Bulgarian Journal of Agricultural Science, 21 (No 2) 2015, 251–256
Agricultural Academy

PROFITABILITY ANALYSIS OF SUSTAINABLE COTTON PRODUCTION: A CASE STUDY OF COTTON – WHEAT FARMING SYSTEM IN BAHAWALPUR DISTRICT OF PUNJAB

S. A. AWAN[1], M. ASHFAQ[1], S. A. A. NAQVI[1], S. HASSAN[1], M. A. KAMRAN[2], A. IMRAN[3] and A. H. MAKHDUM[3]

[1] *University of Agriculture, Institute of Agricultural and Resource Economics, 38000 Faisalabad, Pakistan*
[2] *Nuclear Institute for Agriculture and Biology, 38000 Faisalabad, Pakistan*
[3] *World Wide Fund for Nature, Pakistan*

Abstract

AWAN, S. A., M. ASHFAQ, S. A. A. NAQVI, S. HASSAN, M. A. KAMRAN, A. IMRAN and A. H. MAKHDUM, 2015. Profitability analysis of sustainable cotton production: A case study of cotton – wheat farming system in Bahawalpur district of Punjab. *Bulg. J. Agric. Sci.*, 21: 251–256

Basic drive of study was to look at existing level and the factors affecting the rate of adoption of Sustainable Agricultural Practices/Better Management Practices (SAPs/BMPs) in cotton crop. The study was based on farmers data obtained from World Wide Fund (WWF) for Nature. Survey data of 1000 farmers for year 2013 was used from Bahawalpur district with 50% respondents purposively selected from sustainable cotton farmers working with and licensed from WWF-P and other 50% respondents were the farmers using conventional practices and not involved with WWF-P's project. Data were evaluated using partial budgeting and Cobb-Douglas Production Function methods. The data shows that the level of adoption of SAPs was higher among licensed farmers who have strong contract and better understanding and awareness about sustainable cotton program as compared to those of non-licensed. The results further reveals that, education level and land holding size of respondents have positive impact on adoption of SAPs, while the age and farming experience of farmers were found to have a negative effect on SAPs rate of adoption. The results from regression analysis shows that years of schooling of the farmers, quantity of fertilizer used, amount of water used and use of practices like water scouting, natural pesticide, farmyard manure and Bt variety can increase the cotton yield whereas years of farmer's age and amount of pesticide may decrease it. It is evident from the results that extension services have a significant role to disseminate information about sustainable use of resources and introduction of market based and command and control policy instruments to promote BMPs and resource conservation.

Key words: SAPs, BMPs, profitability analysis, partial budgeting, resource conservation, Punjab
Abbreviations: Word Wide Fund, Pakistan – WWF-P; Sustainable Agricultural Practices – SAPs; Better Management Practices – BMPs; Analysis of Variance – ANOVA

Introduction

There is growing evidence that Sustainable Agricultural Practices (SAPs) have potential to increase farm profitability and reducing agriculture induced environmental externalities (WWF, 2006). In Pakistan, focus has been on input intensive agriculture which is not only negatively influencing the farmers' profit and yield but also causing environmental pollution**.** While agriculture currently employs approximately 90–97% of the water extracted from the River Indus and its tributaries, it

**E-mail: syedasif_1@yahoo.com, ashfaq9@hotmail.com, saawan632@gmail.com, shassan63@hotmail.com, agriecon.niab@gmail.com, aimran@wwf.org.pk, amakhdum@wwf.org.pk*

is estimated that only 30–35% reaches the crop and the rest is lost in irrigation canals as a result of water seepage and soil, as runoff from fields. To fulfill the crop water requirement farmers are pumping the ground water. Groundwater pumped through tube wells not only increases the cost of production but also effecting soil health by increasing soil salinity and vandalizing ground and fresh water purity. Moreover huge amount of artificial fertilizers and pesticides are being used to cure crops from nutrient deficiency and different infestations respectively. Mechanization, which is driven at the cost of fuel consumption and machinery depreciation, adds many kinds of greenhouse gases and other harmful volatiles as well as non-volatile components in the environment. Agriculture and environment have a deep relation with each other. If agriculture is degrading the environment, the environmental degradation in return affects us ecologically as well as huge threat to sustainability of agriculture and global food security (Jobbaggy et al., 2001).

SAPs are techniques aiming at minimizing environmental degradation while using economies of scale and ensuring qualified farm product at sustainable basis. Profitability directly or indirectly depends on input use efficiency therefore; like in other crops technical efficiency is an important issue in cotton production. Several studies on the technical and economic efficiencies of crop production, particularly for wheat and rice, have pointed out the existence of gap in yield gap. This gap refers to the difference in productivity on SAPs and on other farms operating with comparable resource endowments under similar circumstances (Kebede, 2001; Villano, 2005).

Several studies have analyzed linkage between SAPs and economies of scale for different crops (Beth and Cher, 2007; Graham, 2006; Muhrely et al., 2009; Mallarino and Reuber, 2011; Akudugu et al., 2012; Fanning et al., 2012). Keeping this in view, the analysis in this study is attempting to relate awareness about the use of SAPs which will help policy managers to allocate limited resources in a more efficient and productive manner.

The significance of SAPs in environmental and resource conservation is well proven however profits much debated for such SAPs in Pakistan due to lack of market for resource conservation and organic production systems. Moreover, there is lack of empirical investigation about area and cop specific SAPs in existing literature. Therefore, the basic purpose of present study was to conduct and compare profitability analysis of adopters and non-adopter farms, to identify most relevant SAPs for cotton in the selected district, and to estimate the determinants of adoption and their impact on cotton production The rest of the paper is organized as: second part includes data collection procedure and about model used, third section presents empirical results and discusses their implications, and fourth and the last section offer conclusion and policy suggestions.

Materials and Methods

Data Collection Procedure

Study was built on farmers data obtained from World Wide Fund for Nature collected during 2013. Survey data for 1000 farmers was used from Bahawalpur where WWF-P was popularizing the use of Sustainable Agricultural Practices (SAPs)/Better Management Practices (BMPs) on a large scale. Eleven SAPs were identified by WWF-P and it had already collected comprehensive information from the farmers regarding their farm size/cropped area; input used in each crop, management practices, etc. The list of farmers from whom WWF-P collected data was obtained along with the data of farmers. These farmers were given knowledge in the form of training in farmer field schools. About half of the farmers in data, collected from WWF-P, were practicing about five or more SAPs/BMPs, so the WWF-P contact farmers were divided into two groups, one following 5 or more practices and other with less than five practices. First group was given license as sustainable cotton farmer by WWF-P and other one is non-licensed so we consider them as non-sustainable cotton farmer. It is important to mention that non-licensed farmers in the study area were also following 2–3 practices.

Secondary data for sustainable and non-sustainable cotton producers were collected from WWF-P Bahawalpur two tehsils of Bahawalpur district of Punjab-Pakistan. From Bahawalpur 1000 famers' data were collected among them 500 were Sustainable cotton producers and other 500 were not. Cotton was chosen for analysis because cotton is major cash crop of Pakistan (Government of Pakistan, 2013) and globally it is considered as one of the most input intensive crop contributing in the use of plentiful irrigation water, fertilizer, pesticide, labor, etc. (Mohanty et al., 2003).

Statistical Methods

Gross margins of both sustainable cotton farmers and non-sustainable cotton farmers were calculated by partial budgeting technique (Ahmad, 2001). The gross margins were calculated as:

$$GM = TR - TVC,$$

where GM is gross margin measured in rupees per acre, TR is total revenue measured in rupees per acre and TVC is total variable cost measured in rupees per acre. Variable costs items are pesticide, weedicide, fertilizer, irrigation, seed cost, land preparation cost, thinning cost, spraying cost, transportation, sowing cost, picking cost, hoeing, gap filling cost. Variable costs were worked out by multiplying the average input used per acre with the average market price and summing all terms. Total revenue was worked out by multiplying the main and by products of cotton with their respective prices and summing both the terms.

To see the impact of SAPs and other inputs on cotton yield, Cobb Douglas production function was used. This function is widely used in agriculture for economic analysis (Hassan et al., 2009; Gill, 2005; Bakhsh et al., 2005). Cobb Douglas production function with single input could be written as (Gujrati and Sangheeta, 2003).

$$Y_i = \beta_o X_i^{\beta i} e^{\mu}$$

It is a non-linear function but it can be converted to a linear function after taking log of both sides of equation and in log form it could be written as:

$$\ln Y = \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \\ + \beta_5 \ln X_5 + \beta_6 D_1 + \beta_7 D_2 + \beta_8 D_3 + \beta_9 D_4 + \mu,$$

where "ln" represents natural logarithm to base 2.47 and Y_i is yield of cotton measured in kg/acre, X_1 is equal to age (years), X_2 is education of respondent measured in years of schooling, X_3 is shows fertilizers use in kilograms/acre, X_4 represents the amount applied to an acre of cotton measured in pesticide measured in grams/liters. And X_5 is equal to water applied to an acre of cotton in acre inches. In the analysis dummies variables were also introduced and D_1 was the dummy for natural pesticide and if have value equal to 1 pesticide was used otherwise 0, D_2 was the dummy for water scouting its value would be 1 if water scouting was done otherwise 0, while D_3 was the dummy for hybrid seed varieties with value equal to 1 if hybrid varieties were sown otherwise it was 0 and the D_4 dummy for farm yard manure with value equal to 1 if it was applied otherwise 0.

To check the difference in mean yield and gross margins among the user and non-user of SAPs t-test for equality of means was used (Paternoster et al., 1998). Before the application of t-test equality of variance of yield and gross margins for the two gross was checked by applying Levene's test (Gastwirth et al., 2009).

Results and Discussion

The average values of summary statistics for different relevant variables are presented in Table 1. The rate of adoption of sustainable agriculture practices was taken as the function of socioeconomic variable, institutional variable and environmental behavior of respondents. It was observed that mean year of age, education, and farming experience of sustainable cotton farmers were 33.5, 7 and 13.6 years, respectively. And the average farm size was 3.5 hectare for sustainable cotton farmers. It was observed that mean year of age, education, and farming experience of sustainable cotton farmers were 41, 5.4 and 17.2 years, respectively. And the average farm size was 2.93 ha for non-sustainable cotton farmers.

Table 1

Summary statistics for variables by categories of cotton farmers in Bahawalpur

Category	Sustainable Farmers	Non-Sustainable Farmers
Age (years)	32.57	35.25
Education (Years)	7.34	5.56
Farming Experience (Years)	13.18	14.63
Land Holding (Acres)	8.84	8.82

In case of sustainable cotton farmers age was less than the non-sustainable cotton growers. It was found that there was a positive relation between rate of adoption of sustainable agriculture practices and education level of farmers. In their studies Isign et al. (2008); Frisvold et al. (2009) and Toma and Mathijs (2007) concluded that educated farmers have higher ability to adopt SAPs as compared to less educated people. Sustainable cotton farmers owned more area for cultivation than the non-sustainable cotton farmer. Our findings are in line with the results of Kouser et al. (2006) and Ghazalian et al. (2009). Farming experience of sustainable cotton farmers was significantly less than non-sustainable cotton because it relates to the age of farmer and study findings were consistent with the findings of Muhrely et al. (2009). Significance of these variables can be seen in Table 2.

Table 2

Factors affecting adoption of sustainable agricultural practices (Logit Estimates)

Variable	Co-efficient	t-value
Age	–0.014***	2.05
Education	0.047***	4.18
Farming Experience	–0.08**	3.15
Land Holding	0.043***	2.36
LG Attendance	10.46***	8.04
Constant	0.044ns	0.17
R2	0.312	–
LR X2	29.25	–
No. of Observation	1000	–

Note: *** = 1% Significance Level, ** = 5% Significance Level, * = 10% Significance Level, ns = Non-Significant

Comparison was made on the basis of agriculture inputs, gross margin and yield. It was noted that mean costs of land preparation, seed, intercultural operations, plant protection, irrigation, fertilizer and post-harvest costs are PKR 4867.5, 1572, 1795.5, 3761, 241, 7316 and 5273 per acre for adopters of sustainable agriculture practices respectively. Similarly these mean costs for non-sustainable cotton farmers are PKR 4750, 1561.5, 1926.5, 4555, 288.5, 7366.5 and 5989.5 per acre respectively. Costs increases have no significant effect on gross yield especially for land preparation; the outcomes are in correlation with the finding of Hassan et al. (2005). The gross margins per acre of adopter of sustainable agriculture practices were PKR 41987.5 while the non-adopters have PKR 38287 per acre respectively.

The results revealed the impact of different agriculture inputs and sustainable agriculture practices on cotton yield, the age of farmer has coefficients –0.011. The coefficients for education are 0.001. Coefficients for water, fertilizer quantity, and quantity of pesticide used are 0.033, 0.015, and –0.02 respectively.

The dummy variables use of farm yard manure, alternative natural pesticide ,water scouting; and Bt seed variety have positive coefficients 0.04, 0.011, 0.042 and 0.009 respectively. From the all dummy variables farm yard manure, alternative natural pesticide, water scouting and hybrid seed variety have positive significant impact on cotton yield.

Negative sign for education coefficients indicates that with the increase in age of farmers yield decreases. It is non-significant for Bahawalpur. These results were similar to that of Ajayi (2000) and Zhong (2008) that older the farmer less would be his ability to adopt modern techniques to increase the yield. Positive sign for education coefficients shows that education has a positive correlation with the adoption of SAPs and finding are consistent with the outcomes of Dasgupta et al. (2005). Positive sign for irrigation shows that water quantity has positive impact on the cotton yield. It is non-significant and these results are in positive relation to the study results of Farooqi (2009). Coefficient of fertilizer quantity used is positive for both districts but is insignificant for Bahawalpur district. Pesticide coefficients have negative sign that shows that there is over utilization of pesticide that causes the plants to bear less fruit by killing useful insects is in practice.

Finally, the F value is 18.89 generated from the ANOVA Table 3 shows that the model was significant. The model also indicates that the production function fit well to the given data set (Table 4). So production function in this study was statistically significant.

As shown in Table 5 Levene's test (Gastwirth et al., 2009) was used to assess the equality of variances the Sig. value is 0.173 which is greater than 0.05 which shows that t-values are equal whether we assume variances equal or unequal the results.

Table 3

Comparative economics of sustainable and non-sustainable cotton farmers (PKR/Acre)

Variable	Sustainable	Non-sustainable
Land Preparation Cost	3723	3573
Seed Cost	1941	1910
Intercultural Practices Cost	2450	2652
Plant Protection Cost	2886	3071
Irrigation Cost	237	267
Fertilizer Cost	4231	4324
Post-Harvest Cost	4412	4794
Total Cost	20 065	20 597
Gross Margins	39 952	29 070

Table 4

Factors effecting sustainable cotton production

Dependent Variable: Cotton yield percentage per hectare		
Independent Variables	Coefficients	t-Statistics
Constant	7.524***	36.762
Farmer Characteristics		
Age	–0.011ns	–0.855
Education	0.001***	1.558
Input Variables		
Irrigation	0.033ns	0.621
Fertilizer	0.015ns	1.243
Pesticide	–0.020*	-1.655
Sustainability Indicators		
Farm Yard Manure	0.040*	7.335
Alternate Natural Pesticide	0.011**	2.158
Water Scouting	0.042*	7.765
Hybrid Seed Varieties	0.009*	1.667
No. of Observation	500	
F-Statistics	18.891	
p-Value	0	

*** = 1% Significance Level, ** = 5% Significance Level, * = 10% Significance Level, ns = Non-Significant

Table 5

Category-wise statistics for cotton farmers

Status	No. of Observations	Mean	Standard Deviation	Standard Error Mean
Sustainable Farmer	500	2218.81	138.42	6.19
Non-sustainable Farmer	500	1762.9	98.99	4.43

Table 6

Yield difference significance

Assumed Variances	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	T	Df	Sig. (2-tailed)
Equal	51.19	0	59.906	998	0
Non-Equal			59.906	903.6	0

Table 6 revealed that the mean for yield of sustainable cotton farmer was higher than the mean for yield of non-sustainable cotton farmers. So it could be concluded that the sustainable cotton farmers were in a position to produce more cotton than non-sustainable cotton farmers.

Conclusions

Profitability is an important economic motivation to the farmers to take up sustainable agricultural practices. From the empirical results gained from taking SAPs adoption rate as a function of socioeconomic, institutional and environmental behavior, it is clear that education of the farmers and average farm size of farmers have positive effect on SAPs adoption rate. It has been observed that younger farmers with less farming experience should be focused because both age and farming experience are inversely related to SAPs adoption rate. The results of regression model revealed that irrigation, fertilizers application and alternate/skip row irrigation have positive impact on cotton yield per acre. While the age of farmers and pesticide show negative relationship with cotton yield. Water scouting and irrigation are not having much significant effect on cotton yields.

The results gained from comparative economic analysis for the adopter of sustainable agriculture practices and non-adopters describe that the total cost for non-adopter is greater than that of adopters. Gross margin as well as yield of cotton per acre is higher for adopter of sustainable agricultural practices. Adopters are in better position to earn reasonable profit by following sustainable agricultural practices. Here it is concluded that adopters are sustainable agriculture practices are quite profitable for their adopters due to difference in their per acre yield. It also here be concluded that adopters of sustainable agriculture practices made greater saving due to optimal and timely use of irrigations, fertilizers and pesticides.

Recommendations

On the basis of investigated results of study to date some recommendations to tackle the problems in adopting SAPs of cotton crop could be made. Government may ensure the injudicious and wasteful use of fertilizers and by imposing penalties for non-compliance. The pesticides and fertilizer companies as well as extension department may be given strict instructions to educate farmers and ensure application of recommended input dose. Pesticide and fertilizers price policy may be reviewed by adding pollution tax, to control its overuse and environmentally hazardous chemicals may be banned. Majority of farmers in Pakistan have small holdings of less than 5 acres and SAPs have potential to increase their net income and farm profitability. Well organized farmers training programmers should be initiated for the capability enhancement of farmers and create awareness about the efficient use of scarce resources. Approved seed varieties for different agro-ecologies should be made available for farmers to ensure timely and cost effective availability to farmers. The non-compliance penalties may be imposed on agro-chemical companies marketing banned chemicals and the revenues from penalties may be used to finance higher price premium for farmers following SAPs.

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Received September, 2, 2014; accepted for printing February, 7, 2015.