Pak. J. Agri. Sci., Vol. 51(3), 765-769; 2014
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

AGRO-ECONOMIC DIMENSIONS OF INTERCROPPING IN CITRUS FARMS: THE CASE OF DISTRICT TOBA TEK SINGH, PAKISTAN

Adeel Ijaz, Sultan Ali Adil, Sarfraz Hassan, Khuda Bakhsh, Muhammad Khalid Bashir* and Qasir Abbas

Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan
***Corresponding author e-mail: khalid450@uaf.edu.pk**

This study aims to assess the impact of intercropping on citrus yield in District Toba Tek Singh. The research questions are: What is the economic benefit of intercropping? What is the impact of intercropping on citrus yield? Primary data were collected from 120 citrus (Kinnow) growers (60 each with and without intercropping) from the district. Benefit cost analysis and Cobb-Douglas regression were used to answer the research questions. The results showed that the average yield of Kinnow without intercropping (12454 kg ha^{-1}) was higher than those with intercropping (7492 kg ha^{-1}). A similar trend was observed for average incomes per acre of orchards. The economic analysis showed that the orchard without intercropping was earning more benefit (benefit cost ratio of 1.59) than with intercropping (1.31 including income from intercrops). The results of the Cobb-Douglas model showed that intercropping had a negative impact on citrus yield. It is recommended that awareness among the farmers must be created about the harmful effects of intercropping on citrus yield and income. If the need for intercropping arises; suitable intercrop(s) should be identified and its use be popularized among the farmers by using print and electronic media through private and public organizations. Also, we recommend the replication of such studies in broad areas for getting a robust answer.

Keywords: Intercropping, Cobb-Douglas Model, BCA, citrus, Kinnow, yield

INTRODUCTION

Horticulture has become an important sector in agricultural GDP in Pakistan. It contributes 6.3 percent towards the agricultural GDP and has a share of 22.7 percent in national food production (GOP, 2011a). It has a great potential to reduce socio-economic problems of rural communities by increasing their income (Alam and Mujtaba, 2002). During 2011-12, annual production of fruits and vegetables in Pakistan was 13.55 billion KGs. Fruit production was 5.55 billion KGs, out of which citrus production was 2.33 billion KGs i.e., 42 percent (GOP, 2013b). The share of Mandrin (Kinnow) is about 70 percent. Pakistan is ranked among the top ten producers of the world for citrus production (Nawaz *et al.,* 2011) and is the sixth largest producer of Kinnow (Syed, 2009).

Pakistan's average yield of citrus (11000 kg ha^{-1}) is low as compared to the average yields of other citrus producing countries e.g. Brazil, USA and Turkey (22000, 26000 and 27000 KGs/hectare, respectively) (Nawaz *et al.,* 2011). The potential yield of citrus in Pakistan is 18000-20000 kg ha^{-1} (PHDEB, 2006). Similarly, the productive life span of citrus in Pakistan is very short i.e., 20-30 years compared to up to 50 years in other countries. Lack of knowledge about management practices, intercropping of wheat, maize, berseem and other crops in citrus orchards and low doses of fertilizers are regarded as the factors for low yield and short life span in Pakistan (Nawaz *et al.,* 2011).

Intercropping in fruit orchards is a common practice in many countries. For example, intercropping of mustard with bananas and cucumber with citrus (mandarin) orchards improved the yields of mustard and cucumber without harming the yields of banana and Citrus in India (Ouma and Jeruto, 2010). Intercropping of legumes especially Egyptian clover in citrus orchards is beneficial for the citrus production. Similarly, soybean and chickpea improve fruit yield as compared to sole orchard. Such crops help increase the yield of the main crop by fixing nitrogen biologically in the soil (Aziz *et al.,* 2008; Srivastava *et al.,* 2007). Furthermore, cover crops used in organic citrus orchards suppress weeds, and thus improved the yield of citrus fruit in Florida organic citrus orchards (Linares *et al.,* 2008). Similarly, French-beans intercropped with lemon (citrus) proved to be the best combination in India (Hnamte *et al.,* 2013). In Pakistan, it was observed that sowing maize in citrus orchard helped to improve the predators' population that controls citrus leaf minor (Ahmed *el al.,* 2013).

In Pakistan, farmers tend to cultivate wheat, maize, cotton and berseem in citrus orchards, but this affects the yield of citrus adversely. This is due to the competition for light and nutrients and different water and fertilizer requirements of the both crops, e.g. berseem requires irrigation weekly while citrus requires less water. The excessive use of water

deoxygenates the root system of citrus plants that affects yield and growth. Similarly, at wheat harvesting time, irrigation is stopped but orchards require irrigation at that time which adversely affects yield and growth of citrus (Lachungpa, 2004; Srivastava *et al.,* 2007; Khan and Tariq, 2010; Sarwar *et al.,* 2012; and Raza, 2013). This study aims to assess the impact of intercropping on citrus yield in District Toba Tek Singh. The research questions are: What is the economic benefit of intercropping? What is the impact of intercropping on citrus yield? The hypothesis tested is:

H_0: Intercropping has no impact on citrus yield.

H_1: Intercropping has a significant negative impact on citrus yield.

MATERIALS AND METHODS

***Data collection*:** Despite the fact that citrus is grown in all four provinces of Pakistan, more than 95 percent of production is from Punjab. The top citrus producing districts in Punjab are Sargodha, Toba Tek Singh, Rahim Yar Khan, Multan, Sahiwal, Lahore, Sialkot, Jhang, Mianwali and Gujranwala (Ahmed, 2010).This study is confined to district Toba Tek Singh due to its fame for citrus (Kinnow) cultivation. Four villages were randomly selected from the district. From each village 30 Kinnow growers were purposively selected to ensure that the orchards were not less than 10 years of age. For comparison purposes, half of the selected farmers (i.e. 15) were those who were not practicing intercropping. This made the total sample size of 120 Kinnow growers. Data were collected through a well designed and structured questionnaire. Both open-ended and close-ended questions were included in the questionnaire. The questionnaire was pre-tested before data collection.

***Empirical model*:** To answer our first research question, we applied Benefit Cost Analysis to calculate the economic benefits of orchards with and without intercropping. Such analysis is commonly used to compare the economic benefits of different enterprises/ projects / farms (see for example Mukhebi *et al.,* 1990; Ozkan *et al.,* 2003; Uzunoz and Akcay, 2006; Khair *et al.,* 2009; Ravitchandirane and Haripriya, 2011). The benefit cost ratio can be calculated using the formula:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Total Income or Benefits}}{\text{Total Costs}}$$

To answer our second research question, multiple regression analysis was used to assess the impact of intercropping along with other socio-economic factors on Kinnow productivity. The initial analysis guided us to apply a Cobb Douglas production function (see for example Hassan *et al.,* 2012; Sarwar, *et al.,* 2012; Bashir *et al.,* 2007). The general form of the function with single input can be written as:

$$Y_{1i} = \beta_1 X_{2i}^{\beta 2i} e^{\mu i}$$

Where, Y_{1i} = Yield of Kinnow in kgs/ha; X_{2i} = independent variable; B_1 = Intercept; B_{2i} = elasticity of independent variables; μ_i = disturbance term; e = base of natural log (2.47) ; More specifically, Cobb-Douglas Production function in log form for more than one input is written as:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 D_1 + \mu_i$$

Where, ln = Natural log; Y= Yield of Kinnow in Kg/Ha; X_1 = Age of the orchard in years; X_2= No. of Irrigations applied to a hectar of Kinnow; X_3= Labour cost in Rs/Ha; X_4= Nutrient Kgs applied to a hectar of Kinnow; X_5= Use of pesticides (Number of sprays/hectar); X_6= Intercultural practices i.e. hoeing and weeding (Numbers/hectar); D_1= dummy for intercropping (D_1= 1 with intercropping and 0 otherwise); β_0 = Intercept; $\beta_{1\text{-}7}$= Parameters of the model to be estimated; μ_i = disturbance term

RESULTS AND DISCUSSION

The descriptive statistics for the socio-economic variables used in regression analysis is given in Table 1. It was found that the yield varied from 5525 kg ha^{-1} to 20856 kg ha^{-1} with a mean of 10477 kg ha^{-1}. The age of orchards varied from 10 to 35 years, with a mean of 16 years. The number of irrigations applied also showed some variations, with minimum of 17 irrigations and a maximum of 26 irrigations. Total number of fertilizer application showed great variation: the minimum fertilizer application was 121 kg ha^{-1} and the maximum was 628 kg ha^{-1}, with a mean of 381 kg ha^{-1}. A similar trend was observed in the labor costs, where the minimum cost was Rs. 2250 per acre and the maximum was Rs. 9883 per acre. Furthermore it was observed that the yield of farms without intercropping was greater than those where intercropping was applied. It ranged between 5525-20856 kg ha^{-1}.

***Economic analysis*:** The results of the economic analysis are presented in Table 2. The total cost per hectare of Kinnow production of the orchards with and without intercropping was estimated as Rs. 210,240 and Rs. 188,487, respectively. The difference is due to the additional cost of production of intercrops. Similar trends were observed for total income per acre of the orchards with (orchard + intercrops income) and without intercropping i.e. Rs. 111,654 and Rs. 121,436, respectively. Planting of wheat and berseem as intercrops adversely affected the yield of citrus due to the competition for nutrients and different requirements of irrigation and nutrients of the crops (Srivastava *et al.,* 2007; Lachungpa, 2004; Khan and Tariq, 2010). Similar trends were observed for per plant yield. It was found that per plant yield of the orchard without intercropping was 14 kg (24 percent) greater than those which were intercropped. These results confirm to the earlier results of Srivastava *et al*. (2007), Lachungpa (2004) and Khan and Tariq (2010). It was also found that the orchards with intercropping had less number of plants/hectar i.e., 177 as compared to orchard without intercropping i.e 227/hectar

Table 1. Descriptive Statistics

Variable	With Intercropping			Without intercropping			Whole sample
	Min	Mean	Max	Min	Mean	Max	Mean
Yield (kg/ha)	5525	7492 (963)	10378	7818	12454 (2510)	20856	10477 (3252)
Age of orchard (Years)	10	15 (4)	30	10	18 (6)	35	16 (5)
Irrigation (No/ha)	17	21 (3)	26	18	24 (3)	31	23 (3)
Labor cost (Rs/ha)	5560	14703 (4248)	24421	6919	13964 (4502)	23969	14278 (4394)
Amount of NPK (Kg/ha)	121	331 (79)	470	175	415 (79)	628	381 (89)
Use of Pesticides (No/ha)	1	2.5 (0.7)	5	2	3 (0.7)	5	2.8 (0.7)
Intercultural practices (No/ha)	1	2 (1)	3	1	2 (0.5)	4	2 (0.5)

Figures in parentheses are the standard deviations

plants. This is because of the requirement of space between the plants for sowing intercrops and less of plants due to intensive cultural operation required for the intercrop.

The income from orchards with intercropping was less because the number of plants in this type of orchard was less and yield per plant and hectare also decreased. Income from intercrops was not sufficient to fill the losses of production due to intercropping in Kinnow orchards. As a result, net profits from a hectare of the orchard with intercropping was significantly lower (Rs. 65,663) than that of the orchard without intercropping (Rs. 111,588). A similar difference was observed in the benefit cost ratio analysis. An investment of Rs. 1 on an orchard without intercropping returns Rs.1.59 while this value for orchard practicing intercropping gets Rs. 1.13 and 1.31 (including income from intercrops). The BCR for both types of orchards is greater than 1, but the rate of return on investment is much higher on orchard not practicing intercropping. This result is in line with Ozkan *et al.* (2003), Uzunoz and Akcay (2006), Khair *et al.* (2009) and Ravitchandirane and Haripriya (2011).

Table 2. Economic analysis of orchards with and without intercropping

Type	Orchard with intercropping	Orchard without intercropping
Total income (Rs/ha)	275903	300075
Total cost (Rs/ha)	210240	188487
Net profit (Rs/ha)	65663	111588
No. of plants/ ha	178	227
Yield/plant (kg)	42	56
Income/plant (Rs)	998	1320
BCR (only orchard)	1.13	1.59
BCR (including income from intercrops)	1.31	1.59

***Factors affecting yield of citrus (Kinnow)*:** The results of Cobb Douglas production function are presented in Table 3. The first explanatory variable in the model was age of the orchard ($\ln X_1$). The coefficient of this variable has correct negative sign but is non-significant. The non-significance could be due to less variation in the age of orchards in the study area. de Miranda *et al.* (2012) found that increasing age of the orchard is more vulnerable to diseases resulting in lower yield. The coefficient of the number of irrigations ($\ln X_2$) is 0.464, with a t-value 4.520. This coefficient indicates that citrus yield increases by 0.464 percent with a percent increase in the application of irrigation. The coefficient of the labor cost ($\ln X_3$) is 0.076, with a t-value of 2.409. This implies that one percent increase in labor cost would improve the yield of citrus by 0.076 percent. This result is in line with the findings of Sarwar *et al.* (2012). The coefficient of the number of fertilizer applications ($\ln X_4$) variable is 0.189, with a t-value of 3.748. This means that a 1 percent increase in the use of fertilizers will bring 0.189 percent increase in the yield. This result is in line with the findings of Sarwar *et al.* (2012). The coefficient of plant protection applications ($\ln X_5$) is 0.187, with a t-value of 4.520. This implies that one percent increase in the number of sprays would increase the yield of citrus by 0.187 percent. de Miranda *et al.* (2012) stated that proper action against diseases may result in better yield. Similarly, the coefficient of intercultural practices ($\mathrm{Ln}X_6$) is 0.082 with a t-value of 1.883. This implies than an increase of one percent in the practice of applying intercultural practices would increase the yield by 0.082 percent. The coefficient of intercropping (D_1) is -0.388 with a t-value of -14.451. This implies that the farmers who are practicing intercropping get 0.388 percent lower yield than the farmers who are not practicing intercropping.

Thus, the null hypothesis is rejected i.e. intercropping has a significant negative impact on citrus productivity. These results are also in line with the findings of Lachungpa (2004), Dhimmar and Raj (2009), Srivastava *et al.* (2007), Khan and Tariq (2010) and Anwar *et al.* (2012).

The F-calculated value (92.12) is highly significant and the R^2 value is high (0.85). This suggests that the seven independent variables included in the model are jointly explaining 85 percent of the variation in the yields of citrus crops in the study area.

Table 3.Determinants of citrus yield:

Variables	Coefficients	Standard Errors	t-value
Constant	1.156*	0.420	2.751
$\ln X_1$	-0.020	0.400	-0.488
$\ln X_2$	0.464*	0.103	4.520
$\ln X_3$	0.076**	0.032	2.409
$\ln X_4$	0.189*	0.051	3.748
$\ln X_5$	0.187*	0.045	4.520
$\ln X_6$	0.082***	0.043	1.883
D_1	-0.388*	0.027	-14.451

R^2 =0.85, F-Calculated = 92.12

*, **, *** are the significance levels of 1 %, 5 % and 10 %

***Conclusions*:** Our findings indicate that the orchards without intercropping were performing better in terms of citrus yield as indicated by descriptive analysis and regression analysis. Cost benefit ratio also support these results by showing more benefit for the orchards without intercropping. Gross income, net income and BCR from citrus orchard without intercropping are much higher than the citrus orchard with intercropping even after including the income earned from the intercrops. Awareness among the farmers must be created about the harmful effects of current ways of intercropping on citrus yield and income. The population of Pakistan is rapidly increasing as a result of which per capita land availability is continuously declining. The need for intercropping may well increase; but more suitable intercrop(s) should be identified keeping in view the supplementary and complimentary relationships among the citrus and the intercrop(s) such as legumes. Use of such intercrop(s) should be popularized among the farmers by using print and electronic media through private and public organizations. Furthermore, in future, comprehensive studies should be designed and carried out at a larger scale to benefit the farmers. One should be careful to generalize these findings as the socio-economic characteristics of the regions, input configuration being employed in such orchards and structure and texture of soil along with various crop/plant varieties may change the findings substantially.

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