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Research Article

Enhancing cotton production in Pakistan: Evaluating and addressing challenges in agribusinesses

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ABSTRACT
For Pakistan's economy, agriculture, especially cotton, is vital. Seventy percent of the nation's export revenue comes from the cotton crop, which accounts for 0.6 percent of the GDP. However, over the past 20 years, the nation's cotton production and area have decreased, but since 2023, the cotton production has improved. The study explores the various obstacles hindering cotton production in Pakistan and proposes strategies to overcome them. It delves into factors such as outdated farming practices, limited access to modern technology, climate change impacts, and water scarcity affecting cotton cultivation. By analyzing these challenges, the paper aims to provide insights into improving cotton production efficiency and enhancing the livelihoods of cotton farmers in Pakistan. This study uses the primary data to investigate the variables influencing cotton output in the Multan region. The findings showed that all farmer categories in the Multan district were experiencing a shortage of seed, fertilizer, and irrigation. These limited inputs are essential for cotton, and there is an urgent need to focus on the availability of such resources. Recommendations may include implementing modern farming techniques, providing access to advanced technology, addressing climate change vulnerabilities, and managing water resources more effectively.

Keywords: Cotton, Challenges, Opportunities, Cotton Production, Pakistan, Agribusiness

INTRODUCTION
Pakistan's Federal Ministry of Industries and Commerce declared that, after eleven years, the country has once again produced a record amount of cotton. In 2023, cotton arrivals surpassed five million bales, a significant accomplishment for Pakistan (Nazeer et al., 2023). This is even higher than the 4.9 million bales from the previous full year, representing a 34% YOY (year over year) decrease from the previous year. Throughout the world, cotton is a significant fiber crop, and it is scientifically known as Gossypium herbaceum (Parekh et al., 2018). In some nations, it is called "white gold" since it generates foreign exchange (Khan et al., 2020). Throughout the world, cotton is a notable fiber used as a raw material in the textile industry.

The agriculture industry generates 37.4% of jobs and contributes 22.9 percent of GDP; it guarantees food security and raw materials used by the manufacturing sector (Dar et al., 2023). The fall in cotton production has resulted in a 23.01 percent decline in cotton ginning, which accounted for 0.97 percent of agriculture and 0.22 percent of GDP. Because of the considerable variation in fiber quality and ginning outcomes, lint quality is a problem for the industry. Farmers often plant different varieties as a precaution against poor germination, which can lead to variations in fiber quality prices. One of Pakistan's most significant crops is cotton. After rice and wheat, it is Pakistan's third most important crop. Elevated temperatures cause evapotranspiration, intensifying water stress and diminishing cotton crop productivity and plant growth. Cotton is typically planted in regions of Punjab and Sindh with high temperatures and little precipitation (Iqbal, 2011).

According to the Commodity Intelligence Report presented by USDA, Pakistan is expected to produce 6.5 million 480-pound bales of cotton in the marketing years (MY) 2023–2024, which is 2.6 million bales or 67% more than the crop devastated by flooding in MY 2022–2023 (US Department of Agriculture, 2023). The anticipated rise in output results from an area recovery following losses from the previous season and a yield return to almost average. Ayub Agricultural Research Institute, under the supervision of the Government of Punjab, stated that Punjab has the best conditions for producing cotton; it produces over 70% of the nation's cotton, with Sindh contributing 28% (Nazeer et al., 2023). Punjab grows cotton annually on 4.7 million acres, producing 7 million bales and 700 kg of lint per hectare. Punjab's principal cotton-growing districts include Muzaffargarh, Rajanpur, D.G. Khan, Lodhran, Bahawalpur, Bahawalnagar, Rahim Yar Khan, Vehari, Sahiwal, Muzaffargarh, and Faisalabad (Ahmad et al., 2021).

According to the Pakistan Central Cotton Committee (PCCC), in the region where it is technically possible to cultivate all other crops, cotton, a Kharif crop, competes with rice, sugarcane, and other crops for land, water, and other agricultural resources. Sugarcane is the leading indirect rival to cotton as it is an annual crop that occupies land all year round. Cotton production is confronted with numerous social and economic challenges, the most important of which is the high cost of production (Mollaee et al., 2019). Other issues include an illiterate farming community, high input costs, small land holdings, a lack of farmer guidance, a high cost of production, and market instability. Even with abundant knowledge of the variables affecting Pakistan's cotton production, much remains to learn about the complex relationships and feedback loops between these variables in the context of shifting socioeconomic and environmental circumstances.

To get a more comprehensive understanding of the opportunities and problems that cotton growers and other stakeholders involved in production encounter within the agricultural sector, this study aims to collect information concerning these topics. This will allow for a more complete awareness of the situation. The result will be a deeper and more comprehensive understanding of our respective areas of responsibility. This initiative aims to provide ideas and solutions to discover a means to expand Pakistan's ability to produce cotton in an environmentally friendly and competitive manner. This goal is for Pakistan to produce environmentally friendly and competitive cotton. The producers, stakeholders, and policymakers in Pakistan are the individuals who are supposed to receive the recommendations provided by this initiative. This project aims to inform these stakeholders on how the cotton industry may be made more resilient, efficient, and productive by providing recommendations.

LITERATURE REVIEW

Pakistan's most significant cash crop is cotton. Because of its capacity to bring in money for farmers, it is frequently described as "white gold" in the nation's farming community. Since cotton is Pakistan's primary source of foreign exchange profits, which go directly towards the nation's GDP, cotton plays a crucial part in the country's economy. The introduction of novel germplasm and Bt cotton cultivars to the nation has resulted in a notable increase in seed cotton yield in recent years (Razzaq et al., 2021).

The second-largest crop in Pakistan, cotton is a significant contributor to the country's economy and a source of income for cotton-producing nations. Pakistan's cotton productivity has been erratic over the last few decades, with climate change significantly influencing cotton yield. Understanding the trend in climate change and how it affects cotton crops at the

regional level is crucial (Han et al., 2022). One of the most famous textile materials is cotton, and 24% of all textile waste is made of waste cotton (Lu et al., 2023). In addition to being the most significant crop for natural fiber in the world, cotton provides an excellent model system for researching the evolution of genomes, polyploidization, and cell elongation (Huang et al., 2021). Cotton (Gossypium hirsutum L.) productivity depends heavily on finding and controlling pests, although farmers frequently lack this information (Wagan et al., 2023). Pakistan faces numerous obstacles in its cotton production: temperature fluctuations and high levels of weed infestation; outdated Bt. Bollgard-I technology; poor seed quality; pest problems (pink bollworm and whitefly in particular); insecticide resistance; low levels of mechanization adaptation; low cotton profitability (Nazeer et al., 2023). Research on the elements that affect information availability in Pakistan has neglected chiefly the importance of marketing information in favor of information from the standpoint of agricultural productivity (Yaseen et al., 2023). The production of cotton is essential to Pakistan's economy. Numerous environmental conditions that it encounters limit its ability to grow and produce. Cotton cultivation in Pakistan is under increased strain due to climate change, particularly in the Sindh region (Deho, 2023).

Farmers must grow those crops that need fewer resources but give higher yields. Similarly, to encourage farmers to grow cotton in the cotton-wheat zone, efforts should be made to lessen price fluctuation in the input and output market supplies, particularly in the case of cotton prices. Since Baluchistan produces cotton at a comparative advantage, efforts should be made to boost cotton output to fortify the market system (Baig et al., 2023). Around 25% of the world's textile fibers come from cotton, which has several adverse environmental effects, including toxicity, eutrophication, water usage, and greenhouse gas emissions (Zhang et al., 2023).

Artificial intelligence has transformed cotton harvesting and sustainable agriculture and has revolutionized agriculture (Khonturaev & Kodirov, 2023). The long seed fibers, high edible oil, and protein content of upland cotton make it a significant global cash crop. A new age in cotton research and breeding has been ushered in by advances in cotton genomics, which support the advancement of cotton genetics, evolutionary studies, functional genetics, and breeding (Yang et al., 2023). It was suggested that rising temperatures are not suitable for Pakistan's cotton crop because the average temperature is rising. Pakistan should implement more ecologically friendly industrial methods and inputs, plant trees, build dams across significant rivers, and slow down the rate of climate change to conserve water (Abbas, 2020).

DATA AND METHODOLOGY

The primary data for this study was collected in March 2006 from a sample of cotton growers in the Multan district. The sample included 60 small producers with less than 12.5 acres of land, 25 medium growers with more than 12.5 acres but less than 25 acres of land, and 15 large growers with more than 25 acres of land. These growers were randomly selected from two tehsils (sub-districts) in Multan, namely Shujabad and Multan. Ten villages were chosen at random from the five union councils in each tehsil, with the number of sample growers in each village being proportionate to the distribution of small, medium, and large growers.

The study employed the crop budgeting approach and this method involves the consideration of multiple fixed and variable inputs. The primary fixed input identified was land rent, while the variable costs included labor (LLC), plant protection (LPPC), cultivation (LCC), fertilizer (LFC), irrigation (comprising canal and tube-well) (LIC), inter-culture/hoeing (LINTC), and sowing expenses (LSC). To investigate economies of scale, the researchers utilized the Cobb-Douglas Production function. The following provides a full explanation of the log-linear representation of this production function:

$$LnY = \alpha + \beta1LnX1 + \beta2LnX2 + \beta3LnX3 + \beta4LnX4 + \beta5LnX5 + \beta6LnX6 + \beta7LnX7 + u$$

Where

LnY is the dependent variable that stands for yield per acre.

The costs associated with X1 are cultivation; X2 are fertilizer; X3 are irrigation; X4 are inter-culturing + hoeing; X5 are labor; X6 are plant protection; and X7 are seed and sowing costs.

α = Constant/Intercept βs = To Be Estimated Coefficients

u is the random disturbance term.

Natural Logarithms = Ln

The Ordinary Least Squares (OLS) method was used to estimate the production function. The study first calculated the gross income and total cost before calculating the cost-benefit ratio, which can be formally represented as:

GI / TC is the CB ratio.

Whereas, measure of cost-benefit

GI stands for gross income.

TC stands for total cost.

The Marginal Value Product (MVP) was determined in order to evaluate the inputs' allocative efficiency.

where X represents the mean of each input cost and Y is the average output value. The ratio of MVP Xi to the opportunity cost of Xi is then used to calculate the allocative efficiency of Xi.

RESULTS

The findings indicate that medium and large producers had a net per acre return of 16 percent and 112 percent higher, respectively, compared to small producers. Additionally, the cost of production for large producers was 12 percent and 7 percent higher than that of small and medium producers, respectively, across all farmer categories. Seeds are widely recognized as essential to cotton production. Several studies have shown their significance in cotton production. The data analysis for the Multan region indicates that a 1 percent rise in seed expenditure correlates with a significant 10.3 percent increase in cotton output per acre. Investing in seed guarantees the use of superior-quality seed and maximizes the efficiency of sowing processes.

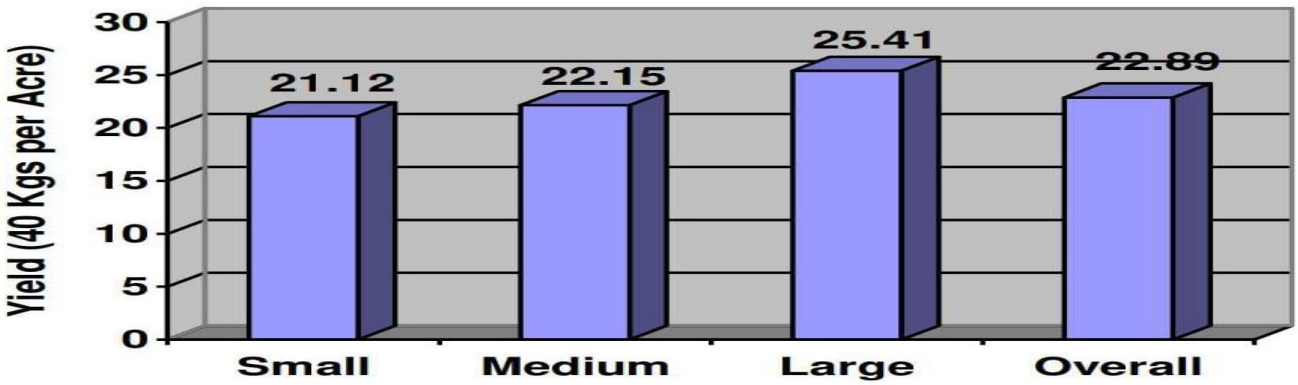
Table 2. Cobb-Douglas production function

Description of factors	Coefficient	SE	t-values
Cultivations	0.146***	0.023	7.685
Seed	0.102***	0.015	3.851
DAP (Fertilizer)	0.182*	0.073	2.382
Urea (Fertilizer)	0.147**	0.051	3.123
Irrigations	0.231*	0.096	2.425
Plant Protection (PP)	0.158*	0.054	2.477
Hoeing/intercultural	0.113*	0.039	2.245

*** Significant at 0.01 level; ** Significant at 0.05 level; * Significant at 0.10 level

The coefficient for the cultivation variable is 0.113, signifying a direct correlation between the number of cultivations and yields. It illustrates that a slight 1% rise in cultivation expenses will lead to a significant 11.3% boost in the value of produce per acre. This variable's high level of importance demonstrates its substantial influence on cotton output. Research has concluded that using DAP fertilizer, which promotes fruit growth in plants, substantially influences cotton productivity. The estimated response of the dependent variable to this independent variable is 0.191, suggesting that a 1% increase in DAP fertilizer expense would lead to a 19% increase in cotton yield in rupees. In the district of Multan, based on statistical data, this variable is significant and significantly affects the cotton output.

In the Multan district, the estimated coefficient for this variable is 0.158. This indicates that a 1% increase in urea fertilizer use leads to a 15.8% larger reaction in the district's cotton yield. Irrigation refers to supplying water to a crop using multiple water sources. Observers noted that farmers used different irrigation supplies, considering this element's significance. Each 1% increase in irrigation costs will result in a 22% increase in cotton production. A statistical analysis conducted at a significance threshold of five percent determines that the results are statistically significant. Among the other variables, the coefficient of this one is at its maximum value, suggesting the factor's significant relevance.



. Figure 1. Cotton production in Multan district

The cotton crop is highly vulnerable to illnesses and pests. Farmers employed a plethora of pesticides to mitigate the proliferation of diseases and pests. Therefore, this factor exerts a substantial impact on the cotton production. The factor productivity for this variable was assessed and found to be 0.169, suggesting that a one percent increase in expenditure on plant protection measures can lead to a 17 percent increase in cotton income per acre in the Multan area. Upon evaluating its significance. Therefore, it can be concluded that this component is crucial for cotton production in the Multan district. Yield refers to the quantity of cotton harvested from each acre of land. In the field of study, the rates for small, medium, and large farmers are 22.15, 23.41, and 25.41 (40 kg per acre), respectively. The optimal temperature range for cotton production is generally between 28.5 to 35 degrees Celsius. However, in Pakistan, temperatures can reach as high as 35 degrees Celsius during the cotton growing seasons. At times, it can increase further, reaching a maximum temperature of at least 50 degrees Celsius, which is exceedingly high for the survival of both humans and animals. Heat stress is a severe obstacle to Pakistan's efforts to increase productivity per acre.

Table 3: Cost and benefit ratio analysis

Description	Gross Income	Total Cost	Net Income	Cost Benefit Ratio
Small Farmers	20051.00	15315.39	3548.52	1.33
Medium Farmers	21485.20	18263.33	4332.81	1.13
Large Farmers	25315.30	19821.27	7827.32	1.22
Overall farmers	23584.33	16412.5	5282.82	1.42

Jhang, Raheem Yaar, Bahawalnagar, Bahawalpur, Vehari, Multan, Khanewal, Rajanpur, Ranipur, Muzaffarabad, Lodran, and Faisalabad are the central regions in Punjab where cotton is predominantly cultivated. The cultivation in Punjab's districts with the highest cotton production is widely recognized. However, it is commonly cultivated in Nawabshah, Kazi Ahmed, Nausheroferoze, Ghotki, and Khairpur in the Sindh province. All the areas mentioned above are classified as being in the D zone. These regions of the Sindh province are characterized by their intense heat and aridity, making them suitable for cotton cultivation.

DISCUSSION AND PROSPECTS FOR COTTON PRODUCTION

One can assess Pakistan's cotton production prospects for the future by considering several variables, such as the effects of climate change, market demands, policy actions, and socioeconomic situations. There are a few suggestions to work for in the future: Implementing contemporary agricultural techniques, including mechanization, effective irrigation methods, better seeds, and insect control, can increase cotton productivity. Funding research and development to create cotton types that are tolerant to climate change and yield well may also facilitate future expansion. Pakistan's cotton production is susceptible to the effects of climate change, including unpredictable weather patterns, limited water supplies, and pest

outbreaks. To reduce these risks, adopt climate-smart agriculture methods and create pest—and drought-resistant cotton types. To satisfy market demands, Pakistan's cotton sector can benefit from understanding global market trends and consumer preferences for cotton produced sustainably. Certification schemes supporting fair trade and organic cotton in foreign markets can command higher prices.

Cotton growers can benefit from government policies prioritizing infrastructure development, agricultural extension services, finance availability, and subsidies. Investment in the cotton industry depends on policy consistency and stability. Addressing socioeconomic issues such as land fragmentation, access to healthcare, education, and other livelihood possibilities can enhance cotton farmers' resilience and general well-being. Pakistan faces competition in the international cotton market from other producing nations. It must monitor and adjust to shifts in production technologies, pricing, and international trade laws to stay competitive. Investing in value-added sectors like textile production can boost the market for locally grown cotton, generate jobs, and spur economic expansion. The long-term sustainability of Pakistan's cotton production depends on adopting sustainable farming techniques to minimize environmental deterioration, such as lowering water use, chemical inputs, and soil erosion.

In conclusion, despite certain obstacles, there is much room for growth in Pakistan's cotton sector if strategic initiatives centered around technology, market orientation, climate resilience, governmental support, social development, and environmental sustainability are implemented. Cooperation between the government, business leaders, academic institutions, and global organizations is crucial to realize these opportunities.

CONCLUSION AND RECOMMENDATIONS

More than 1.7 million farmers in Pakistan cultivate cotton and its related value chain. Pakistan is the fourth-largest global producer of cotton lint. The main emphasis of research and evaluation endeavors in the country is to expand lint production and improve the quality of lint sweetening. Pakistan also fulfills 18.8% of its edible oil requirements using cottonseed oil. Industries are highly motivated to enhance the production of sublimated cotton oil, which may be directly utilized for frying and cooking, eliminating the need for hydrogenation to produce solid ghee. Nevertheless, this heightened production renders cotton more vulnerable to non-living and living dangers. Studies have demonstrated that diploid cotton farming cultivars exhibit desirable traits, including the ability to withstand drought, tolerate heat stress, resist insect diseases and pests, and contain advantageous physiological and morphological properties. To identify advantageous traits in different cotton varieties, it is feasible to hybridize many species like G. arboretum, G. herbaceum, G. barbadense, and Gossypium laxum with Barbadense and G. hirsutum. By subjecting the embryos to controlled culture conditions, it may be more feasible to overcome cytogenetic barriers. This method increases the genetic variation and adds genes that provide characteristics lacking cotton.

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