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RESEARCH NOTE

Economic Viability of G.M. Crops in India: A Comparative Study between G. M. Cotton and Non-G.M. Cotton in Punjab

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ABSTRACT

Genetically modified crops brought a huge controversy in India after its introduction in the form of G.M. Cotton. Debates are continuously going on amongst the scientists, economists, social workers and other stakeholders of the society. The aim of this study is to determine the economic viability of genetically modified (G.M.) cotton and compare its cost-benefit analysis with non-G.M. cotton. It is a type of ex-post facto research. This investigation depends on both primary and secondary data and covered 200 cotton producers out of which 100 were G.M. cotton producers and 100 were non-G.M. cotton producers. A survey was conducted in summer season of June, in the different areas of Punjab like Bhatinda, Faridkot, Kotkapura, Fazilka, Muktasar relatingto the agricultural year 2016. The analysis of the survey demonstrated that G.M. cotton provide higher yield and more profit. This study is very useful for policymakers to prepare the most favourable policy for different stakeholders of G.M. crop.

Keywords: Genetically modified (GM) crops, Punjab, Yield, Benefit, Pesticide, Cotton.

JEL: O33, Q10, Q14.

I

INTRODUCTION

In 2016, India held and fortified the position of the fifth largest cultivator of G.M. crop in the world with the area of 10.8 mha; the USA covered 72.9 mha, followed by Brazil (49.1 mha), Argentina (23.8 mha) and Canada (11.6 mha). India faced a minor reduction (7 per cent) in G.M. cotton planting resulting in a little decrease in the aggregate cotton zone (8 per cent) in the different states of India (ISAAA, 2016). The acceptance rate, however, increased from 95 per cent to 96 per cent and approximately 7.2 million farmers benefitted from this technology in India. India is the main cotton-cultivating nation in the world with cotton production of 35 million bales in a year (ISAAA, 2016). Regardless of adoption of genetically modified crops in India, discussions about their advantages and disadvantages are continuously going on. On one hand, it is firmly favoured by the group of researchers who trust that it can possibly create enough harvests without undermining the biodiversity and assume an essential part in increasing the yield and diminishing the utilisation of dangerous pesticides. (Naboniel and Katerere, 2004) on the other side, critics assert that GM products are a danger to the economic growth of farming.

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This paper attempts to determine the economic viability of G.M. crops by comparing cost-benefit analysis among GM and non-G.M. cotton farms. Cotton is the main cash crop in *kharif* season in the area of south-western regions of the Punjab State. In *kharif* season, 2015 a tremendous harm was caused by the whitefly. To resuscitate cotton during 2016, an activity design was set up by the Department of Agriculture (DoA) with the coordinated effort of Punjab Agricultural University, Ludhiana (PAU). Thus, the state got a huge increase in the crop with an average yield of 756 kg (Table 1) for each hectare (Kalsi, 2017).

TABLE 1. AREA, PRODUCTION, YIELD, AND MSP OF COTTON IN INDIA

Year (1)	Area (000' ha) (2)	Average yield (kg lint per ha. /ha) (3)	Production (lakh bales) (4)	MSP (Rs/qtl.) (5)
2012-13	481	575	16.27	3600
2013-14	446	570	14.95	3700
2014-15	420	543	13.42	3750
2015-16	339	197	3.93	4000
2016-17	257	756	11.43	4060
2017-18 (Targeted)	400	650	15.29	--

Source :(http://agripb.gov.in/home.php?page=cotto). AGRIPB (2007).

II

REVIEW OF LITERATURE

Various investigations examine the economic viability of GM crops in the world. Carpenter, in 2010, analysed 168 previous investigations on the Genetically Modified crop and found that a total 124 of the investigations observed yield increments, thirty-two studies found that no change, and just thirteen studies revealing the lower amount of yields. Finger *et al*. in 2011, in 203 peer-reviewed studies, analysed that productivity increments with GM crop adoption, however, he noticed that these increments were because of diminished weed and insect population and not because of real transgenic crop yield increments. Subramanian and Qaim (2010) investigated that adoption of Bt cotton in India leads to increase in household incomes by 134 per cent. Choudhary and Gaur (2010) demonstrated that G.M. cotton producer's profit thrice than non-G.M. cotton producers in the region of Guntur district and eight times higher in the region of Warangal district in Andhra Pradesh. Andhra Pradesh Government carried out the investigation to inspect the cost of development and net revenue to G.M. cotton when contrasted with other cotton hybrids in selected regions. The investigation affirmed that the non-G.M. cotton farmers had a 46 per cent more production and used 55 per cent lower use of pesticides than the non-G.M. cotton producers in the area of Guntur. In Warangal region, G.M. cotton farmers used 16 per cent lower pesticides and procured 47 per cent higher cotton production when compared with non-G.M. cotton producers. Producers noticed that G.M. cotton permitted prior picking because of low pest attack. He also observed that the quality of G.M. cotton thread was superior to the non G.M. cotton thread. Ali and Abdulai (2010), used propensity score-matching approach to deal with immediate impacts of G.M. cotton on production, insecticide need, family income and poverty, utilising cross-sectional information in Pakistan. The discoveries uncover that selection of G.M. crops have a positive effect on cotton productivity, family income and a decrease in poverty and pesticides. This decrease in utilisation of insecticide leads to rise in income, decrease poverty and positively affects the financial status of the farmers.

A study of 500 producers led by the Center for Chinese Agricultural Policy in two different cotton-developing locales in 2004, 2006, and 2007 reported that the average productivity of Bt cotton crop was 500 kilograms/ha more than another type of cotton production (Pray *et al*., 2011). Stone, Glenn Davis (2011) conducted a longitudinal study on cotton production in Warangal District of Andhra Pradesh, India. The investigators compared a group of respondents before and after the adoption of Bt cotton. In the duration of 5 years, yields increased by 18 per cent overall, and pesticide use decreased by 55 per cent.

Brookes and Barfoot in 2012, on the worldwide investigation of advantages produced by G.M. crops, evaluated that India garnered profit cumulatively from G.M. cotton by US$ 9.4 billion in the time period between 2002 to 2010 and US$2.5 billion in 2010 . Profit was roughly 31 per cent, a noteworthy 39 per cent decrease in the quantity of pesticide spray, 88 per cent growth in profit that is equal to a significant rise of around US$250 per hectare. According to him, G.M. cotton has changed cotton productivity in India by yield increase, diminishing pesticide in the year 2011. Vitale *et al*. (2014), discovered that Bt. cotton acceptance in Burkina Faso brought a benefit of $150/ha in comparison to $70/ha for regular cotton. Kathage and Qaim (2012), surveyed about 1,655 farmers and observed that Bt cotton improved yield/hectare by 24 per cent, and Bt cotton producers made 50 per cent higher profit on their cotton crops in contrast with non-Bt farmers. Stone (2012) concluded that a group of investigators and writers have created a description of technological success for Bt. cotton in India, based on an experimental record of better performance compared to non-Bt cotton seed. Luttrell and Jackson (2012) probed on the U.S. cotton produce failure due to the pest in 2000– 2007. They assessed that the average level of yield failure due to pest was brought down for GM cotton in comparison to non-GM cotton, however, no difference in productivity amongst Bt and non-Bt cotton was observed. Gruere and Sun in 2012 undertook a team investigation of productivity factors in nine Indian cotton-delivering regions between 1975 to 2009. The outcomes demonstrate that GM cotton share is 19 per cent in aggregate yield. The yield increment and insect resistance properties are significantly dependent upon the cultivar into which the Bt. is planted instead of the trait, that is exclusively dangerous to different types of pests (Stone and Flachs, 2015; Herring and Rao, 2012). Cotton production requires a high amount of water and it does not perform well in rainfed conditions. Herring noticed that in case of sufficient availability of water, transgenic crops yield were superior in comparison to non-transgenic crops (Herring and Rao, 2012).

Rao (2013) in his investigation of Bt cotton yields and performance presumed that Bt cotton has had measurably noteworthy positive yield impacts. Herring, (2013) inferred that Bt cotton represents neither a silver bullet nor a suicide seed, but a surprisingly significant innovation. The meta-investigation led by Areal *et al*. (2013) discovered that on an average Bt cotton yield was 0.30 tonne/hectare more than non-Bt cotton. In Madhya Pradesh, Forster *et al*. in 2013 looked at cotton generation for more than two production seasons (2007–2008 and 2009–2010) in four cultivating frameworks: Bt cotton, non-Bt cotton, biodynamic and organic crop. In the 2007–2008 season, the framework with Bt had 16 per cent more productivity than the non-Bt framework; in the period of 2009–2010. The framework with Bt cotton has 13.6-per cent more yield. An examination by Qaim and Kouser (2013) on 1,431 families in India, from 2002 to 2008 discovered that the acceptance of GM cotton has increased the income of the family. The innovation decreased food uncertainty by 15-20 per cent among cotton-growing family.

The examination was directed by Klumper and Qaim in 2014, who performed an investigation of 147 investigations on the effects of GM crops, concluded that pesticide utilisation decreased by 37 per cent, crop productivity improved by 22 per cent, farmers profit improved by 68 per cent. A meta-examination of 17 pieces of research performed in China with information from1999 to 2005 revealed that GM cotton found an 18.4 per cent improvement in yield (480 kg/ha) in comparison to non- GM cotton (Witjaksono *et al*., 2014). Fernandez-Cornejo *et al*. (2014) looked into 3 trials and 6 surveys of GM cotton generation in the United States distributed in the year 1997 to 2007. A more noteworthy yield of GM than non-GM cotton hybrid was accounted in reviews.

Romeu-Dalmau *et al*. (2015) analysed Bt cotton G. hirsutum L. with non-GM cotton G. arboretum. The researchers interviewed 36 producers who worked less than 5 ha of land. The analysis of the study revealed that in a dry environment in Maharashtra, India, productivity for Bt G. hirsutum was not found high, in comparison to non-GM cotton G. arboretum. Abedullah *et al*. (2015) revealed a productivity benefit of 26 per cent for producers of GM cotton. Kerns *et al*. (2015) assessed the productivity of non-Bt hybrid and Bt hybrid of the cotton plot in Arkansas, Louisiana, Mississippi, and Tennessee. They found that Bt variety had a yield increase in the range of 9 per cent to 52 per cent

Brookes and Barfoot in 2016, analysed the monetary benefits of GM crops and according to his investigation, the worldwide monetary advantages of GM crops surpassed US$17 billion. In total, over the period from 1996 to 2014, the monetary advantages of GM crops have achieved US$150 billion. Khuda Bakhsh (2017) in his examination evaluates the advantages from using Bt cotton in Punjab, Pakistan more than two seasons between 2008 and 2009. This investigation utilises the panel modelling methodology to deal with the effect of GM cotton innovation on benefits, yields and inputs of the farm. The investigation demonstrates that Bt cotton farmers get 9 per cent more yields/ha, decrease use of pesticide by 21.7 per cent, and utilization of water increased by 6 per cent. Some African countries like Kenya is at cutting edge phases of field trials of Bt cotton, and in September 2016, affirmed national level trials of Bollgard II to keep running for a few years (FoEA and ACB, 2017). Cameroon, where field trials are continuing and it has changed its bio-safety rules to speed up the commercialisation of Bt cotton. Field investigations have started in Ethiopia while Zambia is unwinding their bio-safety laws in an arrangement for Bt cotton investigation (FoEA and ACB, 2017). Likewise, in Ghana, the Council for Scientific and Industrial Research (CSIR) suspended trials after Monsanto pulled back its funds (Ibrahim, 2017).

III

RESEARCH METHODOLOGY

3.1 *Objectives of the Study*

The study aims (i) to analyse the economic viability of genetically modified crops, (ii) to analyse the difference in the farm practices between GM crop and conventional crop farmers and (iii) to determine the factors affecting the adoption of GM cotton in India.

3.2 *Study Area*

The study covered five towns of Punjab state, in India. The survey covers 100 G.M. cotton farmers and 100 non G.M. cotton farmers. A quota sampling was used to select the sample. In quota of 200 respondents, 100 Bt cotton farmers and its nearby 100 non-Bt cotton farmers were selected to avoid the biases due to the fertility of soil, availability of water, weather condition and availability of other inputs in farming. Direct personal interview method was used to collect data from farmers, by a structured questionnaire. Descriptive statistics and t-test used to compare the significant difference between the group of GM cotton farmers and non-GM cotton farmers, at 5 per cent level of significance. Logistic regression model was used to determine the relationship between various inputs used in farming. Table 2 describe the sampling plan of data collection.

TABLE 2. SAMPLING PLAN

S.No. (1)	Area covered (2)	GM cotton (3)	Non-GM cotton (4)
1	Bhatinda	20	20
2	Faridkot	20	20
3	Kotkapura	20	20
4	Fazilka	20	20
5	Muktasar	20	20
	Total	100	100

Source: Field survey data.

Table 3 indicates a normal size of land amongst GM and regular cotton growers does not vary altogether, so the chance of biases in deciding the financial circumstance of GM and non-G.M. cotton farming because of contrast in size of land is very less. The normal size of the family of non-G.M. cotton producers is more than G.M. cotton producers, but not significantly different.

TABLE 3. DESCRIPTIVE STATISTICS OF GM AND NON-G.M. COTTON FARMERS

Particulars (1)	G.M. cotton farmers (2)	Non-G.M. cotton farmers (3)	t-test (P value) (4)	Remarks (5)
Number of respondents	100	100	-	-
Female	3	9	-	-
Male	97	91	-	-
Average family size	5.29	4.91	0.186	Since (p > 0.05). So average family sizes do not differ significantly.
Average respondent's age	45.50	42.11	0.319	Since (p > 0.05) i.e. So the average land size is not differing significantly.
The average size of land in (acre)	6.37	5.29	0.09	Since (p > 0.05).So average age of respondents is not differing significantly.

Source: Data collected from field survey, t-test at 5 per cent level of significance.

There are many variable costs involved in farming, i.e., fertiliser cost, seed cost, farm yard manure cost, pesticide cost, labour cost. This is the basic composition of cost of cultivation. In the present study, cotton is taken because it is the only GM crop which is commercially approved for cultivation in India. To compare the cost-benefit analysis between GM and conventional crop production, cost patterns of both GM and the conventional crop has been taking into consideration. In the present study difference in the quantity of inputs used by both types of farming techniques is observed and the difference in cost is also taken into consideration. There is a different factor that influences farmers to adopt GM or conventional cotton. These factors may be their personal characteristics, input use pattern or price of input and output quantity of yield, age, family size, land size. With the help of logistic regression analysis, the most important factor in the adoption of GM cotton will be determined. Economic Threshold Level (ETL) strategy was utilised to quantify pest infestation. Economic Threshold Level (ETL) is the pest density at which control measures ought to be applied to keep growing pest populace from achieving the financial damage level.

IV

COST-BENEFIT ANALYSES (CBA)

The growth of any crop relies upon different variables like climatic conditions, variety of the crop, its pest pervasion and production practices. A good-performing

GM or non-G.M. cotton crop in any region may not give a similar outcome in all regions or area, so mean growth of G.M. cotton and natural cotton is evaluated in a similar territory and climatic condition in a similar time period. Field of G.M. cotton and its close-by non-G.M. cotton field had been selected to diminish the contrast between climate conditions like an irrigation system, nature of soil and insects attack to minimise any biases from these factors. To evaluate the financial feasibility of G.M. crops, following hypothesis are formed.

V

HYPOTHESES

•H_{1o}: There is no significant difference between the cost of G.M. cotton and regular cotton production.

•H_{1a}: There is a significant difference between the cost of G.M. cotton and regular cotton production.

•H_{2o}: There is no significant difference in profit between G.M. cotton and regular cotton production.

•H_{2a}: There is a significant difference in profit between G.M. cotton and regular cotton production.

To understand the difference in farm practices between and G.M. cotton and non-G.M. cotton farming, data was gathered and assembled in following Table 4. This table analyses the normal cost of input, production, return and benefit.

TABLE 4. COST-BENEFIT ANALYSIS OF COTTON LINT

(*Rs./acre*)

Particulars (1)	GM Cotton (100 farmers) (2)	Non-G.M. cotton (100 farmers) (3)	t-test (P value) (4)	Remarks (5)
Average seed cost	1931	943	0.001	Difference is significant
The average cost of fertiliser and micronutrient;	2419	1437	0.002	Difference is significant
The average cost of farm yard manure	1729	1337	0.000	Difference is significant
Pesticide's cost	3007	4984	0.000	Difference is significant
Cost of irrigation	1800	829	0.003	Difference is significant
Wages of labour	5095	4101	0.007	Difference is significant
Charges of transportation	2000	1700	-	-
Other*	500	500	-	-
Total cost	18481	15831	0.019	Difference is significant
Total cotton lint yield (kg/acre)	490	385	0.002	Difference is significant
Price per Kg	55	50	-	-
Total revenue	26950	15831	0.004	Difference is significant
Profit (Rs./acre)	8469	3419	0.009	Difference is significant

Source: Field survey data.

*Purchase of bamboo bucket, bags etc.

*N:P:K:- (80Kg:50Kg:50Kg)for water-scarce land and 100Kg:50Kg:50Kg for irrigated land, micronutrient; Magnesium Sulphate and zinc sulphate; **1 cartload = 63 kg superphosphate and 65 Kg urea.;***combination of pesticides. (for jassids, for WF and for Fungicides); ****labour for sowing, weeding, harvesting, spraying, ploughing, preparation of land and collection of cotton balls.

VI

RESULTS AND DISCUSSION

Traditional cotton producers utilise 695.27 gm seed/acre, which is 14.92 per cent more than normal amount of seeds utilised by G.M. cotton producers of 605 gm/acre. In any case, cost of production for G.M. cotton seed is considerably on the higher side of Rs. 1931 for every acre in contrast with Rs. 943.21 of non-G.M. cottonseed/acre (Table 4). This cost of G.M. cotton seed was 104.72 per cent more than non-G.M. cottonseed/ acre.

G.M. cotton needs a high amount of fertiliser. Producers use on a normal 103.7 kg fertiliser for each acre of land which is roughly two-fold in contrast with traditional cotton farmers of 54.45 Kg. G.M. cotton farmers spent a normal of Rs. 2419 for per acre of land on chemical fertiliser that is 68.33 per cent more than normal consumption of Rs. 1437/acre of land on traditional cotton cultivators.

With chemical fertiliser, G.M. cotton producers utilise more farmyard manure than normal cotton farmers. A normal 4.27 cartload per acre of land was utilised as a part of G.M. cotton cultivates in contrast with 3.01 cartload acre of land of non-G.M. cotton farms. The costs on FYM were Rs. 1729 for G.M. cotton 29.31 per cent more than the use of normal cartload of Rs. 1337/acre.

The bollworm pesticide use for G.M. cotton was significantly lower when compared with traditional cotton. The main motive for the use of G.M. cotton in this area is its pest resistance properties. On comparing the amount of pesticides utilised as a part of G.M. cotton cultivate was found to be 1.92 liter/acre. It was 55.14 per cent less than 4.28 liter of chemical pesticide/per acre. Normal use of a pesticide for G.M. cotton was Rs. 3007/acre of land. It was 39.66 per cent lower than normal consumption of pesticide on regular cotton of Rs. 4984.

G.M. cotton needs more water during peak production season around September. Otherwise, cotton balls start shrinking. G.M. cotton producers depleted Rs. 1800 on water, which was higher than two-fold of mean measure of Rs. 829 on water system of customary cotton.

Cotton generation is exceedingly work escalated, labour is utilised as a part of preparation of land, sowing of seed, showering of insecticide and collection of cotton buds. Labour wages for G.M. cotton was Rs. 5095 which was Rs. 994 more than by normal cotton producers of Rs. 4101. This increase in cost is because of high production that increases picking cost. The labour utilised was 37.29 man-days/acre of land in normal cotton and 42.83 man-days/acre of land for G.M. cotton.

Transport charges from the field to market rely upon fare and type of vehicle and distance from a warehouse. An average transportation charge of Rs.2000 was taken for GM cotton due to high production and Rs. 1700 was taken for non-GM cotton. Costs like buying of a container of Bamboo or other minor costs were taken as Rs. 500/acre for every group.

The final rate of production for G.M. cotton crop was 18481 Rs./acre. It was 114.84 per cent more than the non-G.M. cotton cost of production of Rs. 15831.61 per acre. The purpose of this high cost was the utilisation of costly seeds, more quantity of fertiliser, more irrigation cost and high requirement of labour.

Normal production of G.M. cotton was 490 kg/acre 27.27 per cent higher than 385 kg/ acre of non-G.M. cotton yield.

Since selling price of G.M. cotton crop is higher than normal cotton crop so the aggregate income received by G.M. cotton was Rs. 26950/acre that was 70.23 per cent more than revenue of Rs .15831/acre of non-G.M. cotton producers. Profit earned by G.M. cotton was 8469 Rs./acre 156.471 per cent more than traditional cotton farmer's benefit of Rs. 3419. Statistical test rejects null hypothesis H_0. This demonstrates there is a significant difference in cost and profit at 5 per cent significance level. The results demonstrate that G.M. cotton gives more yield and higher profit in contrast with non-G.M. cotton.

VII

LOGISTIC REGRESSION MODEL

A logistic regression model has been used to investigate the behaviour of cotton farmers (Adeogun *et al*., 2008)**.** In this research, the farmers were assembled as users and non-users of Bt. cotton. The logistic regression model for this investigation is given below:

$$\text{logit}(p) = \log(p/(1-p)) = \beta_0 + \beta_1 * x1 + \ldots + \beta_k * xk$$

where; logit (p) = (1 for users and 0 for non-users); β_k are the coefficient of the predictor variables.

The logistic regression analysis tries to determine the association between the adoption of Bt cotton with the age of producers, education level, size of family, size of operational holding, availability of capital, initial seed cost, availability of information and innovativeness (Table 5).

TABLE 5. DESCRIPTIVE STATISTICS OF VARIABLES USED IN LOGISTICS REGRESSION ANALYSIS

Variables (1)	Description (2)	Mean value (3)	Standard deviation (4)
Age (X_1)	Measured in years	43.805	6.912
Education (X_2)	Illiterate-0, primary-1, secondary-2, graduation-3	2.143	0.783
Family size (X_3)	In numbers	5.1	2.19
Operation holding(X_4)	Measured in acre	5.83	1.29
Availability of capital (X_5)	Own capital-2 and borrowed capital-1	1.73	0.32
Initial seed cost (X_6)	Rs./acre	1437	237.65
Availability of information (X_7)	Pluralistic source-2, otherwise-1	1.232	0.284
Innovativeness(willingness to use new technology) (X_8)	Five-point Likert scale	3.127	1.72

Chi-square value tests the hypothesis that the overall model is statistically significant or not. The omnibus test of model coefficient shows that the model is statistically significant because p-value corresponding to model is less than 0.05 (Table 6).

TABLE 6. THE OMNIBUS TEST OF MODEL COEFFICIENT

		Chi-square	Sig.
(1)		(2)	(3)
Step	Step	127.21	0.000
	Block	127.21	0.000
	Model	127.21	0.000

In Table 7, -2Log likelihood indicates how well the model fits the data. Cox &Snell R Square value as 0.753 is generally interpreted that "the independent variable in the logit regression model take together account for 75.3 per cent of the explanation for why farmers use Bt cotton or not.

TABLE 7. MODEL SUMMARY

Step	-2 Log likelihood	Cox & Snell R Square
(1)	(2)	(3)
1	78.16	0.753

The results of logistic regression analysis are provided in Table 8. The analysis shows the coefficients (B), the Wald value, standard errors, Significance p-values and odds ratio (Exp (B).

TABLE 8. RESULTS OF LOGISTIC REGRESSION ANALYSIS

Variables	B	Standard error	Wald	Significance P-value	Exp (B)
(1)	(2)	(3)	(4)	(5)	(6)
Constant	- 11.209	2.319	23.3632	0.00	0.00
Age	0.132	0.026	25.77515	0.019	1.1411
Education	0.217	0.315	0.474568	0.03	1.2423
Family size	0.318	0.111	8.207451	0.468	1.3743
Operation holding	0.619	0.124	24.91942	0.002	1.857
Availability of capital	1.318	0.497	7.032634	0.020	3.735
Initial seed cost	- 1.431	0.398	12.92746	0.021	0.2390
Availability of information	0.569	0.245	5.393769	0.033	1.7665
Innovativeness	0.792	0.356	4.949375	0.048	2.179

Level of significance: ($P< 0.05$).

Table 8 explained that the age of the farmers had a significant positive coefficient, that demonstrate that the probability of adoption is expected to increase with age. Bt cotton in the study is largely adopted by the aged farmers in contrast with young producers. Education was found a significant positive influence on adoption decision of Bt cotton producers. The possibility of acceptance of Bt cotton was likely to increase along with the increase in education. Size of the family is not a significant factor in the adoption of Bt cotton, however, a positive coefficient shows that the large family size is more likely to use Bt cotton. The study demonstrates a significant positive impact of the size of operation holding with the adoption of Bt cotton. Bt cotton is probably adopted by those farmers which have the large operational landholding in contrast to small farmers. Price of Bt cotton seed has a reverse association with its adoption. Seed cost of Bt cotton is approximately thrice in comparison to non-Bt cotton. This high cost discourages the farmers to adopt Bt cotton seed. Non-Bt cotton users are either not willing to purchase or unable to purchase expensive Bt cotton seed.

Availability of proper information about the new types of varieties and benefits of Bt cotton has a significant positive association on the adoption of this crop. Innovativeness (willingness to use new technology) also has a significant positive association on the adoption of Bt cotton.

The main important benefit from G.M. cotton is its insect resistance characteristic. Producers experienced low pesticide usage in G.M. cotton. Use of insecticide is altogether less in G.M. cotton. Utilisation of chemical fertiliser in G.M. cotton rise, however, it specifically connected with more production, since more production requires more utilisation of chemical fertiliser and high utilisation of chemical fertiliser require more irrigation. That prompts high use of water in G.M. cotton farming. Demand and price of G.M. cotton rely upon different factors that change with the passage of time. In any case, change is approximately same for both GM and non-G.M. cotton. The main demerit observed by the producers is expensive seed cost of G.M. cotton which is on a higher side than traditional cotton. However, the average benefit for G.M. cotton was more than non-G.M. cotton. This is summarising the positive and negative aspect of investigation on G.M. cotton.

VIII

CONCLUSION

The results of the examination demonstrated that G.M. cotton is more beneficial than traditional cotton because of high return and low utilisation of costly pesticides. Most important property of G.M. cotton product is its pest resistance characteristic. The cost-benefit analysis of GM and customary cotton indicate G.M. cotton is more profitable than non-G.M. cotton. Alongside these positive effects, a few negative complaints identified by the farmers with G.M. crops. G.M. cotton needs an increased supply of water. Production cost for G.M. cotton is more than traditional cotton because of expensive seed cost, more utilisation of water and irrigation that imposed an additional monetary load on producers. The study revealed that Bt cotton is more profitable than non-Bt cotton. Logistic regression analysis shows a significant positive relationship with age, level of education, size of operation holding and availability of capital, availability of information and innovativeness.

IX

MANAGERIAL IMPLEMENTATION

The investigations attempted in this study give some imperative managerial implementation.

- Government should subsidies the cost of GM seeds to support the farmers to receive G.M. cotton seeds. This is relied upon to be more helpful to Indian farmers.
- There is a strong requirement for G.M. crop researchers to make specific information accessible to the overall population, policymakers, and political activists in a simple dialect. So that negative perception of the public about the innovation could be diminished.
- Some dishonest sellers offering fake/illegal G.M. cotton seeds since regulations in the market are insufficient to protect the farmers from contaminated seeds and pesticides. So the administrative framework ought to be sufficiently strict. The farmers should also evade such illegal varieties.

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