

## DETERMINANTS OF ADOPTION OF IMPROVED COTTON VARIETIES AND THEIR IMPACT ON YIELD AND INCOME IN INDIA

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**This study examined the adoption of improved cotton varieties among farmers in India. Its objectives were to examine the determinants of the adoption of improved cotton varieties and the impact of adoption on yield and income. Data for the study were obtained from the NSSO 77th round with a sample size of 588 farmers who were cultivating only cotton. The factors determining the adoption of improved varieties were obtained using the Logit model. The impact was assessed by employing the Regression Adjustment treatment effect model on STATA. The findings revealed that the level of adoption of improved cotton varieties was very high (90.57%) which is driven by a host of socio-economic factors. The results of the logit regression analysis showed that the farm size, access to irrigation, membership of farmer organizations, and Kisan credit card had a significant positive impact while the social group (SC&ST) had a negative influence on the adoption of improved cotton varieties and was statistically significant. The findings showed that the improved cotton varieties have higher yields (578 kg/ha) compared to local varieties (428 kg/ha). The impact on the yield and income was significant at a 1 percent level of significance. The adopters' yield was 578 kg/ha (34.91 percent) higher than non-adopters i.e., 428 kg/ha. The adopter earned Rs 29995 /ha (37.54 %) more gross income compared to the non-adopter i.e., Rs 21807/ha. In conclusion, the study highlights the importance of improved cotton varieties in enhancing farm productivity, generating income, and providing employment opportunities for farmers in India. To promote their adoption, addressing socio-economic disparities, fostering farmer-producer organizations (FPOs), enhancing credit accessibility, and promoting irrigation facilities are recommended.**

### Introduction

Cotton is one of the most important cash crops, accounting for approximately one-fourth of

worldwide fiber production. India also boasts the distinction of possessing the world's largest cotton-growing area, at approximately 13 million hectares. Cotton is a vital crop for India's long-term economic viability and the livelihood of the country's cotton farmers. Cotton yarn is produced and exported in enormous quantities in India. The textile sector in India generates approximately 5% of the country's GDP, 14% of industrial production, and 11% of total export revenues. After agriculture, the industry employs approximately 51 million people directly and indirectly employs 68 million people, including un-skilled women, making it the country's second-largest employer. By 2021, the textile sector is anticipated to be worth \$223 billion (Cotton Industry and Exports, IBEF, 2021).

Cotton continues to be the pre-eminent and most preferred fiber among Indian textile mills as the primary raw material for the industry. Cotton production, marketing, processing and exports provide a living for approximately 60 million people worldwide (Chockalingam, 2015). India occupies first place in the world in terms of acreage under cotton and second largest producer of cotton (FAOSTAT, 2021). All four types of cultivated cotton, *Gossypium arboreum* and herbaceum (Asiatic cotton), *G. barbadense* (Egyptian cotton), and *G. hirsutum* (American upland cotton), are grown in India. *Gossypium hirsutum* accounts for 88% of hybrid cotton in India and *G. hirsutum* is the source of all contemporary Bt cotton hybrids (Ministry of Textiles, GoI, 2017). India is also the only country in the world that commercially farms four cultivated cotton species, as well as their intra and interspecific hybrids (P. Singh and Kairon, 2001). Currently, the majority of the country's cotton is produced in eleven major cotton-growing states, which are divided into three zones: the northern zone (Punjab, Haryana, and Rajasthan),

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central zone (Orissa, Madhya Pradesh, Maharashtra, and Gujarat), and Southern zone (Andhra Pradesh, Telangana, Karnataka and Tamil Nadu) (Chockalingam, 2015).

Globally, cotton was harvested in 32.87 million hectares in 2021. Out of all countries India has emerged as the largest cotton cultivator in the world, where the country alone accounted for approximately 40% of world cotton acreage and 24% of world cotton production in 2021. India is the second largest consumer of cotton after China and uses 76% of its production. India is the third largest exporter of cotton after the USA & Brazil.

Bt cotton introduction has amplified cotton yield and there has been a marked improvement in the quality of Indian cotton over the years. Significant progress has been made in increasing the yield and production since the government of India launched the Cotton Technology Mission in February 2000 through the development of high-yielding varieties, appropriate technology transfer, improved farm management practices, and increased area under cultivation of Bt cotton

hybrids, among other things. All these initiatives resulted in enormous cotton production of good quality since the introduction of Bt cotton (National Cotton scenario, CCI, 2022). However, the yield per hectare, which had been stable for many years at approximately 300 kg/ha, surged to 566 kg in 2017-18 and reached its maximum level of 566 kg/ha. Although the country's per-hectare output remains below the world average of 762 kg per hectare, technological breakthroughs in cotton cultivation in the country have the potential to bring the country's present productivity closer to the world average in the near future (National cotton scenario, 2022). Among the major cotton-producing countries, India had a lower yield rate per hectare, i.e., 464 kg per hectare in 2019-20.

Adoption of improved cotton varieties depends upon many factors that include Age, Household size, Education, Gender, Farm size, Kisan credit card, social groups, Awareness about MSP, Access to irrigation, Crop insurance, Membership in farmer organization, Crop loss experienced, etc. and resultantly yield and income of the farmers affects.

**Table 1: Countrywide Area, Production, and Productivity of Cotton during 2021-22**

Particular	Area		Production		Productivity
	(Million ha)	(%)	(Million tons)	(%)	Tons/ha
India	<b>13.18</b>	<b>(39.86)</b>	17.83	(23.34)	1.35
USA	4.02	(12.17)	11.08	(14.51)	2.75
China	3.24	(9.80)	<b>19.59</b>	<b>(25.65)</b>	<b>6.04</b>
Pakistan	2.17	(6.58)	4.01	(5.25)	1.84
Brazil	1.54	(4.66)	6.55	(8.58)	4.25
Uzbekistan	1.04	(3.15)	3.04	(3.98)	2.92
Turkmenistan	0.59	(1.81)	1.16	(1.52)	1.96
Turkey	0.42	(1.27)	2.07	(2.71)	4.92
Greece	0.28	(0.85)	0.93	(1.22)	3.32
Australia	0.21	(0.65)	0.88	(1.16)	4.19
Others	6.18	(18.80)	6.59	(8.93)	-
<b>World</b>	<b>32.87</b>	<b>73.73</b>	<b>2.30</b>		

**Source: FAOSTAT, 2023**

## MATERIALS AND METHODS

The present study is based on information collected from published sources. Data on cotton crops was obtained from the NSSO 77th round with a sample size of 588 farmers who were cultivating only cotton.

### 1. Factors Determining the adoption of improved cotton varieties

To identify and analyze the factors that governed the farmer's decision to adopt improved varieties, the logit model analysis was carried out. The influence of various socioeconomic factors on the willingness of decision-makers to adopt new technologies has been investigated by several studies (Shakya and Flinn, 1985; Thomas et al., 1990; Satyasai et al., 1997; Kiresur et al., 1999 and Nayak and Kiresur, 2001). In most of the studies on adoption behaviour, the dependent variable is constrained to lie between 0 and 1 and the models used are exponential functions (Kebede et al., 1990). The univariate logit model and its forms have been used extensively to study the adoption behaviour of farmers. It is generally recommended to use a probit model for functional forms with limited dependent variables that are continuous between 0 and 1 and a logit model for discrete dependent variables. Thus, the univariate logit model, as specified below, was estimated using the maximum likelihood method.

### Logistic regression

The logit model was employed using STATA to identify the factors determining the adoption of improved cotton varieties with dummy variable 1 for adopter and 0 for non-adopter. The logit model was fit as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_{12} X_{12} + \mu$$

Where:

Y = Adoption of improved cotton varieties (1 = adopter, 0 = non-adopter)

$X_1$  = Age (years)

$X_2$  = Gender (Male=1, Female=0)

$X_3$  = Education (1=literate, 0=non-literate)

$X_4$  = Household size (Number)

$X_5$  = Farm size (ha)

$X_6$  = Kisan credit card (Yes=1, No=0)

$X_7$  = Social group (SC&ST = 1 Others = 0)

$X_8$  = Awareness about MSP (yes =1, No = 0)

$X_9$  = Access to irrigation (Yes=1, No=0)

$X_{10}$  = Crop insurance (Yes=1, No=0)

$X_{11}$  = Membership in farmer organization (Yes=1, No=0)

$X_{12}$  = Crop loss experienced (Yes=1, No=0)

$\beta_0$  = intercept

$\beta_1 - \beta_{12}$  = The coefficients for the respective variables in the logit function

$\mu$  = Error term

### 2. Assessing the economic impact of the adoption of improved cotton varieties on members through Regression Adjustment

Economic impact was measured in terms of yield and gross income. The hypotheses for the study were as follows.

H0: There is no significant difference in the yield of members and non-members

H0: There is no significant difference in the gross income of members and non-members

H1: There is a significant difference in the gross income of members and non-members.

### Regression Adjustment

Regression Adjustment is a treatment effect model used for impact assessment of an intervention. It takes into account the endogeneity problems. If we use simple regression such as  $Y_i = \alpha + \delta T_i + \hat{\alpha}_j X_{ij} + E_i$  (Where  $Y_i$  = dependent variable,  $X_{ij}$  = independent variables,  $T_i$  = Treatment variable,  $\alpha$  = constant, and  $E_i$  = error term), then some unobserved confounders may affect  $Y_i$  and  $T_i$ . Here,  $T_i$  is endogenous. Hence, in Regression Adjustment, the use of an endogenous treatment dummy in regression is avoided and two separate regressions are formed as follows. (NAHEP-CAAST IARI, 2020)

$$Y_i = \hat{\alpha} + \hat{\alpha}_j X_{ij} + E_i \text{ (for the treated group)}$$

$$Y_i = \hat{\alpha} + \hat{\alpha}_j X_{ij} + U_i \text{ (for the control group)}$$

Then the potential outcome means for treated and control groups are calculated using the following formula:

$(PMO)_{treated} = E(\text{Outcome} | \text{coefficient of regression on treated units})$

$(PMO)_{control} = E(\text{Outcome} | \text{coefficient of regression on control units})$

Then to assess the impact of the intervention on the treated, ATET (Average Treatment Effect on the Treated) is calculated by subtracting the value of  $(PMO)_{control}$  from  $(PMO)_{treated}$

$$ATET = (PMO)_{treated} - (PMO)_{control}$$

In the present study, the treatment variable considered was adoption. If the respondent was an adopter of improved cotton varieties, he/she was assigned the numeral 1, if non-adopter 0. Two outcome variables were considered viz. yield and gross income. Thus, two outcome equations were formed on STATA choosing appropriate explanatory variables. Finally, the ATET coefficients were calculated for each of the outcome variables to assess the impact. The description of the outcome variables and explanatory variables and their measurements are explained below.

### Outcome variables

There were three outcome variables in this study. The variables and their description are given below.

- i. Yield: It refers to the amount of cotton produced (in quintals) per hectare.
- ii. Gross Income: Income here reflects the gross income from one hectare of land.

### Explanatory variables

The following explanatory variables were considered for formulating the outcome equations for Regression Adjustment.

For this study, three outcome equations were formed. For the equations having yield and gross income as outcome variables, the explanatory variables used were education, farm size, access to irrigation, access to KCC, seed expenditure, irrigation expenditure, power consumption

expenditure, cost of chemical fertilizer, cost of bio-fertilizer, and pesticide expenditure.

## RESULTS AND DISCUSSION

The descriptive statistics reveal a diverse range of characteristics among the farmers in the study. The age of the farmers spans from 19 to 103 years, with a mean age of 49.52 years. A substantial majority of the farmers, 91.87%, were male, while only 8.13% were female. Additionally, most of the farmers belonged to the OBC & others category, accounting for 72.44%, whereas the remaining 27.56% were from the SC & ST categories. When it comes to irrigation access, only 43.27% of the farmers had this privilege, leaving the majority, 56.73%, without irrigation access. Awareness about MSP (Minimum Support Price) among the farmers was limited, with only 27.21% knowing it, while the majority, 72.79%, were unaware. Furthermore, 43.97% of the farmers reported experiencing crop losses. Household sizes varied, with an average of 4.46 members and a range from one to twenty members. The study revealed a high level of adoption of improved cotton varieties, with 90.57% of the farmers cultivating them, influenced by various socio-economic factors. In contrast, only 9.43% of the farmers were found to be cultivating local varieties. Educational backgrounds also varied, with 59.68% of the respondents having formal education, while 40.32% had no formal education at all. Farm sizes in the study ranged from 0.01 hectares to 28.35 hectares, with an average farm size of 1.38 hectares. Access to Kisan Credit Card (KCC) was limited to only 11% of the farmers, and just 1.9% had membership with any agricultural organization. Additionally, only 12.7% of the farmers reported having crop insurance. Only 10.94% of farmers had registered as a member of FPO while the majority (89.06%) of the farmers had not registered.

The results of the logit regression analysis showed that the farm size, access to irrigation, membership of farmer organizations, and Kisan credit card had a significant positive impact while the social group (SC&ST) had a negative influence on the adoption of improved cotton varieties and was statistically significant. The findings showed that the improved cotton varieties have higher yields compared to local varieties. The impact on the yield and income was significant at 1 percent

level of significance. The adopters' average yield was 577.74 Kg/Ha(34.91 percent) higher than non-adopters i.e., 428.24 Kg/Ha. The adopter earned 29994.52 Rs. /Ha (37.54 %) more gross income compared to non-adopter i.e., 21806.86 Rs. /Ha.

## CONCLUSION AND SUGGESTION

The study concluded that the level of adoption of improved cotton varieties was very high (90.57%) which is driven by a host of socio-economic factors. This study underscores the pivotal role of

**Table 2: Summary statistics of logit and regression adjustment model**

Variables	Mean/ Percentage	Std. dev.	Min	Max
Age (Years)	49.52	12.64	19	103
Gender (Male=1, Female=0)	91.87	-	0	1
Social Group (SC&ST=1 and others = 0)	27.56	-	0	1
Access to irrigation (Yes=1, No=0)	43.27	-	0	1
Awareness about MSP (Yes=1, No=0)	27.21	-	0	1
Crop loss experienced (Yes=1, No=0)	43.97	-	0	1
Household size (Numbers)	4.46	2.17	1	20
Improved varieties adopted (Yes=1, No=0)	90.57(532)	-	0	1
Education (1=literate,0-non-literate)	59.68	-	0	1
Access to KCC (Yes=1, No=0)	10.94	-	0	1
Member of farmer organization (Yes=1, No=0)	1.89	-	0	1
Farm size (ha)	1.38	1.65	0.01	28.35
PMFBY (Yes=1, No=0)	12.89	-	0	1
Power consumption (Rs/ha)	373.96	933.98	0	12550.61
Chemical fertilizer (Rs/ha)	2268.60	2968.57	0	29757.09
Bio-fertilizer expenditure (Rs/ha)	798.02	1829.45	0	24291.50
Irrigation expenditure (Rs/ha)	167.43	973.36	0	21457.49
Plant protection (Rs/ha)	1729.17	3358.68	0	40485.83

**Table 3: Determinants of adoption of improved cotton varieties using logit model**

VARIABLES	COEFFICIENT	STD. ERR.
Experienced crop loss (Yes=1, No=0)	-0.033	0.169
Awareness about MSP (Yes=1, No=0)	0.109	0.080
Farm Size (ha)	<b>0.173***</b>	0.024
Access to irrigation (Yes=1, No=0)	<b>0.300***</b>	0.073
Household Size (Numbers)	0.019	0.016
Social Group (Sc&ST = 1, Others = 0 )	<b>-0.362**</b>	0.175
Gender (Male=1, Female=0)	-0.167	0.334
Age (Years )	-0.001	0.006
Education (1=literate,0- illiterate)	0.009	0.182
Member of farmer organization (Yes=1, No=0)	<b>0.416**</b>	0.201
Crop insurance (Yes=1, No=0)	0.013	0.11 2
Kisan Credit Card (Yes=1, No=0)	<b>0.199*</b>	0.115
<b>cons</b>	1.438	0.523

**Table 4: Estimation of yield and income of adopter and non-adopter using Regression Adjustment Model**

Outcome variable	POM Adopter		POM Non-adopter	
	Coefficient	SE	Coefficient	SE
Yield (kg/ha)	577.74***	22.23	428.24***	17.74
Income (Rs. /ha)	29994.52***	1421.57	21806.86***	881.83

improved cotton varieties as a transformative input in augmenting farm productivity, income generation, and employment opportunities. While their adoption is crucial along with addressing socio-economic disparities, fostering FPOs, enhancing credit accessibility, and promoting irrigation facilities are equally indispensable.

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