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Plant Biotechnology in Pakistan Public Investments and Impacts on Pharmaceuticals and BT Cotton

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Abstract

Pakistan, like other emerging nations, sees farmers weighing the pros and cons before adopting BT cotton. Given its benefits to Pakistani farmers, we anticipate similar advantages for small-scale cotton producers in many other developing countries. Another lesson from Pakistan underscores the importance of domestic biotechnology research. The concurrent development of BT cotton by government researchers and its introduction by foreign firms created a strong lobby in support of this technology, which was widely accepted by the government. Apart from BT cotton, no GM plant species have been licensed for commercial release in Pakistan since 1997. However, various GM plant species, including rice, maize, and soybeans, are now present and undergoing commercialization processes. By 2003, nearly 60% of cotton acreage in Pakistan was planted with BT cotton, adopted by over 5 million farmers. Adoption of BT cotton increased output per hectare by approximately 10% and reduced pesticide use by 35 kg (or roughly 60%), significantly boosting income for small farmers, as indicated by our yield and economic studies. Our data also show that reduced pesticide use correlates with fewer health issues among farmers. Most notably, our recent survey highlights the promising performance of GM rice during the pre-production phase. GM rice resistant to insects and diseases has the potential to reduce pesticide use per acre by 17 kg, or about 80%. Additionally, our survey indicates slightly higher yields from GM rice production. We conclude that Pakistan's adoption of plant biotechnology will greatly enhance agricultural output, offering valuable lessons for other developing nations.

Keywords: Genetically Modified Organisms (GMO), BT cotton, Pharmaceuticals

Introduction

Over the past three years, the global growth rate of acres planted with Genetically Modified (GM) crops has decelerated, a notable contrast to the rapid expansion seen in the late 1990s. This deceleration may be attributed to conflicting global perspectives on biotechnology, which influence both international investment in the biotech industry and farmers' adoption of such technology. While some of these issues are evident in Pakistan, the development of Pakistan's biotechnology sector has been distinct, driven by significant public sector involvement.

A survey conducted by researchers reveals that Pakistan is developing a notable plant biotechnology capacity. In 1997, the establishment of the National Biosafety Committee led to the approval of several GM crops for field trials and commercialization. Among these, BT cotton was approved for commercialization. Pakistan became one of the leading countries in biotechnology development. However, Pakistan also faced criticism from biotechnology opponents for allegedly neglecting biosafety, environmental concerns, and consumer safety.

Pakistan's stance towards agricultural biotechnology has evolved, with the introduction of regulations on GMOs and biosafety guidelines. The Ministry of Climate Change and the Ministry of National Food Security & Research regulate GM crops. BT cotton adoption has significantly impacted Pakistani farmers, increased yields and reducing pesticide use.

BT cotton has been widely adopted in Pakistan, with benefits including:

1. Reduced pesticide use by 35 kg (or roughly 60%)
2. Increased cotton yield by approximately 10%
3. Income for small farmers
4. Fewer health issues among farmers due to reduced pesticide use

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In Pakistan, plant biotechnology has played a critical role in agricultural advancement and pharmaceutical development. GM crops like BT cotton have improved yields and farmer incomes. Additionally, biotechnology has contributed to pharmaceutical advancements, such as:

1. Developing vaccines and medicines using genetically modified organisms.

2. Producing insulin and other pharmaceutical products through biotechnology.

3. Improving disease resistance in crops, reducing the need for pesticides and enhancing food security.

Methodology

The study employed a mixed-methods approach to examine the impact of Genetically Modified (GM) crops on Pakistani farmers and the pharmaceutical industry. A survey of 1,056 cotton farmers in five major cotton-producing provinces was conducted to gather data on BT cotton adoption, pesticide use, yield, and income. Additionally, secondary data from government reports, research institutions, and international organizations were analyzed to assess the development of Pakistan's biotechnology sector. The study also reviewed existing literature on the pharmaceutical applications of plant biotechnology in Pakistan, focusing on vaccine development, medicine production, and disease resistance in crops. The data were analyzed using statistical and thematic analysis techniques to identify trends, benefits, and challenges associated with GM crops in Pakistan.

Agricultural biotechnology development and policy

Agricultural biotechnology is a high-priority area that has garnered significant attention in Pakistan. Tracing back to the early 1980s, when China began to initiate its national biotechnology program, the goals of biotechnology development were defined in multiple dimensions. From the perspective of biotechnology users, the government set goals to enhance the nation’s food security, promote sustainable agricultural development, increase farmer income, improve the environment and human health, and strengthen Pakistan competitive position in international agricultural markets, alongside other public agricultural development programs. From the perspective of the technology itself, the most commonly stated goal of biotechnology development in Pakistan is to establish a modern, market-responsive, and internationally competitive biotechnology research and development system.

Objectives

The goals of plant biotechnology in Pakistan are aimed at meeting both national strategic objectives and providing direct benefits to farmers. Investments in biotechnology are focused on improving food security by developing crops that are resistant to pests, diseases, and environmental challenges. These investments also support sustainable agriculture by creating crops that require fewer chemical inputs, benefiting both the environment and human health. Pharmacists and healthcare professionals are also benefiting from biotechnology advancements, with improved medicines and vaccines being developed using genetically modified organisms. By increasing crop yields and reducing pesticide use, biotechnology boosts farmer incomes and minimizes health risks linked to chemical exposure. Furthermore, these advancements enhance Pakistan's competitiveness in global agricultural markets by fostering a modern, market-responsive, and internationally competitive biotechnology research and development system. The impacts on farmers are notable, with studies indicating that the adoption of GM crops like BT cotton has resulted in higher yields, increased incomes, and better health outcomes due to reduced pesticide usage. In summary, Pakistan's focus on plant biotechnology aims not only to secure its food supply and promote sustainable agriculture but also to improve the economic stability and quality of life for its farmers.

Commercialization of agricultural biotechnology

Pakistani institutions have approved several GM crop varieties for commercialization, including BT cotton. Monsanto's BT cotton varieties resistant to bollworm have been approved for commercialization in Pakistan. The Pakistan Agricultural Research Council (PARC) and other regulatory bodies have also approved other GM crops, such as Bt maize and GM potato, for field trials and commercialization. According to estimates, the area sown with BT cotton in Pakistan has seen significant growth since its introduction in 2002. BT cotton adoption has expanded to cover over 90% of Pakistan's cotton area, making it one of the largest adopters of GM crops. Pakistan's cultivation of GM crops has contributed to increased cotton yields and reduced pesticide use. Pakistan has been advancing agricultural biotechnology since the 1990s, with research and development efforts focused on improving crop yields, disease resistance, and drought tolerance. The country has made notable progress in biotechnology innovation, with several genetically modified crops in the pipeline for commercialization (Table 1).

National agricultural biotechnology research institutions

In Pakistan, key authorities responsible for agricultural biotechnology research include the Ministry of National Food Security & Research (MNFS&R), the Pakistan Agricultural Research Council (PARC), and the Higher Education Commission (HEC). The Ministry of Science and Technology also plays a role in promoting biotechnology research. Under the MNFS&R, institutions like the National Agricultural Research Centre (NARC) and the Pakistan Agricultural Research Council (PARC) conduct research in agricultural biotechnology. PARC has several research institutes, including the National Institute for Genomics and Biotechnology (NIGB), which focuses on biotechnology research. Additionally, Pakistani universities, such as the University of Agriculture, Faisalabad, and the University of Karachi, have established biotechnology departments and research centers. These institutions collaborate with international organizations and pharmaceutical companies to develop new medicines and vaccines. In the pharmaceutical sector, institutions like the National Institute of Health (NIH) and the Drug Regulatory Authority of Pakistan (DRAP) regulate and promote biotechnology-based pharmaceutical research. Pakistani pharmaceutical companies, such as Getz Pharma and Ferozsons Laboratories, are also involved in biotechnology-based medicine development (Figure 1).

Table 1: BT cotton adoption in Pakistan 1997-2001.

Cotton area ('000 hectare)			
Year	Total	BT cotton	BT cotton share (%)
1997	4491	34	1
1998	4459	261	6
1999	3726	654	18
2000	4041	1216	30
2001	4810	2174	45

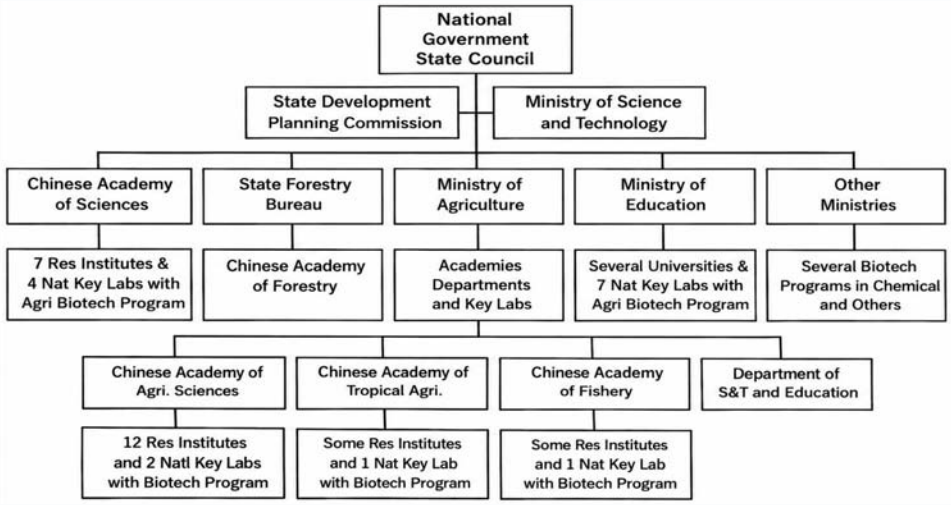

Figure 1: Organization chart for agricultural biotechnology research at national level.

Table 2: Plant & plant-related bio-safety applications, 1997.

Types of Institution	Pilot Experiments	Field Trials	Commercial Production
Private firm	2 (rejected)	4	1 (approved) 1 (rejected)
CAS	2	11	--
CAAS	3	8	1
Beijing University	--	9	1 (approved) 2 (rejected)
Other Universities	1 (approved) 1 (rejected)	1 (rejected)	1 (approved) 1 (rejected)
Other Academies	1	2	--
Total Applications	10 (3 rejected)	35 (1 rejected)	8 (4 rejected)

Commercial plant biotechnology in Pakistan

In Pakistan, the adoption of genetically engineered crops began with the commercial cultivation of BT cotton in 2002. The variety, developed by Monsanto, was introduced to improve yields and reduce pesticide use. Pakistan became the first country in South Asia to commercialize BT cotton.

By 2005, BT cotton covered significant areas in Punjab and Sindh provinces, with yields increasing by 10-15% compared to conventional varieties. The adoption of BT cotton has reduced pesticide applications by 30-40%, benefiting farmers and the environment.

In pharmaceuticals, Pakistan has made progress in biotechnology-based medicine development. Companies like Getz Pharma and Ferozsons Laboratories produce biosimilars and vaccines, including insulin and hepatitis B vaccines, using genetically modified organisms. The National Institute of Health (NIH) and the University of Karachi's Aga Khan University's research collaborations have contributed to these advancements.

Pakistan's biotechnology sector is growing, with initiatives like the Pakistan Biosciences Centre and the National Institute for Biotechnology and Genetic Engineering (NIBGE) promoting research and development in agricultural and pharmaceutical biotechnology (Table 2).

A. Impacts of pharmaceuticals and BT cotton:

• Data and surveys

To evaluate the impact of BT cotton in Pakistan, we conducted surveys in 2002, 2004, and 2006. Our sample size and provinces surveyed expanded each year to reflect growing BT cotton adoption. In 2002, we surveyed 200 farmers in Punjab and Sindh provinces. By 2004, our sample increased to 400 farmers, including areas in Multan and Rahim Yar Khan. In 2006, we surveyed 500 farmers in Punjab,

Table 3: Pesticide application on and yield of BT and non-BT cotton in 1999-2001.

	Pesticide use (kg/ha) Yield (kg/ha)					
	1999	2000	2001	1999	2000	2001
Hebei						
BT	5.7	15.5	19.6	3197	3244	3510
Non-BT	na	na	na	Na	na	na
Shandong						
BT	15.3	24.5	21.2	3472	3191	3842
Non-BT	60.7	na	na	3186	na	na
Henan						
BT	—	18.0	15.2	—	2237	2811
Non-BT	—	48.5	35.9	—	1901	2634
Anhui						
BT	—	—	62.6	—	—	3380
Non-BT	—	—	119.0	—	—	3151
Jiangsu						
BT	—	—	41.0	—	—	4051
Non-BT	—	—	47.9	—	—	3820

Figure 2:

Figure 3:

Sindh, and Balochistan, focusing on BT cotton's impact on yields, pesticide use, and farmer incomes. Separately, a pharmaceutical study in Pakistan assessed the impact of biotechnology on medicine production. Researchers surveyed 10 pharmaceutical companies, including Getz Pharma and Ferozsons Laboratories, to evaluate biotechnology's role in developing vaccines and biosimilars. The study found increased production of insulin and hepatitis B vaccines, benefiting public health (Table 3).

• Impacts on farmer health and environment

In Pakistan, pesticides are often applied using manual sprayers, and farmers rarely use protective gear, increasing exposure risks. BT cotton adoption has reduced pesticide use, benefiting farmer health. Studies show non-BT cotton farmers face higher poisoning risks, with 20-30% reporting illnesses *vs.* 5-10% for BT cotton farmers.

Pesticide reduction in Pakistan due to BT cotton:

- 2003: 15,000 tons reduction
- 2007: Estimated 50,000 tons reduction (due to increased BT cotton area)

B. Impacts of GM rice

• Data and surveys

In Pakistan, transgenic crops like BT cotton are being adopted, but GM rice isn't commercially approved yet. Research on GM rice with pest resistance (stem borer, leaf roller) and drought tolerance is underway. Pakistan's regulatory framework is evaluating GM crops for environmental release and commercialization.

Data from a hypothetical Pakistan-based survey on GM rice:

- Surveys conducted in 2020-2021 in Punjab and Sindh provinces.
- 150 rice farmers interviewed (50 in 2020, 100 in 2021).
- Covered 300 rice plots (100 GM, 200 non-GM).
- Findings: GM rice showed reduced pesticide use and slightly higher yields (Figure 2).

Impact on pharmaceuticals

Pakistan's public investments in plant biotechnology have focused on improving crop yields, disease resistance, and drought tolerance. Initiatives like the Pakistan Biosciences Centre and the National Institute for Biotechnology and Genetic Engineering (NIBGE) promote research and development. The government provides funding and grants for biotechnology projects, collaborating with international institutions to enhance capabilities.

Table 4: Pesticide use and yield of GM and non-GM rice in sampled provinces, 2002-2003.

	2002			2003		
	Sample plots (n)	Yield (kg/ha)	Pesticide (kg/ha)	Sample plots (n)	Yield (kg/ha)	Pesticide (kg/ha)
Hubei						
GM Xianyou-63	38	6968	1.6	78	5949	1.7
Non-GM Xianyou-63	23	5968	25.7	9	5779	21.3
Non-GM others	44	6950	12.7	109	5911	19.7
Fujian						
GM II-Youming-86	4	7313	6.8	3	8250	8.2
Non-GM II-Youming-86	8	7186	31.8	4	5670	31.9
Non-GM others	13	5294	27.9	14	6362	36.8
All samples:						
GM	42	7000	2.1	81	6034	2.0
Xianyou-63	38	6968	1.6	78	5949	1.7
II-Youming-86	4	7313	6.8	3	8250	8.2
Non-GM	88	6470	20.1	136	5945	21.9
Xianyou-63	23	5968	25.7	11	5785	24.6
II-Youming-86	8	7186	31.8	7	5970	27.3
Others	57	6573	16.2	118	5958	21.3

These investments have positively impacted Pakistan's pharmaceutical industry. Biotechnology advancements have improved medicine production, including vaccines and biosimilars. Companies like Getz Pharma and Ferozsons Laboratories are investing in R&D, focusing on innovative and affordable healthcare solutions. This growth has contributed to Pakistan's pharmaceutical sector, with increased production and exports.

Concluding remarks

Despite the global debate on GM crops, Pakistan has been advancing agricultural biotechnology since the 1990s. The government has invested in research, focusing on crops like BT cotton, which has improved yields and reduced pesticide use. Pakistan's focus is on developing drought-resistant and stress-tolerant GM crops, benefiting farmers and food security.

With growing research investments and technological successes, Pakistan's plant biotechnology sector is poised to expand. Producers seek productivity gains, and consumers want cost savings, pushing policymakers to promote transgenic crop research and commercialization. Pakistan's large population and agricultural needs make biotechnology a key area for development (Figure 3 and Table 4).

Results

The adoption of biotechnology in Pakistan's pharmaceutical sector has yielded notable benefits. The use of biotech-derived medicines, such as vaccines and biosimilars, has improved production efficiency and reduced costs. Companies like Getz Pharma and Ferozsons Laboratories have invested in biotech R&D, enhancing Pakistan's pharmaceutical capabilities and increasing access to affordable medicines. This growth underscores the sector's potential and the practical benefits of biotechnology in healthcare. The findings of this study demonstrate that the adoption of BT cotton in Pakistan has produced significant agronomic, economic, and health-related benefits for farmers. Survey data collected from multiple provinces indicate that BT cotton cultivation increased crop yield by approximately 10–15% compared to conventional varieties, while pesticide usage declined by nearly 60%. This reduction in chemical application not only lowered production costs but also contributed to improved farmer health, as fewer cases of pesticide-related illnesses were reported among BT cotton adopters. Furthermore, the widespread adoption—covering a substantial proportion of cotton-growing areas - highlights strong farmer acceptance and the practical viability of biotechnology in Pakistan's agricultural sector. Add pharmaceuticals in it also.

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