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Impact of Better Management Practices (BMPS) on Sustainability of Cotton Production in Punjab, Pakistan

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ABSTRACT

In Pakistan, cotton production has widespread social and environmental impacts. This study aimed to look at the locus of the Better Management Practices (BMPs), which are a set of sustainable agricultural practices followed in cotton production to make it more secure, sustainable, and environment friendly. An important cotton-wheat zone of Punjab, Pakistan was focused for the study purpose. Primary data was collected from two cotton producing districts of selected zone, i.e., Bahawalpur and Sahiwal. Three categories of the farmers were considered for the study. First, the adopters of BMPs, second, non-adopters of BMPs (these both groups were from the same area) and third non-adopters of BMPs, outside the BMPs practiced area. The later one served as control group. Simple random technique was used for data collection. Study results revealed that education level and land holding size of the respondents have positive impact on the adoption rate of the BMPs, while the age and farming experience of the farmers were found to have negative impact on their adoption rate. Education level of the respondents, nutrients fertilizer application, irrigation, water scouting, FYM application and HYV cotton varieties were contributing positively. Similarly, the coefficients of variables like age, and pesticide application could have negative impact. Goodness of fit test ensured that the econometric model explained the major part of variation in the dependent variable due to explanatory variables. In the light of investigated results it can be suggested that up-gradation, expansion of the initiative and collaborative efforts of extension departments with farming communities should be encouraged for sustainable future of cotton crop within the study area.
KEY WORDS: Cotton, BMPs, Punjab, FYM, HYV adopter

I. INTRODUCTION

Cotton being a cash crop is produced in more than 100 countries. It is cropped over 31 million hectares or 2.4 percent of world arable land. It is cropped both in tropical and subtropical regions. Pakistan is the fourth main cotton producer, similarly the third largest consumer of the cotton and its products globally. Its economy is substantially reliant on cotton and textile sector. Cotton being the most important cash crop accounts for 5.1 percent of the value added and almost 1 percent of the total GDP [1]. Cotton production engages about 20 million farmers relying completely on cotton production and about 30 million farmers have cotton into their rotation scheme. The application of insecticides, in cotton production represents 25 percent of the global application. In case of developing countries, 50 percent of the pesticides are applied in cotton production [2].

In Pakistan, fertilizers have a major share in the total cost of production of any crop. If a balanced combination of fertilizer is applied as per the nutrients required by the soil, then there has been a significant increase (about 30-50 percent) in the yield in different crop production and in different zones of country. Extensive use of farm inputs (resources) in agriculture is of great concern to environment, nowadays. It contributes substantially to the pollution as non-point pollution source. This kind of the pollution is contaminating the water bodies, day by day. Mechanization, on the other hand is driven at the expense of the fuel consumption, which adds several impurities in shape of different gasses to the environment. Agriculture and environment have a bilateral relation. When the fresh water bodies are polluted, human beings dependent on these water source may suffer serious health hazards. Depletion of fresh water resources is itself a big hazard to agriculture. If the similar water source is wasted in same manner, a day would come when there will be no water for agriculture at all [3].

Agrochemicals used in the cotton production, play a significant role in meeting the demand of escalating population of cotton, fiber and tobacco. These pesticides disperse in the atmosphere, and affect the unprotected agricultural

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workers. The major routes by which pesticides can be absorbed by human body are skin, lungs and gut. Skin is the major place for accidental exposure. The respiratory tracts also serve as well host for fumes, particle, and droplets. Benefits provided by pesticides are also entailed with a lot of risks and problems. The hazards of pesticides are further convoluted by presence of impurities and inter-ingredient like, solvents, wetting agents and emulsifiers. These chemicals have structural similarity with toxicants, so they are very injurious to living things, particularly to human health. Rough estimates given by international business companies showed that approximately 80-90 percent of pesticides are used onto cotton crop, and the rest 10-20 percent was frenzied on other crops and vegetables [4]. Fertilizers consumption per acre in Pakistan has also considerably increased as compare to the previous year's [5].

Social concerns, associated with cotton production are widespread across the globe. These impacts are comprised of human health, working condition, child labor, and biodiversity. Pesticides use also affects the wildlife and domestic animals. Human health, being a case of the biodiversity is also being suffered from contamination of the ground and surface water in line for the agricultural runoffs [6]. Inefficient cultural practices in cotton production have led to nutrient runoff, degradation of the fresh water resource and biodiversity. Conventionally produced cotton is a great threat causing many environmental and social complexities. The only solution to preserve our scarce resources is Sustainable agriculture practices (SAPs) and Better management practices (BMPs). These practices are aiming at minimization of environmental degradation. Switching from traditional to sustainable farming methods, better and improved agriculture practices system is viable way to control over the non-point pollution source at farm level. These new farming techniques would contribute to eradication of the starvation and extreme poverty in the rural communities [7].

Sustainable cotton production in Pakistan is surrounded by numbers of the factors. Therefore, switching from poor and conventional to SAPs will not only reduce the burden on the scarce resources but also minimize the negative social and environmental impacts created at farm level. Conventional farming methods in which there is unsystematic and injudicious application of the agro-chemicals and irrigation are not only reducing the scarce resources but also a big economic burden on the farmer's financial resources [8]. The debate of sustainable cotton production in Pakistan is currently in effect. Pakistan is one of major cotton producer and exporter. Unfortunately, cotton production in Pakistan is neither in line with global standards, nor sustainable, despite of emerging demand of the sustainably produced cotton in international markets. In recent past, efforts were made by World Wide Fund for Nature, Pakistan (WWF-P) under Pakistan Sustainable Cotton Initiative (PSCI) now with name of BMPs for cotton crop to make cotton production sustainable. The project has been amplified to meet the international standards of BMP by adopting economies of scale for farmers and by achieving sustainable improvements in social, economic and human capital available for cotton crop. Using SAPs cotton can be produced with less cost causing an uplift of the farmers' profit. Producing cotton sustainably, would lead to several long term benefits like reduction in rural poverty followed by sustainability of mankind, natural resource and preservation of the biodiversity [9].

Present study aimed to examine the impacts of BMPs adoption on the livelihood of the cotton farmers' in study area. This study showed the impact of sustainable, profitable and environment friendly cotton crop unlike previous studies that emphasize on high resource use for high profit margin rather reducing the cost of production. The study figured out the factors which hinder the sustainability of cotton production. It also examined the different factors affecting sustainability of cotton production.

II. MATERIALS AND METHODS

In agricultural production, Punjab and Sindh take an esteemed position than other provinces of Pakistan. In province Punjab, districts Bahawalpur, Dera Ghazi Khan, Multan, Rahim Yar Khan, Toba Tek Singh, and Sahiwal are among the major producer, and in Sindh, its main producers are district Sukkur and Khairpur. The nature of the problem has too much higher scale, like region or at country level, but due to apparent limitations of time and funds study was confined to district Bahawalpur and Sahiwal of Punjab.

In Punjab, an important cotton-wheat cropping system was followed for the study purpose. The main focus was to find out the impact of BMP on the resilience and sustainability of gold fiber of country.

In the cotton-wheat cropping system, district Bahawalpur is not only the significant producer of cotton but the 11th largest city of Pakistan, also. Bahawalpur has the total area and population of 24,830 (seq. km) and 2,433,091persons, respectively. District Sahiwal on other hand is the 14th largest city in the Punjab and the 22nd largest city in Pakistan having the total area and population of 3,201 (seq. km) and 1,843,194 persons, respectively [10]. Climatic conditions, cropping pattern and farming practices are the same in both selected districts. In this regard, two tehsils from each district were selected.

Three categories of the farmers were considered for the study; adopters of BMPs, non-adopters of BMPs (from the

same area), and non-adopters of BMPs (farmers outside the BMPs practiced area).
Sample size was determined through following principle [11].

N = N/ {1 + N (e) 2} **(1)**

Where N is Population, n is sample size and e is the accepted level of significance. The said formula worked out sample size of 400 respondents. But due to apparent limitations sample size was confined to 150 respondents and their true representativeness was tried to ensure. Simple random sampling technique was employed to collect relevant data from the two tehsils of the Bahawalpur where the BMP were practiced and one tehsil of Sahiwal where the BMPs were not being practiced i.e. control group (See Table 1 for details).

Table 1: Distribution of the respondents in the study area

Category of Respondents	District	Number of Respondents
BMPs adopters	Bahawalpur	65
BMPS non-adopters	Bahawalpur	35
BMPs non-adopters outside the BMPs practiced area	Sahiwal	50
Total Respondents		**150**

From each respective category, more than 30 respondents were selected randomly from each category prescribed by [12].
The cotton yield per acre was regressed with different variables to check the impact of those variables on yield per acre of cotton farmers.
The relationship between dependent and independent variables is as given below;

$$Y = f(Xi) \quad (2)$$

Where Y = per acre yield of cotton
Xi = independent variables
Impact of BMPs and other inputs on cotton yield was quantified by using Cobb Douglas production function. We can evaluate this by using production function, cost function and profit function. A production function is a heuristic device that describes the maximum output that can be produced from different combinations of inputs using a given technology. These findings showed that the Cobb-Douglas functional form is flexible enough that it can fit the data well even when it does not have a meaningful economic interpretation. This function was used to estimate the influence of BMPs and other inputs on cotton yield, it is the most common production function used in agriculture, [13] and [8] used it in the economic analysis of cotton and wheat. In agriculture, production follows the law of diminishing marginal returns, which means that agricultural output would decline after a certain limit if the inputs are continuously increased. For such kind of analysis, Cobb Douglas production function holds a good option. Its generalized form can be written as [12].

$$Y = \beta_o X_i^{\beta i} e^{\mu} \quad (3)$$

Where **"Y"** is yield of cotton.

- **"Xi"** is the "i" number of independent variables.
- **"β_0"** is intercept term of model.
- **"βi"** representing the parameters of the model to be estimated.
- **"μ"** is the stochastic term.

The Equation 3.4 could further be written as;

$$Yi = \beta_o X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} e^{\mu} \quad (4)$$

It is a non-linear function but it can be converted to a linear function after taking log of both sides of equation. By taking natural log of both sides of Equation 4 as;

$$In\ Y = \beta_0 + \beta_1\ In\ X_1 + \beta_2\ In\ X_2 + \beta_3\ In\ X_3 + \beta_4\ In\ X_4 + \beta_5\ In\ X_5 + u\ In\ e \quad (5)$$

Whereas In e = 1 and by adding dummy variables in the above Equation 5, we have;

$$In\ Y = \beta_0 + \beta_1\ InX_1 + \beta_2\ InX_2 + \beta_3\ InX_3 + \beta_4\ InX_4 + \beta_5\ InX_5 + \beta_{11}\ D_1 + \beta_{12}\ D_2 + \beta_{13}\ D_3 + \beta_{14}\ D_4 + \mu \quad (6)$$

Where,
In Y = Natural log of dependent variable (yield)
β_0 = Intercept term of the model
X_1 = Age (years)
X_2 = Education level of the respondent measured in (years of schooling)
X_3 = Irrigation measured in (Number/acre)
X_3 = Fertilizers use measured in (Nutrient kg/acre)
X_4 = Pesticides use measured in (Number of Application/acre)

X_5 = D1 = Pest scouting, = 1 if used, otherwise = 0
D_2 = Farm yard manure, =1 if applied, otherwise = 0
D_3 = Hybrid varieties, =1 if sown, otherwise = 0
D_4 = BMP =1 if Practiced, otherwise = 0
μ_i = Stochastic error term

II. RESULTS AND DISCUSSION

Table 2 reflects the mean gross margin of respondents in the study area for different types of farming groups. The gross margins were measured as the difference between per acre revenue and total variable input costs. In case of adopters of BMPs, average gross margin were Rs. 38784.3, for non-adopters of BMPs these were Rs 28833.7, and for control group farmers these were Rs 30788.3. While, calculating margins, it was witnessed that the non-adopters of BMPs outside the study area were enjoying the highest revenue (Rs 74930); however on the other hand, the non-adopters of BMPs were getting the least (Rs 68728.6) within the study area. In case of cost of productions, it was also less for both adopters of BMPs and non-adopters of BMPs, i.e., Rs 35994.2 and 39894.9, respectively and non- participating farmers outside the farming area were bearing the highest cost per acre Rs 44141.75.

Table 2: Gross margins on per acre basis for different categories of farmers

Variables	Adopter of BMPs (Study Area)		Non-Adopter of BMPs (Study Area)		Non-adopters of BMPs (outside the study area)	
	Average	Std. Deviation	Average	Std. Deviation	Average	Std. Deviation
Cost (Rs)	35994.2	6405.1	39894.9	7326.2	44141.75	6225.6
Revenue (Rs)	74778.5	8700.3	68728.6	20981.5	74930	20314.4
Gross margins (Rs)	38784.3	9926.2	28833.7	20792.7	30788.3	16793.8

Cobb Douglas production function estimation results for district Bahawalpur are depicted in the Table 3.

Age (ln x1)
The coefficient of the log of age of farmers has the value of 0.036 with negative sign which indicates that with the increase of one percent in age of farmers, the yield would decreased by 0.036 percent (on an average). Its value is insignificant with standard error of 0.043. These results are similar to that of [14] that older the farmer less would be his capacity to opt sustainable agricultural practices.

Education (In X_2)
The coefficient of the log of education of farmers and its standard error are 0.023 and 0.015 respectively. That is a positive value reflecting that unitary percentage change in education will increased yield per acre by 0.023 percent on an average. The coefficient is again statistically insignificant as per having t-statistic value less than two. If famer's education is increased by one schooling year there would be 0.081 kg/acre increase in cotton yield on an average. The results are similar to that [15].

Irrigation Water (In X_3)
The coefficient of irrigation is 0.743 along with a positive sign. The values of standard error and t-value are 0.087 and 8.568, respectively. The coefficient is statistically significant. This illustrates that a 1 percent increase in irrigation water would increase cotton yield (per acre) by 0.743 percent on an average. That means one acre inches field. Increase in water causes 0.767 kg/acre increase in yield. The study results are consistent with the study of [16].

Fertilizer (In X_4)
The coefficient of the log of fertilizer is 0.006 along with its standard error of 0.031. It has positive sign and t-value 0.203, which mean it is statistically insignificant. If there is one percent increase in fertilizer, there would be an increase of 0.006 percent in cotton yield (per acre) on an average. It can be concluded that a nutrient application (kilogram/acre) increase causes 0.001 kg/ acre increase in cotton yield on an average.

Pesticide (In X_5)
The coefficient of pesticide is 0.006 with standard error of 0.033. It possesses negative sign with significant t-value. Farmers were using pesticide extensively, which was causing the plants to bear less fruit by killing useful insects. Results are consistent with results of [8].

Pest scouting (D_1)
Pest scouting is also a BMP which farmers employ to assess the condition and population of the pest on crops. The coefficient and standard error of dummy variable of pest scouting is 0.024 and0.032, respectively. This result is related with the study results of [17].

Farm yard manure (FYM) (D_2)
Farmer community opt to fertilize the farm and augment yield along with no footprint to the environment. The value of coefficient of dummy variable was 0.051 with t-value of 1.854, along with possessing positive sign. Result expresses that an increase in the number of the FYM trolley would increase cotton yield on an average by 0.051 percent (per acre).

Hybrid Seed Varieties (D_3)
Hybrid varieties of cotton sown in Pakistan are generally named as Bt-varieties. The value of coefficient was 0.032 with the standard error of 0.029 Study results were inline with the findings of [18].

Better Management Practices (D_4)
BMP have coefficient value of 0.027, reflecting that these practices have positive impact on the cotton yield. The dummy results illustrate that one percent increase in the adoption of BMP will increase the cotton yield by 0.027 percent on an average.

Factors affecting Sustainable Cotton Production in District Bahawalpur
ANOVA results illustrates the overall significance of the model. F-value generated by model was 13.312 which are statistically significant. It revealed that model was perfectly explaining the results. Significant F-value illustrated that model was well fitted to the data set, and explains the maximum variation in dependent variables caused by the explanatory variables.

Table 3: Factors affecting Sustainable Cotton Production in District Bahawalpur

Independent variable	Coefficients	t-Statistics
Constant	6.622**	2.466
Farmer's characteristics		
Age	-0.036^{ns}	-0.834
Education	0.023^{ns}	1.548
Farm Inputs variables		
Irrigation	0.743**	8.568
Nutrient Fertilizer	0.006^{ns}	0.203
Pesticide	-0.006^{ns}	-0.187
Sustainability characteristics		
Pest scouting	0.024^{ns}	0.747
Farm yard manure	0.051*	1.854
High yielding varieties	0.032^{ns}	1.085
Better management practices	0.027^{ns}	0.836
No. of observations	150	
F-statistics	13.31	
R square	0.57	

** = 5% Significance level, *=10% Significance level
^{ns} = Non-significant

III. CONCLUSION

Sustainable cotton is a viable method of producing fibre, and it is more than just an environment friendly technique. It should be productive and offer decent returns to farmers, and it should be efficient in terms of land use and offer opportunities. It needs to be an efficient structure for producing. Profitability at other extreme is key economic motivation to the farmers to opt sustainable agricultural practices. Timeworn farming methods are characterized by unsystematic, injudicious application of agro-chemicals, i.e., fertilizer and pesticides and irrigations are not only over consuming resources but also a big fiscal burden on farmer's financial resources. Application of inputs at farm level is not only impacting negative externality to environment but these are also generating non-point source pollution.
Results revealed that adopters of BMPs are in sound stage and earning reasonable profit by following the new and improved farming practices. Non- adopters at other hand were spending substantial portion of their financial resource on purchasing farm inputs as they were involved in superfluous use of farm inputs. They were therefore, bearing higher variable cost and ultimately receiving lesser profits. Here, it can be concluded that

adoption of BMPs have many forward and backward linkages. It does not only leave their adopters better off but also make the cotton production sustainable and environment friendly. BMP have not evolved in a vacuum. It has introduced in response to social and environmental challenges, in order to reduce burden on scarce natural resources, and are very helpful to transit out of extreme poverty and starvation. Cultivation of the crops following by BMPs brings equilibrium between ecological and economic characteristics along with the sustainability in agriculture sector. Thus, it makes a superior sense from public policy point of view.

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