ANALYSIS OF RESOURCE USE EFFICIENCIES AND RETURN TO SCALE OF MEDIUM SIZED BT COTTON FARMERS IN PUNJAB, PAKISTAN

MUHAMMAD ASHFAQ*, MUHAMMAD ABID**, KHUDA BAKHSH*** and NIGHAT FATIMA****

* *Department of Agricultural Economics, University of Agriculture, Faisalabad – Pakistan.*
** *International Water Management Institute (IWMI), Lahore – Pakistan.*
*** *Department of Environmental & Resource Economics, University of Agriculture, Faisalabad – Pakistan.*
**** *Centre of Agricultural Biochemistry and Biotechnology, University of Agriculture, Faisalabad – Pakistan.*
E-mail: abiduaf@gmail.com

ABSTRACT

This Study attempts to examine the resource use efficiency and return to scale of the medium sized Bt cotton farmers in the Punjab province of Pakistan. A sample of 150 farmers was selected through multistage sampling technique from Rahim Yar Khan, Multan and Mianwali districts for cotton season 2009. Bt cotton farmers were categorized on the basis of land holding into small, medium and large farmers. Cobb Douglas production function approach was used to measure the resource use efficiencies by calculating and comparing Marginal Value Products (MVPs) and Marginal Factor Costs (MFCs). Results depicted that ratio of MVP to MFC for fertilizer and numbers of spray were greater than 1 i.e. 1.06 and 3.19 showing under-utilization of these resources. While the ratios for irrigation water and labour i.e. 0.05 and 0.67 were less than 1 indicating over utilization of these resources. While the elasticity of production (E_p) for medium sized Bt cotton farmers was found to be 0.77 showing decreasing returns to scale. Adjustments are required in the use of resources for Bt cotton production by medium sized farmers to increase the profitability of their cotton crop. A clear cut government agricultural policy is needed to improve the profitability of the crops by providing access to information regarding best management practices,

Key Words: **Bt cotton, Medium Bt cotton farmers, Resource use efficiency, Returns to scale**

Citation: Ashfaq, M., M. Abid, K. Bakhsh and N. Fatima. 2012. Analysis of resource use efficiencies and return to scale of medium sized bt cotton farmers in Punjab, Pakistan. Sarhad J. Agric. 28(3):493-498

INTRODUCTION

Pakistan is the fourth largest producer of cotton followed by China, USA and India (Abid *et al.,* 2011). Cotton is second largest grown crop in Pakistan in terms of area after wheat crop (SMEDA, 2010). Around 3 million hectares area of the country is under cotton crop which accounts for 15 % of the total cropped area (Cororaton *et al.,* 2008). Cotton accounts for 6.9 % of the value added in agriculture and about 1.4 % to GDP (GoP, 2011).

The cotton crop has a unique position in economy of Pakistan with its contribution to foreign exchange reserves and provision of livelihood to poor people. Cotton and its made-ups contribute 65 % of the foreign exchange earned from merchandise goods (Cororaton *et al.,* 2008). It also supply feed for livestock and dairy farming. Cotton picking which is highly labor-intensive activity, is an important source of employment for rural women, providing supplementary income to rural farm and non-farm households. In the year 2010-11, cotton crop was grown on an area of 2689 thousand hectares, 13.4% less than preceding year area which was 3106 thousand hectares. While the production is estimated at 11.5 million bales, 11.3% less than the previous year production of 12.9 million bales. Reason behind the reduction in area and production of cotton are loss in area under cotton cultivation due to floods, extensive sucking pest/insect and Cotton Leaf Curl Virus (CLCV) attack in cotton areas, excessive rain and scarcity of irrigation water due to canal closure during flood caused shedding of fruit in early growth period of cotton crop in certain areas. On the other hand one interesting thing was increase in the productivity of cotton which was 725 $kgha^{-1}$, 2.5% more than previous year yield of 707 $kgha^{-1}$ (GoP, 2011).

Currently cotton crop is facing a number of constraints e.g. high prices of agriculture inputs i.e. seeds, fertilizers, pesticides etc; higher intensity of insects and pests attack; shortage of good quality, high-yielding, insect and pests resistant varieties of seeds; deficiency of irrigation water; lack of awareness about good agricultural practices; and adulterations in inputs. Other than these factors natural factors also affect the cotton crop. The yield remains still low as compared to world average world cotton yield due to unavailability of proper crop management measures, access to extension services, uncertain weather conditions and shortage of farm inputs at required time.

All of this have added unbearable burden on cotton growers. Additionally, there is no proper crop insurance system in the country. The absence of a proper cotton crop insurance system or any support system in the shape of subsidies by the government is resulting in frustration and lack of motivation in cotton growers to spend resource in

their fields in order to improve cotton yields. Though the situation has been changed now due to the introduction of Genetically Modified (GM) cotton verities like Bt cotton. Bt cotton is one of the miracles of the genetic engineering. Earlier, cotton farmers had only chemical pesticides to resist against the pests, especially to bollworms. Bt cotton have an in-built pest control mechanism created in the cotton plant to fight against the bollworm pest. In 1990 the first Bt protected cotton crop was tested in fields in USA. Now it is one of the most extensively used transgenic crops being adopted by many developed and developing countries. It is currently grown throughout the United States, China, India, Australia, Mexico, Argentina, South Africa and Colombia on commercial basis (Qaim and Zilberman, 2003).

Cotton area under Bt cotton in Punjab has been increased rapidly from 60% in 2008 to 75% in 2010. While in Sindh almost 80% of cotton area is under Bt cotton in 2010 (PWCR, 2010). Of all these almost 40% cotton area is occupied by genotypes Bt-121 in both provinces (Rao, 2008). One of the most important reasons behind the cultivation of unapproved and not recommended varieties in Pakistan is the slow process of development and adoption of Bt cotton at government level than other countries. Few verities with genetically modified (GM) technology, were introduced during 2005-06 season by different research institutes But these verities were failed to give better results in term of adoption and resistant to pest. There is great demand for enhanced genetically modified verities to improve per acre yield (Rao, 2009). However recently Government of Pakistan has approved some Bt varieties And also negotiating with Monsanto, China and India for importing pure Bt seed.

On the other hand still the cotton production can be increased by making sound macro and micro-economic farm policies are. Mostly the farmers are unaware and uneducated about the good agricultural practices and effective use of farm inputs. There is need to make aware farmers about efficient and optimal use of all farm resources This study therefore examined the resource use efficiency pattern, returns to scale in Bt cotton production on medium scale farms, to report evidence related to resource use and farm productivity.

MATERIALS AND METHODS

Sampling Technique and Data Description

Data was collected for cotton season year 2009 with multi-stage sampling technique. Punjab province was selected as study area in first stage, in the second stage Punjab was divided into three zones i.e. high production zone (Zone I), medium production zone (zone II) and low production zone (zone III), on the basis of contribution to overall cotton production in the province. Then District Rahim Yar Khan (13.9% to total cotton production) from Zone-I, District Multan (6.4%) from Zone-II and District Mianwali (0.8%) from Zone-III were selected randomly as sample districts (Abid *et al.,* 2011). In third stage 150 farmers were divided into small, medium and large Bt cotton farmers. Small farmers were farmers having land holding below 12.5 hectares, medium sized farmers having land holding between 12.5 hectares and 25 hectares while the large farmers were the farmers having land holding above 25 hectares. Well structured questionnaire was used for personal interviews from sampled farmers. Questionnaire was also checked and modified after pretesting in the field.

Descriptive and Econometric Analysis

Both descriptive and quantitative analyses were used in the study. The descriptive statistical analysis was used to analyze the socio demographic characteristics of Bt cotton households and the farming system in the study area. Quantitative analytical tool in form of unrestricted Cobb-Douglas production function was used to determine the extent to which the inputs used explained the variability of Bt cotton output. The Cobb – Douglas production function was selected after the evaluation of four different function forms through the economic, econometric and statistical criteria including plausible signs and magnitudes of the coefficients and standard errors; the magnitude of R^2; t-statistics and F-statistics (Umoh and Yusuf, 1997). Various studies i.e. Khan and Robert, 1979; Othman, 1985; Gani and Omonona, 2009; Ogundari, 2008; Okon and Enete, 2009; Ogundari and Ojo, 2006 and Oladeebo and Ambe-Lamidi, 2007 used Cobb Douglas production function to measure resource use efficiency.

The Cobb Douglas production function used in the present study was represented in equation

$Y = AX_i^{bi}$………………………………………………………………………………………(1)

Where "i" ranges from 1 to 6

The linearised Cobb-Douglas production function was expressed below.

$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + \ln e$.....(3) Where,

ln = Natural logarithm
a = constant
Y = Cotton output (Kg)
X_1 = Farm experience (years)
X_2 = Area under Bt cotton
X_3 = Fertilizer quantity (kg)
X_4 = Spray numbers
X_5 = Irrigation (acre inch)
X_6 = Labour cost
e = error term

The resource use efficiency of Bt cotton farms was obtained from the estimated equation by comparing the Marginal Value Product (MVP) of a particular input with the Marginal Factor Cost (MFC) of that input. The following ratio i.e. r = MVP/MFC, was used to estimate the resource use efficiency. Where:

MVP = value added to Bt cotton output due to the use of an additional unit of farm resource, calculated by multiplying the MPP by the out put price of Bt cotton i.e. $MPP_{Xi} \bullet Py$

MFC = cost of one unit of a particular farm resource.
Decision rule for resource use efficiency was
If r = 1; it shows the resource is efficiently used
If r is <1; resource is being over utilized
If r > 1; resource is being underutilized

When r> 1 or r <1, adjustments could be therefore, be made in the quantity of inputs used and costs in the production process to restore r = 1.

Elasticity of production (EP) is the determination of response of output to changes in the variable input. Based on the Cobb Douglas production function, the elasticity of various inputs was determined by this formula given below.

EP = dy/dxi * X^ /Y^

Where Y is the Bt cotton output

X's are the various input used in production X^ and Y^ are the averages of input and output respectively.

In the Cobb-Douglas production function, regression coefficients are still the elasticities and used to measure the rate of return to scale.

Criteria for return to scale is
ΣE_P =1: constant return to scale
ΣE_P <1: decreasing return to scale
ΣE_P >1: increasing return to scale

RESULTS AND DISCUSSION

The summary statistics of the medium Bt farmers household in Punjab is showed in Table I. Analysis showed that average family size of medium Bt cotton farmers in the study area was 8.04. Besides, an average age of medium Bt cotton farmers was found to be about 43.68 years with 21.4 years of experience in cotton production. Average education of the of medium Bt farmers wad found to be 8.2 years. Average farm size of of the medium Bt cotton farmers was found to be 18.18 acres.

Table I *Summary statistics of medium sized Bt cotton farmers in Punjab*

Indicator	Average	Standard deviation
Family size	8.04	4.30
Age (years)	43.68	10.03
Farming experience (years)	15.82	10.13
Education (years)	8.2	3.84
Farm size (acres)	18.18	3.98

The estimated form of the unrestricted Cobb-Douglas production function for medium Bt farmers is given in Table II. The R^2 for medium sized Bt farmers was found to be 0.72. Thus this explained that 72 % of the variations in the Bt cotton output in the study area was explained by the explanatory variables included in the model.

Table II *Estimated Cobb Douglas production function for medium Bt cotton farmers in Punjab*

Variables	Coefficients	t-statistics	Sig. value
(Constant)	6.18	10.44	0.00**
Ln Farm Experience (X_1)	0.045	1.49	0.14^{NS}
Ln Area under Bt(X_2)	0.25	1.59	0.11*
Ln Fertilizer quantity Kg(X_3)	0.14	2.79	0.01**
Ln Spray Number(X_4)	0.21	3.12	0.00**
Ln irrigation acre inch(X_5)	0.001	0.01	0.99^{NS}
Ln Labour cost (X_6)	0.13	2.29	0.03**

R-Square = 0.72; F-value = 18.76; * significant at P ≤ 12; **significant at P ≤ 10 %; ** significant at P ≤ 1 %; NS = non significant

Generally, experienced farmers are able to obtain more outputs than their counterparts. Coefficient for the farming experience for medium Bt cotton farmers carried positive sign and significant at 14% significance level. This implies that 1% increase in the farming experience will lead to 0.045% increase in the cotton output (Kg). Same positive impact of farming experience on productivity was found by Abid *et al.* (2011a) for cotton crop. Coefficient for area under Bt cotton for medium Bt cotton farmers is positive and significant at 11% level of significance. With 1 % increase in area under Bt cotton, there will be 0.25% increase in Bt cotton output.

Results of the study indicated that fertilizer quantity was significantly affecting Bt cotton output in the study area at 1% significance level. According to the results Bt cotton out put will increase by 0.13% with 1% increase in fertilizer quantity for medium Bt farmers. Same positive and significant impact of fertilizer was found by Abid *et al.* (2011a, 2011b) for cotton crop. Pesticide spray is another important factor for the enhancement of crop productivity by protecting crop form various types of pests. Although Bt cotton has resistance to chewing pests but still it is unable to control sucking pests, even in Pakistan currently growing Bt is not so much effective because of its quality or pureness. In the current study coefficient for number of sprays for medium Bt cotton farmers was positive and significant at less than 1% significance level, which implies that 1% increase in spray numbers will lead to 0.21% increase in cotton output while keeping other variables constant.

Coefficient for irrigation for medium Bt cotton farmers was positive but highly non significant for medium Bt cotton farmers. This may be due to the heavy rains in the cotton growing season in 2009. Labour is very important factor in the cotton cultivation at its different stages. Here the coefficient of labour for medium Bt cotton farmers was positive and highly significant at less than 1% level of significance. This implies that with 1% increase in labour cost, Bt cotton output will increase by 0.13%. Same positive and significant results were found by Abid *et al*. (2011a, 2011b) for cotton productivity.

Table III showed the resource use efficiency ratios for medium Bt cotton farmers. Almost all the ratios were more than unity expects labour cost for which ratio was less than unity. All the ratios above unity implies the under utilization of the farm resources. According to the results, the MVP/MFC ratio for fertilizer resource used for Bt cotton crop was found 1.06 i.e. more than unity which implies that medium Bt farmers were under utilizing the fertilizer resource. A little adjustment is required by medium Bt cotton farmers to increase out put and profit by increasing fertilizer use for Bt cotton crop. The ratio of MVP to MFC of pesticide resource for medium Bt farmers was found 3.19 i.e. greater than unity. Hence Bt cotton farmers has opportunity to increase their profit by using more of spray on Bt cotton crop by equating MVP/MFC equal to unity. This also have an indication that farmers reduced spray use in Bt cultivation with the assumption that Bt will resist against pests. This may be a truth in other world but doubtful for Pakistani farmers because of originality and confirmation of Bt seed being use by them. The analysis of production function gave non-significant value to the amount of irrigation water applied, but the efficiency ratio of 0.05 indicated that this resource is being over utilized by farmers and there is need to limit the use

of irrigation water by the medium size farmers. Labour is another very important resource in cotton production. The resource use efficiency for labour showed the price response of the farmers because model used cost value of labour to calculate coefficient and MPP followed by MVP. The cost for labour already been included in MVP hence MFC will take value 1 (Suresh and Reddy, 2006). According to the study, MVP/MFC ratio for medium Bt cotton farmers was 0.67 indicating over utilization of budget on labour. Medium Bt cotton farmers should limit the budget on labour or its use in Bt cotton production.

Table III ***Resource use efficiency analysis of medium sized Bt cotton farmers***

Resources	MVP = MPP* Py	MFC	r= MVP/MFC
Fertilizer(kg)	32	29.73	1.06
Spray (numbers)	26482	8302	3.19
Irrigation (acre inch)	57	1211	0.05
Labour cost (Rs)	0.67	1	0.67

Elasticity of production (E_p) was found to be 0.77 for medium Bt cotton farms showing a decreasing returns to scale. This implies that if inputs are increased by 100 % then there will be less than 100 % increase in output of medium Bt farmers.

CONCLUSION AND RECOMMENDATIONS

This study has examined the efficiency of resource-use and return-to-scale among medium sized Bt cotton farms in Punjab. The results indicated that Bt cotton production has an decreasing return to- scale. In addition, most of the production inputs i.e. fertilizer, spray, irrigation were being under-utilized except labor which was being over utilized. Opportunities still exists to increase Bt cotton output by increasing the level of area, fertilizer, spray, irrigation and decreasing the use of labour in cotton production. Based on the findings from this study, it is recommended that Bt cotton production should be based on the technique that will utilize all of farm inputs in effective and efficient manner. This needs effective agricultural policies regarding the provision of farm inputs at subsidized and at time with proper extension services to the farmers. Government should play its role by accelerating its federal and provincial agricultural departments.

REFERENCES

Abid, M., M. Ashfaq, S. Hassan and N. Fatima. 2011a. A resource use efficiency analysis of small Bt cotton farmers in Punjab, Pakistan. Pak. J. Agric. Sci. 48 (1) 2011.

Abid, M., M. Ashfaq, I. Khalid and U. Ishaq. 2011b. An economic evaluation of impact of soil quality on Bt *(Bacillus thuringiensis)* cotton productivity. Soil & Envir. 30(1): 78-81, 2011.

Adesina, A.A. and K.K. Djato. 1997. Relative efficiency of women as farm managers. profit function approach in Cote D Voire. J. Agric. Econ. 16: 47-53.

Addison, K. 2007. Bt cotton can kill farm animals, Andhra Govt. Available at http://www.mail-archive.com/sustainablelorgbiofuel@sustainablelists.org/msg70314.html (Accessed on 11-09-2010).

Bravo-Ureta, B.E. and L. Rieger. 1991. Dairy farm efficiency measurement using stochastic frontier and neoclassic duality. Amer. J. Agric. Econ. 73: 421-428.

Govt. of Pakistan. 2011. Economic survey of Pakistan. Econ. Advisor's Wing, Finance Div. Islamabad.

Khan, M.J. and R.A. Young. 1979. Farm resource productivities, allocative efficiencies and development policy in the Indus Basin, Pakistan. Land Econ. 55(3): 388-396.

Othman, M.S.B.H. 1985. Production and input use efficiency in the sawmilling industry of peninsular Malaysia. Pertanika. 8(2): 203-214.

Ogundari, K. 2008. Resource- productivity, allocative efficiency and determinants of technical efficiency of rainfed rice farmers: a guide for food security policy in Nigeria. J. Sustainable Dev. in Agric. & Envir. 3(2): 20-33.

Okon, U.E. and A.A. Enete1. 2009. Resource use efficiency among urban vegetable farmers in Akwa Ibom state, Nigeria. Tropicultura. 27(4): 211-217.

Ogundari, K. and S.O. Ojo. 2006. An examination of technical, economic and allocative efficiency of small farms: the case study of cassava farmers in Osun state of Nigeria. J. Central Europ. Agric. 7(3): 423-432.

Oladeebo, J.O. and A.I. Ambe-Lamidi. 2007. Profitability, input elasticities and economic efficiency of poultry production among youth farmers in Osun State, Nigeria. Int'l. J. Poult. Sci. 6(12): 994-998.

Qaim, M. and D. Zilberman. 2003. Yield effects of genetically modified crops in developing countries. Sci. 299: 900-902.

PCWR. 2011. Pakistan cotton weekly report. Available online at; http://globecotnews.com/system/files/20100326pcwr.pdf [Accessed at 01-06-2011]

Rao, A.I. 2009. First Bt cotton grown in Pakistan. Foundation for Biotechnol. Awareness & Educ. http://fbae.org/2009/FBAE/website/important publications first_bt_cotton_grown_in_pakistan.html (Accessed on 20-11-2010)

SMEDA. 2010. Cluster profile cotton ginning cluster Rahim Yar Khan. http://www.smeda.org/downloads/Cluster_Profile_Cotton-Ginning.pdf (Accessed at 11-10-10)

Suresh, A. and T.R.K. Reddy. 2006. Resource-use efficiency of paddy cultivation in Peechi command area of Thrissur District of Kerala: An economic analysis. Agric. Econ. Res. Rev. 19: 159-171

Umoh, G.S. and S.A. Yusuf. 1997. An empirical analysis of the poverty status and productivity of rural farmers in Obubra Cross River State, Nigeria. Niger. J. Econ. & Soc. Stud. 41: 259 -274.