tonnes, or 12–13% of the total annual production. Developing nations generate 90% of the world's white maize. White maize is produced on bigger plots than yellow maize in tropical and subtropical regions of poor countries, taking up roughly 40% of the tropics (Lopes., 1998). Economic factors play a pivotal role in acceptance of new innovations and technical advancements in numerous earlier studies (Griliches, 1957). Farmers in Pakistan's highlands plant 80–100 kg of seed per hec, which provide both the grain & fodder for cattle. (Byerle, khan & Saleem., 1991). After wheat, maize is the second-largest food crop in Khyber Pakhtunkhwa. It has a good yield for all food crops and is grown throughout the Kharif season. Typically, KPK and Punjab produce 99 percent of the world's maize. KPK contributed 51 % of the area and 31 % of maize productivity, whereas Punjab contributed 48% of the area and 69% of the overall production. Sindh and Baluchistan contributed the final 1%. (Tariq, 2010). The production of maize in KPK has dramatically decreased over time, falling from 68 percent of the nation's GDP to 28 percent in 2006. In 2004, 2005, and 2007, it was 0.871, 0.708, and 0.846 million tons, respectively. Yields per hectare have also changed, decreased to 1,595 kg in 2005 but increased to 2,144 kg in 2006. Then in 2008 onwards the fluctuations in maize production were due to e-floods etc (Economy of Pakistan, 2012). With the growth of farmers' interest in hybrid seeds, and the growing attention of the private seed maize industry, it is not only expected that the maize farming area will increase, but also the yield per hectare will increase. Corn is a very versatile plant. It is consumed as a fast meal, particularly in the country's hilly regions. These areas typically use around half of the overall crop. An estimated 0.8 to 0.9 million tons of maize are produced in the province annually. Food shortages are a problem in KPK. It makes sense to increase the area planted with maize. The food committee has set a national goal of 2.9 million tons for the following year. According to Khatak (2014) from corn, edible oil is produced, and many grain-based products utilize it as well. Each year, hundreds of thousands of tons of corn are used by the livestock and starch sectors. In rural places, their sticks are utilized as firewood and as feed. When compared to conventional maize varieties, the quality of grain production is improved and revenues are increased by using improved varieties or a more productive hybrid (Abbas., 2001). Compared to earlier hybrid types, modern hybrid maize seeds perform better. Russell (1986) Animal feed can also be made from maize. Additionally, it is well established that factors like better / hydride varieties, irrigation regions, planting dates, crop value, herbicides, and wise fertilizer use all contribute significantly to higher agricultural yields (Shafi et al., 2012).

Maize crop is a significant food crop in the Swabi region. This crop performance a crucial role in food security & Swabi livelihoods and the prosperity of many of them is closely linked to food production. The current study is related to the Comparative cost and benefit examination of maize production in the Swabi region. Comparison of total cost and total revenue analysis of local and hybrid types of the maize was performed. The existing study identified factors affecting maize production and comparison of both varieties through Net present, gross margin and Benefit Cost Ratio techniques. This study also highlighted how many improved varieties are beneficial as compared to local maize varieties. Furthermore this study revealed the main causes for the low maize yield in the study area. In addition, this study will assist in formulating policies for maize farmers in Pakistan, especially in the Swabi region.

This study, therefore, acknowledges that there is little in-depth study that focuses on comparing the benefits of both traditional and hybrid seeds. In particular, the researcher found one variable effect (seeds, fertilizer, irrigation, plow, etc.) in maize production. There is no such way to compare profitability (total current value, profit margin, gross margin, etc.) used by the researcher. This study used BCR, NPV, and GM approaches to compare traditional and hybrid types of maize to identify factors impacting maize productivity. The main causes of the low maize yield in the research area are also shown by this investigation. Analyzing the costs and advantages of corn in the study area is the study's main goal. It is created in a manner that is as follows: (1) Calculating the price/cost and overall yield per hectare for the cultivation of maize using approved and uncertified seeds. (2) weighing the advantages and disadvantages of growing maize from certified and non-certified seeds.

Significance of the Study

A major source of nourishment and an essential cereal food crop is maize. Carbohydrates, vitamins, minerals, and fiber are all present. According to Rauf et al. (2016), maize is grown for both grain and feed purposes. The household income and food security are threatened by the erratic maize cultivation pattern during the past 20 years. Contrarily, recent years have seen a significant increase in maize production as a result of the use of new technology and improved seed varieties. The government will be able to combat the issue of food insecurity by increasing maize output in the future thanks to this production success.

Objectives of the Study

1. To find out the total cost per acre of traditional and hybrid varieties of maize,

2. To determine the yield per acre of traditional and hybrid varieties of maize production,

3. comparative investigation of total cost and profitability of traditional & hybrid varieties of maize production.

Research Hypothesis

H1: There is significant difference in production cost of traditional and hybrid maize.

H2: There is significant difference in production Yield of traditional and hybrid maize.

H3: There is significant difference in production Net revenue of traditional and hybrid maize.

Contribution of Current Study

Food insecurity and global hunger is a big challenge to the world now a days. The present study focused on increasing maize production through hybrid varieties of seed to overcome the problem of food insecurity. This study focused on the comparison between traditional and hybrid maize in terms of their cost, yield, profitability, and revenue per acre. Furthermore, this study explained the factors affecting maize productivity. Additionally, this study will be helpful for policymakers and maize growers in Pakistan specifically in the district Swabi.

The remaining article is structured in a way that section 2 describes the research methodology and section 3 is a discussion of the results, while the conclusion and recommendation are mentioned in section 4.

Research Methodology

Research Site and Data

The Swabi region served as the site of the current investigation. The three largest villages in the region Dagi, Maneri, and Lahor, and the primary producers of maize in the area were chosen for the survey. According to Razar, Swabi, and Lahore, each village is part of a different tehsil. To gather the necessary information, several fields in the study locations were visited. Utilizing a face-to-face interview schedule method, basic information was gathered in person using a pre-tested interview plan. This will be accomplished by using a thoughtful questionnaire. A well-crafted questionnaire was used to gather fundamental information from farmers. Typically, the farmers' homes, fields, and community centers served as the meeting locations (Hujras). The second information on the location and harvest of maize in Pakistan, Sources used for KPK and District Swabi include the KPK Department of Agriculture and e-i., Agricultural Research and the Swabi Expansion Center, Bureau of Statistics Economic Survey of Pakistan (with various issues) and Swabi Agriculture Farm Service Center.

Techniques of Sampling

The required size of sample is 100 farmers (approximately 8% of the total number of farmers) which were selected in three phases by using a multi-phase sampling method. In the first phase, the three villages chota Lahor, Maneri and Dagi were selected for the purpose of cultivating a hybrid variety. In Phase 2, in each district, farmers identified whether the farmer was a traditional seed farmer or a mixed seed planter, to form two distinct phases in each area. In the third step, selecting the required sample size of 100 maize growers, using the sample distribution method (Cochran, 1963) s.

Sampling through Proportional Allocation Method

$$NI = \frac{n}{N} * N_i$$

NI = number of respondent in each village, n = total sample size, Ni = number of total growers in each village.

Proportional allocation sampling was utilized to achieve the necessary sample size (at the rate of 8% of total sample size from each village n=100)

From Dagi: N1= 100/1248* 416 = 34

From Maneri: N2= 100/1248*398 = 32

From chota Lahor: N3 100/1248* 434 = 34

Table 1: *Area wise Sample distribution of Respondents in selected area.*

District.	Village	No of growers	Sample size
	Daagi	416	33.33 = 34
Swabi	Maneri.	398	31.89 = 32
	Chota Lahor	434	34.77 = 34
Total	**3**	**1248**	**100**

SOURCE: Model farm service centre Swabi

Time Schedule

Data was gathered in November and December of 2020 during the time that the maize crop was being harvested. Up till June 2021, data analysis and thesis writing were finished.

Model Description

The following model was employed to achieve the goal of studying the factors that affect maize production.

Cobb-Douglas Production Function

The primary characteristics of the corn crop were examined using Cobb-Douglas production . In agricultural production, this model is frequently utilized. Rheman at al., 2007, Khattak and Anwar., 2006, Haq et al., 2002 and Ravikash et al., 1997 all were used Cobb-Douglas log-production function. A modified version of this model was employed in this study.

$$lnY = \beta_\circ + \beta_1 lnA + \beta_2 lnSA + \beta_3 lnIRG + \beta_4 lnFER + \beta_5 lnPLG + \beta_6 lnLAB + \beta_7 D7 + \beta_8 D8 + \beta_9 D9 + \varepsilon \qquad \text{Eqn. 1}$$

Table 2: *Definitions of explanatory and explained variables.*

Coefficients	Explained variable	Definitions	unit	Expected sign
	Ln Y	Natural log of yield of Maize	Kgs	+
	Explanatory variable	**Definitions**	**unit**	**Expected sign**
$\boldsymbol{\beta_1}$	Ln A	Cultivated Area	acres	+
$\boldsymbol{\beta_2}$	Ln SA	Seed applied	Kg/acre	+
$\boldsymbol{\beta_3}$	LN Irg	Irrigation	Number of time	+
$\boldsymbol{\beta_4}$	Ln FER	Fertilizer applied	Number of bages	+
$\boldsymbol{\beta_5}$	Ln PLg	Tractor plough	No of hours	+
$\boldsymbol{\beta_6}$	Ln Lab	Used labour	Number of men	+
$\boldsymbol{D_7}$	HRB.	Herbicides applied	1= herbicides applied 2= not applied	+
$\boldsymbol{D_8}$	Seed Status	Variety of maize seed	1= local seed 2= Hybrid seed	+,-
$\boldsymbol{D_9}$	Land status	Ownership of land	1= owner 2= tenant	+.-

Diagnostic Test for Major Determinants of Maize Production

Test for detection of Heteroscedasticity

The population regression function's disturbance term, ui, has a homoscedastic variance., which is defined as equal variance (2). It can be expressed symbolically as follows:

$E(U_i) = \sigma^2$ i = 1,2,3,4……..

Tests of Specification (Ramsey RESET Test)

Heteroscedasticity will become a concern when the considerations are severely violated. It implies that the distraction term's variability will no longer be the same and could lead to an excessive focus on the elegance of equity. Heteroscedasticity was identified using the Glejser and Bruesh-Pagan tests.

Ramsey proposed RESET, which stands for Regression Specification Error Test (1969). Line specifications are tested against ambiguous meanings using testing. The RESET test (retrieval specification error test) is intended to find errors and omissions in performance.

Other Findings

Definition, limit, minimum, frequency, percentage, and standard deviation were employed as descriptive statistics. The profitability of manufacturing traditional corn in the Swabi region was assessed using GM, profitability analysis NPV, and BCR.

NPV and BCR

To assess your profitability for both conventional corn production and blending in the research area, the NPV and BCR concepts were applied. Magat, S. et al., 2007; Oseni, O. et al., 2013; & Westergard, C., 2006) also employed these techniques. The effective interest rate is used in NPV to minimize costs and benefits (8 percent). The formula shown below can be used to compute the Current Amount.

$$NPV = \sum_{t=1}^{n=1} Bt - Ct/(1+r)t$$

The decision-making formula is as follows: if value of NPV greater than 0, it means investment is acceptable; if NPV = 0, the investor is unconcerned; and if NPV less than 0, it means investment is unacceptable.

The Benefit-Cost Ratio (BCR) was also calculated in the study:

$$BCR = \sum_{t=1}^{n=1} \frac{\frac{Bt}{(1+r)t}}{\frac{Ct}{(1+r)t}}$$

Where n is the number of years, r is rate of interest, and Bt is the benefit per acre in every year. Ct is the production cost per hectare in each year.

Gross Margin Analysis (GMA)

The money received by farmers in the study area is reflected in the gross margin analysis. The cost of preparing the land, using a plough, sowing, fertiliser, irrigation, labour, harvesting, and transportation charges were all included in the TVC (total variable cost).

The formula below can be used to compute the gross margin:

$$GM = TR - TVC$$

Where TR= Total Revenue and TVC= Total Variable Cost

Result and Discussion

Cost and Profit Analysis of Maize Production

Production costs Numerous pre-harvest and post-harvest expenses spent throughout the production process are included in the price of maize. The most frequently utilized inputs are a plot of land, seeds, fertilizer, farm manure, and pesticides, while the actions involved are preparing the soil, sowing the seeds, fertilizing it, applying farm manure and herbicides, cultivating, cultivating, and harvesting. Based on information gathered from 100 respondents, including 33 for each district, the following cost elements have been determined.

Land preparation

The first and most crucial stage in growing maize is to prepare the soil, which rises the ability of the plants to absorb nutrients from the soil and increases the soil's ability to retain water for a longer period. Traditional maize was involved, and the average cost of land reform was Rs. 1900, or 8.47 percent of the overall value shown in Table 3. Nevertheless, the cost of land preparation for hybrid maize (Table 3) was Rs. 1500, or 5.97 percent of the overall production expenses.

Cost of Farming

The cost of seed, the labor utilized for sowing, or the cost of the farmer makes up the cost of planting or sowing. For conventional seeds, manufacturing costs were listed in Table 3. Table 3 shows that the cost of planting conventional maize was Rs. 750, or 3.34 percent of the whole expenditure. While the cost of sowing for mixed seeds (Table 3) was Rs. 1800 and represented 7.16 percent of all variable expenditures.

Irrigation Costs

Agriculture's blood is referred to as water. Without water, life is not possible. Water used for irrigation is one thing that lowers agricultural output. To increase maize yield, irrigation is crucial Haidar et al., (1977). The primary irrigation sources for the study area are the canal and the tube source. For each harvest season, irrigated land has a water cost (Abiana) of Rs. 32 per ditch. Table 5.5 shows that the overall irrigation expenses for conventional maize are Rs. 656, or 6.49 percent of the total production expenses. Hybrid seeds, on the other hand, cost Rs. 1456 and accounted for 2.61 percent of overall production expenses.

Herbicides Cost

Use the proper herbicides to manage the weeds (plants, wild plants, etc.) in order to acquire the best yield. According to Rajaram. S (2001), efficient and effective weed control could result in higher crop yields. Herbicides have not been applied to conventional seeds. because farmers don't want to eradicate weeds and feed them, along with other wild plants, to their cattle. They don't use herbicides derived from conventional corn as a result. In contrast, the entire cost of herbicides for hybrid seeds, as shown in Table 4, was Rs 950, or 3.78 percent of the overall cost of production.

Fertilizer Cost

Both agricultural and chemical fertilizers are crucial inputs. Both increase soil fertility and directly influence crop output. Farmers frequently employed fertilizers like urea, NPK, and DAP to grow maize. Table 3 shows that the price of conventional seed fertilizer was Rs. 2000, or 8.92% of the TC of production. In contrast, the cost of fertilizer for hybrid seeds is Rs. 4,000, or 15.93% of the overall cost of production.

Plough Cost (Hoeing Cost)

Another crucial element in the production of maize is the plough. Both types of ploughs, a hand plough and a bull plough, were required for the corn harvest. After ploughing, the earth is loosened to allow for the growth of the roots and other invasive plants are also cleared from the sides, both of which are beneficial for plant development. According to Table 3, the cost of farming conventional maize is Rs. 800, or 3.75 percent of the overall cost. In contrast, the farming expense for hybrid maize (Table 3) was Rs. 1200, or 4.77 percent of the total cost of production.

Harvesting Cost

In all maize production systems, harvesting is the final and most crucial step. Due to a lack of labor compared to demand, harvesting is also a particularly challenging task. Cutting, gathering, and separating the stalks from the stalks are the steps in this operation. A family member, a hired worker, or a volunteer from the community (Ashar) carry out this task. Table 3 shows that harvesting conventional maize cost Rs. 2000, or 8.92 percent of the overall cost. In Table 3, the price of harvesting hybrid maize was Rs. 1800, or 6.37% of the TC of production.

Land Rent

Landowners and owners are the two different categories of farmers. For their land, they pay rent. At specific times of the year, local rent was paid in cash or, depending on the crop, in grain. Renting is a major share of total costs. Table 3 and Table five exhibited that in both traditional & mixed conditions, land tenure was adjusted. The owner does not worry that farmers are planting traditional or hybrid seeds. With a share of 53.55 percent of the overall production costs in the traditional culture and 47.79 percent in the hybrid maize cultivation, the rental area in the research area was priced at Rs. 12,000 per hectare.

Revenue of Maize Production

The revenue from maize production comprises goods made from maize, such as stalks and straw, as well as maize production, such as kernels (seed cakes). Domestically, maize kernels are utilized to make flour, and the residual goods are offered for sale. Even though seed cakes and maize stalks are both utilized as a fuel in domestic cooking. The following list includes the primary sources of income.

Revenue of Traditional Maize

The revenue share of conventional maize was shown in Table 4. This table shows that the typical yield of conventional maize was 1100 kg per hectare, or approximately Rs. 24200. There were 380 races in total, costing a total of Rs. 4560; also, 100 kg of seed cakes were produced as a by-product. Traditional farmers made Rs. 7354 in income, while the total income from traditional maize per acre was Rs. 29760.

Revenue of Hybrid Maize

The elements of mixed maize revenue were listed in Table 4. According to the table, hybrid maize produced an average yield of 1600 kg per acre, or Rs. 35200. There were 550 races in total, costing Rs. 6600, and 200 kg of seed cakes were produced as a byproduct. Hybrid maize had a total revenue per hectare of Rs. 43800, while hybrid maize growers had a total profit of Rs. 18694.

Table 3: *Average TC (per Acre)of Uncertified Maize*

Particulars.	**Unit**	**Quantity**	**Rate (Rs)**	**Cost (Rs)**	**Total cost**	**%**
Preparation of land						
i. Cost of fertilizer	No of bags	0	0	0		
ii. Tractor Plough	No of hours	1	1100	1100		
iii. Levelling	No of labor	2	400	800	1900	8.47

Tilling cost						
i. Seed cost	kgs	10	35	350		
ii. Manual sowing	no of men	1	400	400	750	3.34
Irrigation cost						
i. Cost of labour	No of labour	3	400	1200		
ii. Water charges	Rs/canal	8	32	256	1456	6.49
Plough Cost						
i. Manual plough	No of labour	2	400	800		
ii. By Bullock	Land total	0	0	0	800	3.57
Cost of fertilizers						
i. Sona Urea	No of bags	1	2000	2000		
ii. DAP	No of bags	0			2000	8.92
iii. Super Nitrate	No of bags	0				
Harvesting Cost						
i. Cutting of maize	No of labor	2	400	800		
ii. Collection cost	No of labor	1	1	400		
iii. Separation cost	No of labor	2	400	800	2000	8.92
Cost of Threshur	No of hours	1	500	500	500	2.23
Transport cost	Rs				500	2.23
Rent of land	Rs				12000	53.55
Miscellaneous cost	Rs				500	2.23
Grand Total					22406	100

Source: Field Survey

Table 4: *Revenue per acre of Uncertified Maize*

Particulars	Units	Quantity	Rates (Rs)	Amounts
Main Product (Maize)	Kgs	1100	22	24200.
By Product (Stalk and straw)				
i. stalks	No of bundles	380	12	4560.
ii. straw	Kgs	100	10	1000.
Total revenue	TR			229760.
Net revenue	**29760-22406**			**7354**

Source: Field Survey

Table 5: *Average TC per acre of Certified (Hybrid) maize*

Particulars	Units	Quantity	Rates (Rs)	Cost (Rs)	Total cost	%
Preparation of land						
i. Tractor Plough	No of hours	1	1100	1100		
ii. Levelling	No of labor	1	400	400	1500	5.97
Tilling cost						
i. Seed cost	No of bags	2	500	1000		
ii. Manual sowing	No of labor	2	400	800	1800	7.16
Cost of irrigation						
i. Cost of labour	No of labor	1	400	400		
ii. Water charges	Rs/canal	8	32	256	656	2.61
Herbicide’s cost						
i. Herbicides cost	No of bottle	1	550	550		
ii. cost of labor	No of labor	1	400	400	950	3.78

Hoeing cost						
i. manual	No of labor	1	400	400		
ii. by Bullocks	Total land	2	400	800	1200	4.77
Cost of fertilizers						
i. Sona Urea	No of bags	2	2000	4000		
ii. DAP	No of bags	0				
iii. Nitrate	No of bags	0			4000	15.93
Harvesting Cost						
i. Cutting	No of labor	2	400	800		
ii. Separating	No of labor	2	400	800	1600	6.37
Threshur cost	No of hours	1	500	500	500	1.99
Transport cost	Rs				400	1.58
Rent of land	Rs				12000	47.79
Mecellenous cost	Rs				500	1.99
Total Cost					25106	100

Source: Field Survey

Table 6: *Total Revenue per acre of Certified (Hybrid) Maize*

Particulars	Units	Quantity	Rates (Rs)	Amounts
Main product (Maize)	Kgs	1600	22	35200
By Product				
i. Stalks	No of bundles	550	12	6600
ii. Straw	Kgs	200	10	2000
Total Revenue	TR			43800
Net Revenue	TR - TC = 43800-25106 =			18694

Source: Field Survey

Comparison of Cost and Revenue of Maize Production

The cost elements of producing maize were compared in Table 7. Hybrid seed costs Rs. 1000 per hectare while traditional seed costs Rs. 350 per hectare. Farmers incur costs when they plant hybrid seeds of 185.7 percent, or more than twice as much. It is noted that the cost of irrigation varies by 95%, while the cost of a plough varies by 50%. Comparing organic fertilizer to conventional seed, there is a 100% rise. Cultivation of maize with traditional seed the need for workers per hectare is 23% lower than for mixed (certified) maize cultivation. The reason for this is the high consumption of maize and this is due to sowing by hand and fertilization by hand.

Table 7: *Cost of maize production (Comparison)*

Components	Traditional Seed Rs	Hybrid Seed Rs	Difference %
Seed Applied	350	1000	185.7
Irrigation	256	500	95.31
Plough	800	1200	50
Fertilizers used	2000	4000	100
Labour hired	16	13	-23.07
Machinery used	1600	2600	26.5
Total variable cost (TVC)	10406	13106	25.94

Land rent	12000	12000	0
Total fixed cost	12000	12000	0
Total production cost	22406	25106	10.75

Source: Author own Calculation

Table 8: *Comparison of Total Output of Maize Production*

Output components	Unit	Traditional seed	Hybrid seed	Difference %
Grain yield	Kgs/acres	1100	1600	45.45
Stalks	No/acres	380	550	44.73
Seed cakes	Kgs/acres	100	200	100
The sale price of maize	Rs/kg	22	22	0
The sale price of Stalks	Rs	12	12	0
The sale price of Straw	Rs/kg	10	10	0
Total financial output	Rs	29760	43800	47.17
Net profit		7354	18694	154.20

Source: Author's calculation

The income portion of maize production was shown in Table 8. The typical grain output for traditional maize farming is 1100 kg, but it is 1600 kg for integrated seed maize farming. There is a significant amount of hybrid maize produced (45.4 percent more than traditional seed). Additionally, compared to traditional seed production, employing mixed seeds to grow maize results in a 44.7 percent higher average yield of maize (Bi Product).

Comparative Analysis of Hybrid and Traditional Maize varieties

The experimental sample compared traditional growers of various types with biotech farmers to assess crop yield methods, production costs, and residual revenue (Raza et al., 2009). Mixed and common maize varieties are calculated using t counts at harvest time per hectare, total production costs per hectare and net income per hectare. The results of the independent sample evaluation are in Table 8.

Table 9: *Outcome of t-test for equality of mean*

Variables	Varieties	mean	St. D	Mean dif	t-values	signif
TC	Traditional seed	22548.45	12070.20	1705.66	.684	.495
	Hybrid varieties	24254.12	10675.94			
Yield	Traditional seed	1056.560	211.13	552.86	9.286***	.000
	Hybrid varieties	1609.423	281.07			
Total Revenue	Traditional seed	30088.82	5239.05	13843.70	9.586***	.000
	Hybrid varieties	43932.52	6784.84			
Net Revenue	Traditional seed	7540.36	11265.92	12138.03	4.647***	.000
	Hybrid varieties	16678.40	11713.20			

**** Significant at 1% (0.01)

The average total cost difference between hybrid and traditional maize varieties is Rs. 1705.66, according to Table 9, and the t-value (0.684) indicates that the difference is insignificant. The reason for the insignificance is that the cost of the seed and fertiliser used differs slightly, but the other cost factors—such as the cost of the plough, irrigation, labour, etc.—are the same. The average yield difference between hybrid and conventional maize types is 552.86 on average, and the t-value of 9.286 indicated that this difference is statistically significant. The overall income difference between hybrid and traditional maize types is significantly different, with a mean difference of Rs. 13843 and a t-value of 9.586. The average difference in net revenue between hybrid and conventional maize types is Rs. 12138.03, and the t-value of 4.647 also showed that this difference is significant.

Financial Feasibility of the Maize crop

The study area's traditional and hybrid maize production costs and returns were contrasted using the Net Present Value (NPV) approach. Table 8 shows that the NPV for traditional maize production is 6809.26 whereas the NPV for hybrid maize production is 13309.26. It is clear that producing hybrid maize is more profitable than producing traditional maize, although both types of production are profitable. Additionally, the hybrid seed is said to have a higher BCR value of 1.74. It suggests that when compared to conventional types of maize, hybrid varieties are more profitable. According to Table 10, the gross margin for growing maize with conventional seed is Rs. 19354 per acre and for growing it with hybrid seed is Rs. 30694 per acre. It suggests that hybrid maize seeds are more lucrative than conventional types. The same table also shows that the net profit of producing conventional maize is Rs. 7354 while the net profit of producing hybrid maize is Rs. 18694. It demonstrates how much more profitable hybrid maize cultivation is than conventional maize production.

Table 10: *NPV, BCR and GM of maize production*

Indicator	Traditional seed	Hybrid seed
NPV	6809.26	13309.26
BC Ratio	1.32	1.74
GM	19354	30694
Net profit	7354	18694

Diagnostic Tests for Major Determinants of Maize Yield

Coefficient Correlation Matrix

Using sample correlation is a quick and easy technique to find multicollinearity. An inappropriate collinear association may be present if the correlation coefficient between the two variables that are independent is more than 0.8 in absolute value. We generate a coefficient correlation matrix between several explanatory factors to determine whether multicollinearity exists or not (Table 11). The outcome demonstrates that plough, area, and fertilizer are significantly correlated variables. Fertilizers and irrigation have a correlation of 0.814, while fertilizers and ploughing have a correlation of 0.708, 0.819, and 0.946, respectively. This suggests that the model's explanatory variables exhibit substantial multicollinearity.

Table 11: *Correlation matrix*

VAR	AREA	SEED APP	IRG	FER	PLG	LAB	HRB	SEED ST	OWN
AREA	1								
SEED APP	.410**	1							
IRG	**.708****	.031	1						
FER	**.819****	.092	**.814****	1					
PLG	**.946****	.412**	.709**	**.801****	1				
LAB	.580**	.127	.533**	.690**	.56**	1			
HRB	.614**	-.193	.624**	**.829****	.59**	.638**	1		
SEED ST	.369**	-.595**	.589**	.627**	.39**	.437**	.715**	1	
L.OWN	-.034	-.099	.013	-.034	-.002	.038	.006	-.002	1

**. Correlation is significant at the 0.01 level (2-tailed).

Tolerance

R2 is the coefficient of determining every variable that is independent in a multiple regression model, and it is used to define tolerance as 1-R2. Due to multicollinearity, independence should be removed from the study when the tolerance value is less than a cut-off value, typically 0.20. A simpler correlation (r = 0.8) is preferable to this one. Since tolerance examines the independent variable in relation to all other independent variables, it takes both the interaction effect and simple correlation into consideration.

Variance inflation factors (VIF)

An indicator of the level of regressor collinearity in an equation is the variance inflation factor. VIF is essentially the inverse of tolerance.

$$VIF = \frac{1}{1-R^2}.$$

The VIF demonstrates how much the variance of a regressor's coefficient estimate has been exaggerated as a result of collinearity with other regressors. Basic Principle: Any VIF values above 10 (VIF>10) indicate that multicollinearity has resulted in an inaccurate estimation of the corresponding regression coefficients (Montgomery, 2001: Drapper and Smith, 2003).

Table 12 lists the variance inflation and tolerance factors for the explanatory variables in the regression model. The tolerance level for fertiliser, area, plough, and seed variety is 0.104, which is less than 0.20, indicating that these variables lead to collinearity in the model and should be removed from the regression. The area's VIF value was 11.310, and the plough value was 12.790, both of which were higher than 10.

Table 12: *Outcome of the Multicollinearity (MC) Test*

Variable	**Tolerance**	**VIF**
Area	**.088**	**11.310**
Seed App	.121	8.272
Irrigation	.289	3.463
Fertilizer	.104	9.572
Plough	**.078**	**12.790**
Labour	.462	2.164
Herbicide	.209	4.790
Seed Variety	.112	8.955
Land. Ownership	.909	1.100

Test for detection of Heteroscedasticity

OLS estimates are biased because of heteroscedasticity, which results in type I and II errors. which indicates that OLS is no longer BLUE. As opposed to time series data, cross sectional data exhibit heteroscedasticity more frequently (Gujrati and Porter, 2009). There are various ways to determine whether heteroscedasticity exists, however the Glesjer test and the Breusch-Pagan test can be used to do so in the following way.

Table 13: *Outcome of the Glejser's Test LM Test*

F-statistic	**1.726140**	**Prob. F(9,90)**	**0.0944**
Obs*R-squared	14.72044	Prob. Chi-Square(9)	0.0989
Scaled explained SS	13.96807	Prob. Chi-Square (9)	0.1235

Source: E-view output

Table 13 demonstrated that there is insufficient evidence to reject our null hypothesis of homoscedasticity because LM (nR2) value 14.7 is less than chi-square critical value with 9 degrees of freedom 16.91 at

0.05 level of significance. As a result, it may be concluded that the error term has a constant variance, and that heteroscedasticity was not a problem.

Table 14: *Results of Breusch-Pagan Test for heteroscedasticity*

F-statistic	**1.850443**	**Prob. F(9,90)**	**0.0699**
Obs*R-squared	15.61497	Prob. Chi-Square(9)	0.0754
Scaled explained SS	16.08369	Prob. Chi-Square(9)	0.0652

Source: E-view output

Tests of Model Specification (Remsey RESET Test)

The results of the Breusch-Pagan test for identifying heteroscedasticity are shown in Table 14. The value of LM (nR2) is 15.61, which, according to the table, is smaller than the critical value of X2 (p-1) at the 0.05 level of significance (15.61>16.91). Therefore, we determined that there is no issue with heteroscedasticity in the model and did not have enough evidence to reject the null hypothesis that it does not exist. Since one method to reduce the impact of heteroskedasticity is to turn the data into logs follow (Koutsoyiannis, 2006), we do not worry about its presence.

Table 15: *Results of Remsey RESET Test*

$\mathbf{H_o = Model\ \ has\ no\ omitted\ variables}$				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1.890	0.263	7.162	0.000
Area	0.325	0.129	2.503	0.014
Seed App	0.307	0.087	3.512	0.000
Irrigation	0.195	0.079	2.442	0.016
Fertilizer	0.299	0.094	3.177	0.002
Plough	0.127	0.103	1.226	0.223
Labor	0.217	0.100	2.172	0.032
Herbicides	0.160	0.072	2.196	0.030
Seed Status	0.596	0.149	3.976	0.000
Land Ownership	-0.065	0.032	-2.021	0.046
FITTED^2	**-0.044**	**0.039**	**-1.119**	**0.266**

Source: E-view output (R-Square 0.9517, F-Statistic 175.545, Adj- R-Square 0.9463, Prob (F-stat) 0.000)

The estimates of the auxiliary regression model were reported using the RESET test (Table 15). The fabricated variable FITTED2 exhibits a very weak connection with the dependent variable. At 0.2660 (95%) the p-value is higher than 0.05. We reject the null hypothesis, which states that there is no omitted variable (correct specification) if the F statistic (175.54) exceeds the critical threshold at a particular level of significance. This suggested that the model might be functionally mis specified or overfit.

Resolving Multicollinearity

Getting more information and considering more significant variables is one way to address the multicollinearity problem. The second option is to limit the coefficient of a variable that has a strong correlation with other explanatory factors. We choose the second choice of the dropped out variable due to time constraints. Therefore, we removed variable 5 (X5 = Plough) from the regression for this reason, and we checked for multicollinearity using the auxiliary regression technique.

Multicollinearity detection Using Auxiliary Regression (after Omitting Plough)

Here, we look at the R^2 values of two regression models. The first is an addition to the original Plough model with the variable left out, while the other two are regression models. According to Klien's thumb rule, multicollinearity is a concern if the auxiliary regression's R2 is higher than the main regressions, and vice versa.

Table 16: *Auxiliary Regression (after Omitting Plough)*

Dependent variable	R^2 of Auxiliary Regression	R^2 of Main Regression	Conclusion
Ln Yield		0.950	
Ln Area	0.825	0.950	No Multicollinearity issue
Ln Seed App	0.844	0.950	No MC
Ln IRG	0.708	0.950	No MC
Ln FER	0.895	0.950	No MC
Ln LAB	0.530	0.950	No MC
HRB	0.790	0.950	No MC
SEED STATUS	0.851	0.950	No MC
LAND OWN	0.052	0.950	No MC

The main regression and auxiliary regression coefficients of determination (R2) were shown in Table 16. The fact that the main regression model's R2 value (0.95) is higher than the auxiliary regression's R2 value demonstrates that there is no multicollinearity in the regression.

Estimation of Cobb-Douglas Production Function

The overall quality of fit or significance of the model is assessed using the F-test. In these cases, at a threshold of significance of 0.05, the calculated value of F (219.35) is greater than the tabular value of F (8, 91) 2.04 (F tabulated>F calculated), showing that the model is significant overall. R2 has a coefficient of determination value of 0.95. The model statistically fits the data pretty well. In terms of economics, it signifies that explanatory variable account for 95% of the variation in the dependent variable (Yield) (Area, Seed application, Irrigation, Fertilizers, herbicides, and labour usage). All of the variables' VIF values are less than 10, which excludes multicollinearity. The table below displays the findings.

Table 17: *Estimation of Cobb-Douglas Production Function*

Variables	Coefficient	Std. Error	t-Statistics	Sig	Tolerance	VIF
C	1.933	0.261	7.409	.000		
Area	0.297	0.074	4.029	.000	.174	5.744
Seed app	0.271	0.060	4.561	.000	.155	6.431
Irrigation	0.143	0.062	2.324	.022	.291	3.435
Fertilizer	0.210	0.052	4.054	.000	.105	9.560
Labor	0.140	0.078	1.799	.075	.469	2.132
Herbicides	0.121	0.063	1.929	.057	.209	4.781
Seed status	0.501	0.085	5.867	.000	.139	7.217
Land. Own	-0.046	0.029	-1.585	.116	.947	1.056
R square	**= 0.950**		**F = 219.35**			
ADJ-R^2	**= 0.946**		**Prob (F-Stat) = 0.000**			

Source: SPSS output

Conclusion and Policy Suggestions

Certified seed production requires higher physical input than maize growing utilizing uncertified seeds (herbicides, insecticides, chemical fertilizers, and machine power). When growing maize with traditional seeds as opposed to hybrid seeds, there is a larger labor force ratio. The manual application of chemical fertilizers, herbicides, insecticides, and seeds is related to the high degree of labor utilization in areas where production is conducted using non-certified seeds. Comparing the output of maize with certified seeds to that of uncertified seeds, over 23% less seeds were used. The grain yield and straw yield of maize grown with certified seeds are both 45.45% higher than those obtained through production utilizing uncertified seeds. It has been established that using uncertified seeds to grow maize results in cheaper total production costs than using certified seeds. Production of maize using certified seeds has a profit margin that is 36.94% larger than production using uncertified seeds. Net profit per acre from the usage of certified seeds is 154.20 percent higher when compared to maize cultivation with uncertified seeds. The hybrid seed has a higher NPV and BCR value than the conventional seed. This suggests that investing in hybrid maize farming is more lucrative than growing traditional maize. Therefore, we infer that cultivating maize from certified seeds has the greatest positive impact on the welfare of the producer. Growing maize using certified seeds is more beneficial to the producer's welfare than growing maize with conventional seeds. The government is urged to work toward putting more and more land under maize production. Instead, then using conventional kinds, farmers should plant better ones. To help farmers, Agricultural Research Stations should play a significant role. The causes of low crop production should be addressed, and ARS should organize seminars and workshops to inform farmers about recent developments in agriculture.

Policy Implication and Future Research

The production expenses and revenue for both conventional and cutting-edge maize varieties were thoroughly analyzed in the current study. The best maize varieties to grow are outlined in this handbook for agricultural economists and farmers (both farmers). In order to boost the production of maize in the studied areas, the government will be able to develop policies that increase the arable land. If properly monitored and carried out, the identified economic activities will significantly increase maize output in the Swabi, KPK, and Pakistan regions. Maize production will make sense in both local and international markets if the methods for producing it are successfully put into practice, as well as the recommendations of agricultural research stations and the model farm resource center. The new study also offers instructions for conducting this kind of investigation wherever. The study can be expanded to include not just other types of crops but also fruits and vegetables throughout Pakistan.

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Conflict of Interest

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