Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 1, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

IMPACT OF BT. COTTON PRODUCTIVITY ON FARMERS' INCOME IN SOUTHERN PUNJAB, PAKISTAN

Nasir NADEEM, Umar Ijaz AHMED, Choudary Ihtasham ALI, Sami ULLAH, Mohsin RAZA, Muhammad Arqam IQBAL, Maryam TAHIR

MNS University of Agriculture Multan, Old Shujabad Road near Chungi No. 21, District Multan, Punjab, Pakistan, Phone: +92-061-9200224, Mobile: +92-304-4342414, E-mails: nasir.nadeem@mnsuam.edu.pk, umar.ijaz@mnsuam.edu.pk, sami.ullah@mnsuam.edu.pk, c.ihtasham@yahoo.com, mohsinji774@gmail.com, arqam.iqbal@mnsuam.edu.pk, maryamtahir286@gmail.com

Corresponding author: c.ihtasham@yahoo.com or ihtasham.ali@mnsuam.edu.pk

Abstract

The increasing adoption of Bt cotton, known for its high productivity and resistance to pests, has prompted this investigation into its impact on farmers' earnings. This study aims to explore how the productivity of Bt cotton affects farmers' income in the Khanewal and Multan districts of Southern Punjab. To gather data, we employed a stratified random sampling method, targeting small, medium, and large-scale farmers in both districts. Using regression analysis, we assessed the influence of Bt cotton productivity, along with other relevant factors, on the annual gross income of these farmers. Results revealed that per acre revenue from Bt cotton, education of farmers, livestock ownership, tractor ownership and distance from the market have significant impacts on the annual gross income of the farmers.

Key words**:** *Bt Cotton, Farmer Income, Productivity, Punjab*

INTRODUCTION

Cotton occupies about 2.5 percent of the world arable land area and is cultivated in around 80 countries in the world [34]. The role of agriculture biotechnology has been acknowledged in the reduction of hunger by increasing crop yield and higher income for farmers, especially in developing countries [3, 25]. As indicated by [4], the only substantial way that biotechnology has contributed to the well-being of the poor is through higher income from the production of genetically modified cotton because the crop has been recognized as the largest consumer of pesticides due to the wider attack of different insects. The agriculture sector is the third largest sector of Pakistan, contributing 22.7 percent share of the gross domestic product (GDP), which absorbs 37.4 percent of the total labour force [10]. The sector has observed 4.40 percent growth rate in 2021-22 against 3.48 percent in 2020-21 [10]. Cotton is an important kharif crop which is one of the main sources of raw materials for the textile industry in Pakistan. Cotton is among the major crops of Pakistan having a share of 3.1% in agriculture value addition, (5% 5 years before) and contributing 0.6% of GDP which was 1% about five years ago [10], Cotton plays a central role in rural economic development in poverty-stricken areas of the cotton belt. In Pakistan, cotton is mainly cultivated in two provinces. Punjab, being the most conducive for cotton cultivation, produces es 66% of the country's cotton followed by Sindh which contributes 33% of production [32]. Around 90% of farmers in Punjab and 82% in Sindh involved in cotton production own less than 5 hectares of the land thus has severe effects on the livelihood of this major chunk of the population [18].

Since the early 1990s cotton production in Pakistan, has been facing the challenge of large-scale pest infestation contributing to unexpected fluctuations in cotton yield and significant economic losses. A wide range of pesticides has been introduced to control various cotton pests during the last 15 years, which has notably increased the cost of cotton

production. Moreover, as the pests developed resistance to these chemicals, their effectiveness declined over time [11]. Therefore, there was a need to reduce this increasing cost of production especially under the scenario of globalization. With the introduction of Bt cotton in Pakistan, its use increased continuously. By 2007, nearly 60 percent of the cotton area was under BT varieties in Pakistan [20, 21]. Currently, numerous developed and developing countries worldwide cultivate Bt cotton across 7.2 million hectares. These countries have reported significant outcomes, including reduced pesticide and fertilizer usage, as well as decreased instances of insects and bollworms. Moreover, there has been an increase in per-acre yield [5,14].

Several empirical studies such as [5, 7, 1, 35, 20, 21, 6, 31, 8] have revealed that the adoption of Bt cotton has reduced not only pest attacks but also increased yields and profits to the farmers. In addition to these empirical studies such as [2, 5, 12, 30, 33, 20, 23, 24, 15, 28, 29] have also concluded the significant impact of Bt crop cultivation on income/poverty of rural households. BT cotton is a genetically modified strain of cotton, and it comprises a gene taken from the bacterium Bacillus thuringiensis. The gene causes the plant to produce an insecticidal protein that kills certain cotton pests [9, 1, 35]. Moreover, [21] has concluded that Bt varieties have higher gross margins than non-bt varieties, but she did not include the implicit cost while calculating gross margin. In this study we have also aimed to calculate the benefit-cost ratio while including implicit cost. In this way, we shall be able to access the true benefits to the farmers they obtain from Bt cotton cultivation.

This study aims to investigate the influence of BT cotton cultivation on farmers' income within the study area. Additionally, it seeks to assess and compare the benefit-cost ratio among Bt growers in both District Multan and District Khanewal.

MATERIALS AND METHODS

The study was conducted during 2016-17. Data were collected from 158 small-scale farmers (who have land less than 12 acres), medium-scale farmers (who have more than 12 and less than 25 acres), and large-scale farmers (who have land more than 25 acres) using a stratified random sampling method.

Multan and Khanewal districts of Punjab province were selected for study purposes. The main reason for the selection of the districts was to save the expenses for data collection as these districts were approachable on a daily basis for data collection even though the districts are equally famous for Bt cotton sowing.

From each district two tehsils were selected randomly and from each tehsil 5 villages were randomly selected for data collection. Data were collected through a well-structured questionnaire.

Regression analysis was utilized to assess the influence of Bt cotton cultivation on the overall income of sampled farmers. Data analysis was conducted using Stata 11 software. In this study, the Log-log multiple regression model was employed to estimate the impact of Bt cotton sowing on farmers' income in the study area.

The log-log model that was employed in this study has the equation shown below.

$$Ltinc = \beta_0 + \beta_1 Lnr\_bt + \beta_2 Ledu + \beta_3 Lexpe + \beta_4 Lls + \beta_5 Ldfm + \beta_6 Lage + \beta_7 dtrac + \beta_8 dsoi + \beta_9 dext + \beta_{10} dtb + \beta_{11} dloan + \mu_i \quad \text{.....(1)}$$

The description of the variables is given below in Table 1. In above the log-log model β_1 , β_2 , β_3 ,…… β_{11} are the coefficients of independent variables and β_0 is the slope parameter, whereas μ_i represents the error term.

To estimate the benefit-cost ratio, we used the given below formulae in our study.

With Imputed Cost:

Benefit cost ratio (BCR) = Economic profit/TC

Without Imputed Cost

Benefit cost ratio (BCR) = Business profit/TVC

Table 1. The description of the variables

Variables	Variable Type	Measuring Units
Ltinc	Dependent	Natural log of total annual income from all sources in thousand rupees.
Lnrbt	Independent	Natural log of net revenue per acre (in thousand rupees) only from sale of Bt crop.
Ledu	Independent	Natural log of education. It is measured as number of schooling years.
Lexpe	Independent	Natural log of work experience. It is measured as number of years of farming.
Lls	Independent	Natural log of livestock holding. It is measured as a number of cows and buffalo farmers have.
Ldfm	Independent	Natural log of distance from the market. It is measured as KM.
Lage	Independent	Natural log of age in years.
dtrac	Independent	Dummy variable for tractor (farmers have tractor = 1, otherwise = 0)
dsoi	Independent	Dummy variable for the source of income (If source of income only form agriculture = 0, If farmers have multiple sources = 1).
dext	Independent	Dummy variable for agriculture extension services availability (1 if service available, 0 otherwise).
dtb	Independent	Dummy variable for tubewell ownership (1 if own tubewell, 0 otherwise).
dloan	Independent	Dummy variable for agriculture loan (1 if loan taken, 0 otherwise).

Source: Own Calculation.

RESULTS AND DISCUSSIONS

The results of the log-log multiple regression model are presented in Table 2. Results show that variable net revenue from the sale of Bt cotton has a positive and significant impact on the total income of farmers. The coefficient of the variables is estimated as 0.459 and it is highly significant. The result can be elaborated that a 1 percent increase in net revenue per acre from Bt crop will increase the total annual income of farmers by almost 0.459 percent. The results are in correspondence of the findings of [20, 21, 31, 8].

Education plays an important role in enhancing the productivity of human resources. The estimated coefficient of the education variable is 0.266 which is significant at a 2 percent level of significance. It means that by increasing one percent increases in education, total income can be increased by 0.266 percent. [19, 26, 27] stated that education with experience can further increase the productivity level of human resources. In this study, the sign of variable experience is as per expectations, but coefficients were found non-significant. This may be owing to the small sample size. Livestock holding is found non-significant. However, it is significant at an 11 percent level of significance.

Existing markets and their distance from production areas play a vital role in enhancing the economic activities in adjacent areas. In our study, the variable distance from the market is found significant with a negative sign as per expectations.

Table 2. Results of the estimated model

dependent variable= Ltinc	Coefficient values	Std. Error	t-value	P-value
Const.	4.113	1.162	3.54	0.001
Lnrbt	0.459	0.208	2.21	0.028
Ledu	0.266	0.114	2.33	0.021
Lexpe	0.117	0.163	0.72	0.474
Lls	0.114	0.072	1.59	0.113
Ldfm	-0.309	0.105	-2.96	0.004
Lage	0.124	0.260	0.48	0.639
dtrac	0.927	0.158	5.88	0.000
dsoi	0.089	0.147	0.61	0.545
dext	0.048	0.135	0.35	0.724
dtb	0.140	0.155	0.90	0.370
dloan	0.008	0.144	0.06	0.953
R^2	**0.44**			
F (11, 146)	**11.38**			
Prob>F	**0.000**			
Jarque-Bera Normality Test	0.3363	**Chi^2**	0.8452	

Source: Own Calculation.

A one percent decrease in distance from the market will cause to increase in the total

annual income of farmers by 0.309 percent. A similar impact has been observed by [16].

Dummy variables are incorporated into the model when quantitative information is lacking, yet their inclusion is deemed crucial for comprehensive model representation. In this study, we included dummy variables for tractor ownership, sources of income, availability of government extension services, ownership of tubewell, and agricultural loans. The dummy variable used for the tractor is found statistically significant. It illustrates that farmers who have tractors earn more income as compared to those who have no tractors if all other factors are kept constant. This result also conforms to the result of [17]. All other dummy variables are found non-significant. It means that these variables do not create a difference between have and have not. Most of the farmers have responded that they have a single source of their income. Similarly, most small and medium farmers have reported that they do not have their tubewells. Extension services are very poor all over Pakistan. The employees of the extension department do not pay regular visits to farmers especially those who reside away from the main road.

Different diagnostic tests were employed to check the normality of error terms, model specification, and heteroscedasticity. The Jarque-Bera (JB) test was employed to assess the normality of the data distribution. Since the calculated chi-square value was found to be less than the tabulated value, we refrained from rejecting the null hypothesis (H_0: distribution of residual term is normal). To test whether the model is correctly specified (H_0: there is no specification error) the link test has been used. The results in Table 3 show that the model was correctly specified. Because the coefficient of the hat was near 1 and the t-statistics of the hat square were insignificant which indicates that the Model is correctly specified, therefore, the null hypothesis was not rejected.

The result of the white test is presented in Table 4 and the calculated value of chi-square for heteroscedasticity is estimated as 80.98. While it's tabulated value at 1 percent level of significance is 100.45. Since calculated value is smaller than tabulated value hence H_0 is not rejected. i.e., variance of error term remains the same throughout the normal distribution.

Table 3. Results of linktest for functional form

Itinc	Coefficient	Std. Error	T-value	P-value
Hat	1.52	1.54	0.99	0.323
Hatsq	-0.36	0.11	-0.34	0.733
Constant	-1.89	5.58	-0.34	0.735

Source: Own Calculation.

Table 4. Results of White test for heteroscedasticity

H_0	Homoscedasticity		
H_1	Heteroscedasticity		
chi^2(72)	80.98	Prob > chi^2	0.2195

Source: Authors' Calculation.

The benefit-cost ratio (BCR) is one of the measures to assess the profitability of any economic activity. Bt cotton technology has been adopted by the farmers due to its profitability.

The results in Table 5 reveal that BCR is highest in the case of small farmers followed by large farmers in both districts. This study negates the viewpoint of [13] who reported that this technology is more suitable for large farmers.

Nevertheless, it is crucial to highlight that the BCR surpasses one only when the imputed cost is not taken into consideration. When factoring in the imputed cost, the BCR is less than one across all categories of farmers in both districts. This observation suggests that factors are exerting a negative impact on the profitability of Bt cotton growers.

These findings stand in contrast to those reported by [22], who asserted that the BCR remains above one even when imputed costs are incorporated. Discrepancies in the results could potentially stem from variations in the province, costs of other inputs, and provincial policies.

These factors may be the low price of output, higher prices of inputs, and inadequate field management practices. The comparative analysis between districts reveals that the BCR without imputed costs is higher for small and large farmers in the Multan district,

whereas for medium farmers, it is greater in the Khanewal district. The primary contributing factors to the higher BCR in the Multan district are the lower land rent and increased yield.

Table 5. Per Acre Benefit Cost Ratio (BCR) of Bt Cotton Growers in District Multan and Khanewal.

Category of Farmers	Multan District		Khanewal District	
	BCR with imputed cost	BCR without imputed cost	BCR with imputed cost	BCR without imputed cost
Small	0.66	1.79	0.54	1.50
Medium	0.43	1.27	0.53	1.34
Large	0.89	1.69	0.52	1.38

Source: Own Calculation.

This study examines the impact of Bt cotton cultivation and other allied factors on the total income of the farmers. The explanatory variables such as net revenue per acre from Bt income, education, distance from market, and tractor ownership are found to have positive and significant impacts on the total income of the farmers. Furthermore, the estimation of the BCR demonstrates that it exceeds one when the imputed cost is excluded from the estimation process.

However, the inclusion of imputed cost in the BCR calculation results in a value less than one. This pattern holds true across all categories of farmers. When making an inter-district comparison, it is observed that the BCR without imputed cost is higher for small and large farmers in Multan district, whereas for medium farmers, it is greater in Khanewal district.

CONCLUSIONS

The proximity of farmers to the market is a pivotal factor, influencing transportation costs and facilitating easy access for selling produce at more favourable prices. The study reveals that the cultivation of Bt cotton is driven by its resistance against bollworm and pest infestation, resulting in reduced pesticide costs.

Considering these findings, several recommendations are proposed. Firstly, despite the positive impact of Bt cotton productivity on farmers' total income, the unreliability of seed quality from various suppliers poses a risk. It is recommended to ensure the provision of high-quality seeds to protect farmers from potential exploitation by seed supplying agencies. Secondly, the establishment of seed testing labs in each district can verify the quality and authenticity of Bt seeds. Thirdly, recognizing the significance of mechanization in timely field operations and increased productivity, the study underscores the positive impact of tractor ownership on total income. Therefore, it is suggested that tractors be made available to farmers at subsidized rates or through interest-free instalment plans, especially for small and medium-sized farmers.

Moreover, the study emphasizes the crucial role of education in human resource development. Education programs, such as farmer's field training, are proposed to impart effective management skills and enhance productivity. Additionally, the establishment of markets at the union council level is recommended, considering that closer proximity to markets positively correlates with higher total income for farmers. This initiative aims to facilitate year-round transactions for the purchase and sale of various agricultural products, reducing transportation costs associated with large distances from markets.

Furthermore, the analysis of the benefit-cost ratio indicates that it is less than one when imputed costs are factored in. This implies that farmers may not be in a profitable position when considering imputed costs due to high inputs and low output prices. Policies aimed at reducing input prices are strongly advocated to uplift the socio-economic conditions of farmers.

REFERENCES

[1]Abbas, M. S. T., 2018, Genetically engineered (Modified) crops (bacillus thuringiensis crops) and the world controversy on their safety, Egypt. J. Biol. Pest Control, Vol. 28(1), 1–12, doi: 10.1186/s41938-018-0051-2.

[2]Abedullah, S. Kouser, Qaim, M., 2015, Bt Cotton, Pesticide Use and Environmental Efficiency in

Pakistan, J. Agric. Econ., Vol. 6691), 66–86, doi: 10.1111/1477-9552.12072.
[3]Adenle, A.A., 2011, Global capture of crop biotechnology in developing world over a decade, J. Genet. Eng. Biotechnol., Vol. 9(2), 83–95, doi: 10.1016/j.jgeb.2011.08.003.
[4]Babar, U., Nawaz, M.A., Arshad, U., Azhar, M.T., Atif, R.M., Golokhvast, K.S., Tsatsakis, A.M., Shcerbakova, K., Chung, G., Rana. I.A., 2019, Transgenic crops for the agricultural improvement in Pakistan: a perspective of environmental stresses and the current status of genetically modified crops, GM Crop. Food, Vol. 11(1), 1–29, doi: 10.1080/21645698.2019.1680078.
[5]Bakhsh, K., 2017, Impacts of Bt cotton on profitability, productivity and farm inputs in Pakistan: Use of panel models, Environ. Dev. Econ., Vol. 22(4), 373–391, 2017, doi: 10.1017/S1355770X17000080.
[6]Bennett, R., Kambhampati, U., Morse, S., Ismael, Y., 2006, Farm-level economic performance of genetically modified cotton in Maharashtra, India, Rev. Agric. Econ., Vol. 28(1), 59–71, doi: 10.1111/j.1467-9353.2006.00273.x.
[7]Cremer, J., 2019, One billion acres of Bt crops, zero 'unintended consequences, Alliance for Science. https://allianceforscience.cornell.edu/blog/2019/02/one-billion-acres-bt-crops-zero-unintended-consequences/ Accessed on Aug. 17, 2022.
[8]Gandhi, V.P., Namboodiri, N.V., 2009, Returns and Economics of Bt Cotton vis-à-visTraditional Cotton Varieties in the State of Maharashtra in India, Ahmedabad, 232, 2009. https://www.researchgate.net/publication/269107473_What_is_governance/link/548173090cf22525dcb61443/download%0Ahttp://www.econ.upf.edu/~reynal/Civil wars_12December2010.pdf%0Ahttps://think-asia.org/handle/11540/8282%0Ahttps://www.jstor.org/stable/41857625, Accessed on August 10, 2023.
[9]Glover, D., 2010, Exploring the Resilience of Bt Cotton's 'Pro-Poor Success Story, Dev. Change, Vol. 41(6), 955–981, doi: 10.1111/j.1467-7660.2010.01667.x.
[10]Government of Pakistan, Finance Division, 2021, Pakistan Economic Survey 2021-22, Islamabad. https://www.finance.gov.pk/survey_2022.html, Accessed on Jan.. 17, 2023.
[11]Haq, Q., Ali, T., Ahmad, M., Nosheen, F., 2008, An analysis of pesticide usage by cotton growers: A case study of district Multan, Punjab-Pakistan, Pak. J. Agri. Sci., Vol. 45(1), 133–137.
[12]Hardee, D., Van Duyn, J. W., Layton, M. B., Bagwell, R. D., 2001, Bt Cotton & management of the tobacco budworm-bollworm complex, Stoneville, USDA, Agricultural Research Service, ARS-154.
[13]Hasnain, T., 2010, Status and Implications of Bt Cotton in Pakistan, Islamabad, Pakistan. https://www.academia.edu/1914651/Bt_Cotton_in_Pakistan, Accessed on August 18, 2023.
[14]James, C., 2010, ISAAA brief 42 Global status of Commercialized biotech / GM Crops : 2010, Ithaca, NY, Brie 42, http://www.isaaa.org/resources/publications/briefs/41/default.asp, Accessed on Aug. 17, 2023.
[15]Kouser, S., Spielman, D.J., Qaim, M., 2019, Transgenic cotton and farmers' health in Pakistan, PLoS One, Vol. 14(10), 1–19, doi: 10.1371/journal.pone.0222617.
[16]Liu, L., 2006, Impacts of Market Location on Rural Poverty and Income Inequality in China, Chinese Econ., Vol. 39(3), 64–78, doi: 10.2753/ces1097-1475390305.
[17]Muhammad, K.I., Muhammad, N., 2009, The tractor impact in the rural area of district peshawar, Sarhad J. Agric., Vol. 25(3), 509–516.
[18]Muhamad Navaz Shareef University of Agriculture Multan, 2017, A Case for Reducing Cotton Imports for Enhancing Cotton Production in Pakistan, Multan, Pakistan, 2017–1.
[19]Nadeem, N., Mushtaq, K., Javed, M.I., 2011, Impact of Social and Physical Infrastructure on Agricultural Productivity in Punjab, Pakistan-A Production Function Approach, Pak. J. life soc. Sci, Vol. 9(2),153–158.
[20]Nazli, H., Order, D., Sarker, R., Meilke, K.D., 2016, Bt cotton adoption and well-being of farmers in Pakistan, International Association of Agricultural Economists, 2012 Conference, August 18-24, 2012, Foz do Iguacu, Brazil, 004, doi: 10.1603/ice.2016.91759.
[21]Nazli, R. Sarker, K. Meilke, Orden, D., 2010, Economic Performance of Bt Cotton Varieties in Pakistan, Agricultural and Applied Economics Association's 2010 AAEA, CAES & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010.
[22]Noonari, S., Memon, I. N., Bhatti, M.A., Perzado, M.B., Wagan, S.A., Memon, Q., Chandio, A.A., Sethar, A.A., Kalwar, G.Y., Shah, S.T., Jamroo, A.S., 2015, Comparative Economics Analysis of the Bt. Cotton V/S Conventional Cotton Production in Khairpur District, Sindh, Pakistan, Int. J. Bus. Econ. Res., Vol. 4(3), 72–85, doi: 10.11648/j.ijber.20150403.11.
[23]Orphal, J., 2005, Comparative Analysis of the Economics of Bt and Non-Bt Cotton Production, Pesticide Policy Project Hannover, January 2005 Special Issue Publication Series, No. 8, Hannover. Germany, 08, 2005.
[24]Pitoro, R., Walker, T.S., Tschirley, D.L., Swinton, S.M., Boughton, D., de Marrule, H.F., 2009, Can Bt Technology Reduce Poverty Among African Cotton Growers? An Ex Ante Analysis of the Private and Social Profitability of Bt Cotton Seed in Mozambique. 2009 Conference, August 16-22, 2009, Beijing, China 51633, International Association of Agricultural Economists. DOI: 10.22004/ag.econ.51633
[25]Qaim, M., Virchow, D., 2000, The Role of Biotechnology for Global Food Security, Agrarwirtschaft, Vol. 49(9), 1-10.
[26]Rehaman, N. U. R., Khan, J., Tariq, M., 2012, The Impact of Education on Agricultural Production in Khyber Pakhtunkhwa Province of Pakistan (1975-2008), Sarhad J. Agric., Vol. 28(2), 345–352.

[27]Rohail, U.A. et al. 2023, Measuring technical efficiency of phalsa production in Multan, Punjab, Custos e @gronegocio line, Vol. 19(1), pp. 320–336, 2023.
[28]Subramanian, A., Qaim, M., 2009, Rural Poverty and Employment Effects of Bt Cotton in India, Proceedings of International Association of Agricultural Economists Conference, Beijing, China, August 18-22, pp. 16–22.
[29]Subramanian, A., Qaim, M., 2010, The impact of Bt Cotton on poor households in rural India, J. Dev. Stud., Vol. 46(2), 295–311, doi: 10.1080/00220380903002954.
[30]Tabashnik, E., Van Rensburg, J. B. J., Carríre, Y., 2009, Field-evolved insect resistance to Bt crops: Definition, theory, and data, J. Econ. Entomol., Vol. 102(6), 2011–2025, doi: 10.1603/029.102.0601.
[31]Thirtle, C., Beyers, L., Ismael, Y., Piesse, J., 2003, Can GM-Technologies help the poor? The impact of Bt cotton in Makhathini Flats, KwaZulu-Natal, World Dev., Vol. 31(4), 717–732, 2003, doi: 10.1016/S0305-750X(03)00004-4.
[32]USDA, Foreign Agricultural Service, 2021, Cotton and Products Annual, Islamabad, Pakistan, 2021. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Cotton%20and%20Products%20Annual_Islamabad_Pakistan_04-01-2021, Accessed on August 10, 2023.
[33]Witt, H., Patel, R., Schnurr, M., 2006, Can the Poor Help GM Crops? Technology, representation & cotton in the Makhathini flats, South Africa, Rev. Afr. Polit. Econ., Vol. 33(109), 497–513, doi: 10.1080/03056240601000945.
[34]WWF.Panda.org, 2007, Cleaner, Greener Cotton: Impacts and better management practices, pp. 1–28. https://wwf.panda.org/wwf_news/?115940/Cleaner-greener-cotton-Impacts-and-better-management-practices, Accessed on August 10, 2023.
[35]Zafar, M.M, Razzak, A., Farooq, M.A., Rehman, A., Firdous, H., Shakeel, A., Huijuan, M.O., Ren, M., 2020, Insect resistance management in *Bacillus thuringiensis* cotton by MGPS (multiple genes pyramiding and silencing), J. Cott. Res., Vol. 3(1), doi: 10.1186/s42397-020-00074-0.