MAXIMUM ECONOMIC RETURN THROUGH INTERCROPPING OF DIFFERENT CROPS IN SEPTEMBER SOWN SUGARCANE (SACCHARUM OFFICINARUM L.)

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ABSTRACT

Sugarcane has a great value as the major source of sugar to more than half of the global population. World population is increasing day-by-day and cultivated land is decreasing rapidly due to urbanization, road construction, and land deterioration. This crisis demands alternate research to increase productivity and maximum economic returns per acre to feed the gigantic population. Intercropping in sugarcane has received much attention due to long duration and late return from sugarcane crop and may become popular among farmers, if it is properly managed. Intercropping has the potential to encourage the farmers to get maximum economic return per acre per annum. For intercropping, wheat, gram, soybean, and potato was used as intercrops in the September-sown sugarcane. Triple row strip planting geometry of sugarcane with four intercropped (SC+ Wheat, SC+ Gram, SC+ Soybean, and SC+ Potato) and check with sole SC was used. Sugarcane was planted during September 2011-12 at the research area of the University College of Agriculture, University of Sargodha, Pakistan. Randomized complete block design with three replications was used. Results showed that number of millable cane, cane diameter; unstripped and stripped cane yield and crop growth rate was higher in sole sugarcane than different inter-crop treatments. The results also showed that intercrops gave higher land equivalent ratio and net return/net income over the sole sugarcane planted, while sole sugarcane gave maximum benefit cost ratio.

Keywords: world population stress, sugarcane, intercropping, economic return, and benefit cost ratio.

Abbreviations: SC = Sugarcane; CGR = Crop growth rate; LER = Land equivalent ratio; BCR = Benefit cost ratio.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is the biggest source of revenue in Pakistan after cotton and rice. It has central position in the growth of sugar industries and economic development. It is a source of providing raw material to many allied industries and employment (Akbar *et al*., 2011). Sugarcane contributes 3.2 % to the value added products in agriculture and 0.7 % to gross domestic production (Govt. of Pakistan, 2012-13). Currently, the area under sugarcane is 1.12 million hectares and total production is 62.4 million tons with an average yield of 55.58 metric ton ha^{-1} (Govt. of Pakistan, 2012-13). Despite a higher yield potential, average stripped cane yield of sugarcane in Pakistan is well below than in most of the sugarcane producing countries of the world (Ali *et al*., 2009).

There are several factors involved in yield stagnant at farmer's field while conventional planting method/ geometry is the main factor (Ehsanullah *et al*., 2011).

To encourage the stripped cane yield, different planting techniques have been developed. Conventionally, sugarcane is planted in 60 to 75 cm apart single rows strip which may result enhanced millable cane per unit area and striped cane yield but hinders different cultural practices necessary for good crop stand and hence, restricting the cane yield to a substantial extent (Ehsanullah *et al*., 2011).

Triple row planting may be suitable and efficient planting system in saving water and decreasing lodging due to easiness in intercultural practice and earthing-up operations (Malik *et al*., 1996). Triple row strip planting plays significant role in increasing plant population and stripped cane yield (Sarwar *et al*., 1996). Sugarcane yield and yield attributes like tillers, plant height, number of millable canes and stripped cane yield produced by 120 cm apart triple row trench planting was higher than 60 cm apart single row trenches (Chattha *et al*., 2007). A triple row spacing of 120 cm produced more total dry matter and stripped cane yield over single row and double row spacing 60 and 90 cm but cane quality were alike with different row spacing (Raskar and Bhoi, 2005). A triple row planting sugarcane with recommended seed rate gave maximum net income/ economic returns than conventional method of planting (Bhullar *et al*., 2008).

Day-by day the population is rapidly increasing which decreasing the area under crop production. The prerequisite is to increase the production and income per unit area by developing such planting techniques and practices, which may help in maintaining proper plant population and intercropping (Hussain *et al*., 2008). Intercropping has been known as a tremendous practice to increase stripped cane yield, maximum net returns, and better resources utilization and fulfill the demand of diversified farms. The gross monetary returns have been recognized as the highest economic benefit earned from intercropping cane with potato and lowest from pure cane (Misra *et al*., 1989). Intercropping produced superior quality cane juice (Jayabal *et al*., 1990a) and gave higher net field benefits than sole sugarcane (Rana *et al*., 2006). The conventional methods of planting cane do not permit the intercrops to grow well due to shading and competition effect. The popularity of intercropping systems on small growers in the developing countries and the demand for more food has required intensive research on intercropping (Rana *et al*., 2006). The contradictory yield results of different intercrops were found in different studies (Li *et al*., 2013; Kannappan *et al*., 1990; Razzaque *et al*., 1978).

Pakistan being a subtropical country with best growing conditions can easily exploit the potentials of growing more than two crops in a year through intercropping, which is considered as an appropriate method for increasing production per unit land area with suitable farm management practices. There are not much reported studies available on the different intercrops in sugarcane growing areas in Pakistan. The present study was conducted with the following objective: *To explore the yield feasibility of sugarcane yield under different intercrops and its economics*

MATERIALS AND METHODS

Experimental site

The study regarding intercropping in spring planted sugarcane was conducted for one year during 2011-12 on a loam soil at research area University College of Agriculture, University of Sargodha, (32°.04' N, 72°.67' E), Pakistan. The climate of the region is subtropical semi-arid with annual average rainfall of 400±5 mm, and more than 70% of the rainfall occurs during June-Sept. (Source: Agro-Metrological Lab, University of Sargodha). Mean monthly minimum temperature is 10˚C in January and maximum temperature is 40˚C in July. The soil is the Hafizabad series (Fine-silty, mixed, hyperthermic typic calciargids) and the soil texture is loam and heavy loam (Khan, 1986). Selected chemical and physical characteristics were done before sowing: pH 7.8±0.1, electrical conductivity 2.18±0.3 dSm^{-1}, soil organic matter content 0.70%, total N 0.05%, available phosphorus 60 mg kg^{-1} and exchangeable potassium 80 mg kg^{-1}.

Layout and the experimental design

The experiment was laid out according to triplicate randomized complete block design using three replications. Net plot size was 4.2 m × 8.0 m for 120 cm spaced strips. The treatments comprised; sole sugarcane, SC + Wheat, SC+ Gram, SC + Soybean and SC + Potato (within 120 cm apart). Trenches were made with the help of tractor drawn ridger.

Crop husbandry

Sugarcane variety HSF-240 with seed rate of 75,000 double budded setts per hectare was sown in September during 2011-12. Fertilizer was applied at the rate of 175, 115 and 115 kg NPK ha^{-1}.

Data recording

Number of millable canes was counted from the two strips in each plot at final harvest and was converted to millable canes per square meter. At the time of harvest, diameter of ten randomly selected stripped canes from the base, middle and top was measured (cm) and averaged. Crop was harvested at maturity by taking an area of two strips x 8.0 m from each plot and stripped cane yield ha^{-1} was estimated. Crop growth rate was worked out as proposed by Hunt (1978).

$$CGR = (gm^{-2}\ d^{-1}) = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

Where W_1 and W_2 are the total dry weights harvested at times T_1 and T_2, respectively

Land equivalent ratio (LER) was computed according to the methods as suggested by Crookston and Hill (1979) using the following formula:

$$LER = \frac{\text{Yield of a in mixture}}{\text{Sole crop yield of a}} + \frac{\text{Yield of b in mixture}}{\text{Sole crop yield of b}}$$

Where a = Sugarcane

b = Intercrops

Net return was determined by subtracting the total cost of production from the gross income of each treatment (CIMMYT, 1988).

Net income = Gross income – Cost of production

Benefit-cost ratio was calculated by dividing the gross income with the total cost of production.

$$BCR = \frac{\text{Gross income}}{\text{Total cost}}$$

Statistical analysis

Data were analyzed statistically using SAS (SAS Institute 2008). The effects of intercropping was evaluated by the least significant difference (LSD) test at $p \leq 0.05$ unless otherwise mentioned. The computer package MS-Excel was used to prepare the graphs.

RESULTS AND DISCUSSION

Different intercrops effect sugarcane yield and land equivalent ratio

Sole SC and different intercrops in SC had a significant impact on all yield parameters (Table 1). Sole SC had (14.3 m^{-2}) that was 8 % higher millable cane compared than SC + Potato. In case of intercrops, SC + Gram gave significantly 3 %, 4 %, and 5 % higher millable cane SC + Wheat, SC + Soybean and SC + Potato. Sole SC produced significantly 6 % higher cane diameter than SC + Wheat. Among intercrops treatments, SC + Potato had significantly higher cane diameter than SC + Gram, SC + Soybean and SC + Wheat. Significantly, higher unstripped cane yield (121.8 t ha^{-1}) was noted in sole SC compared than SC + Wheat (113.57 t ha^{-1}). Among intercrops treatment, SC + Gram had 1 %, 2 % and 4 % higher than SC + Potato, SC + Soybean and SC + Wheat. Trend was same in case of stripped cane yield and significantly higher stripped cane yield (102.43 t ha^{-1}) was noted in sole SC than in the intercropped SC + Wheat (95.30 t ha^{-1}). SC + Gram produced significantly 2 %, 3 % and 4 % higher stripped cane yield than SC + Potato, SC + Soybean and SC + Wheat. The data relating to land equivalent ratio (LER) of sole SC and different intercrops in SC are presented in Table 1. The LER of different intercrops were in range between 1.53 and 1.61. In other words, the intercrops yield advantages varied from 53 to 61 % respectively. It could be inferred, that advantage due to intercrops per hectare yields were equal to sole SC yields obtained from 1.53 to 1.61 hectares. The highest LER of 1.61 was recorded for SC + Wheat intercrop geometry. The lowest LER of 1.53 was observed in SC+ Potato intercrop treatment.

All yield parameters number of millable cane, cane diameter, unstripped and striped cane yield were noted to be significantly higher in sole SC compared than different intercrops in SC. Significantly higher yield attributes in sole SC was due to availability of sufficient soil nutrients and no crop competition (Malik *et al*., 1993; Li *et al*., 2013). Among the intercrops, higher number of millable cane in gram was due to restorative in nature and lower number of millable cane was noted in potato (Rana *et al*., 2006). The difference in cane diameter among different intercrops was attributed to nature of intercrops and available size of spacing area (Cheema *et al*., 2002). Raskar and Bhoi, (2005) also observed same trend due to variation in cane diameter with different intercrops. Significantly, higher un-stripped and stripped cane yield was recorded in SC+ Gram rather than in other intercrops, which was due to the uptake and availability of residual nutrients done by the plants roots (Cabangon *et al*., 2002) and row spacing (Bashir *et al*., 2005). The LER of different intercrops as compared to their sole SC was found to be higher. This showed that different intercrops geometries were biologically more efficient as compared to their sole SC. It revealed that to produce the combined mixture yield by growing sole stands would need 53-61 % more land. Our results supported the findings of Sherma *et al*., (1993), Li *et al*., (2011).

Different intercrops effects on sugarcane growth

Crop growth rate (CGR) shows the rate of dry matter accumulation per unit area per day. Sole SC and different intercrops had significant effect on CGR during the study (Fig. 1). Early in the growing season, crop growth rate was low because of less expansion of leaves. Crop growth rate (Fig. 1) increased and attained maximum level at 210 DAS. After 210 days, it gradually decreased to 240 DAS then sharply declined to 270 DAS. After 270 days, CGR decreased but comparatively at lower rate. Maximum crop growth rate was obtained at 5^{th-} harvest while minimum crop growth rate was recorded at final harvest in all the treatments (Fig.1). Sole SC had significantly maximum crop growth rate (22.9 g m^{-2} d^{-1}) than intercrops. While in case of intercrops, significantly maximum CGR (22.0 g m^{-2} d^{-1}) was noted in SC + Gram and minimum CGR (19.8 g m^{-2} d^{-1}) was recorded in SC+ Wheat.

Significantly higher crop growth rate in sole SC was due to no crop competition, nutrients, space availability, which resulted well-developed root system. Deep root system enhanced the availability of sufficient moisture and nutrients for plant growth and development (Zang *et al*., 2008). Pammenter and Allison, (2002) and Nazir *et al*., (1988) reported higher crop growth rate of sole SC planted at triple row spacing than intercrops.

Different intercrops effects on sugarcane economics

The economic benefits got from different intercrops SC planting was compared with the sole SC (Table. 2). The data presented in Table. 2 revealed that all the intercrop treatments increased the net return from sole SC. The highest net return (Rs. 450244 ha^{-1}) was obtained from SC + Potato. The next highest net return (Rs. 433763 ha^{-1}) and (Rs. 431924 ha^{-1}) were given by the intercrops of SC + Wheat and SC + Gram, respectively. The lowest net return (Rs. 365121 ha^{-1}) was noted at sole SC. During study, maximum benefit cost ratio (5.40) was noted at sole SC while minimum benefit cost ratio in SC + Soybean (5.17) was observed. The sole SC produced 2-4 % greater BCR than different intercrops.

The net return from different treatments was calculated by subtracting the total cost of production for each treatment from its gross income. Higher values of net returns/net income was obtained from different intercrops than sole SC. Benefit cost ratio is another important economic parameter in which farmers are interested to see the gain in net returns with a given increase in total costs. Our findings supported the results of Rana *et al*., (2006) who reported that all the intercrops gave higher net return and lower benefit cost ratio compared than sole SC.

CONCLUSION

Sugarcane is an important cash crop of Pakistan. It has pivotal role in the growth of sugar industry, uplifting the socio-economic conditions of farmers, and contributing in the economic development. Intercropping has been recognized an excellent and alternative way to future crop production under threat of land, population and high monetary returns. The present study revealed that the sole SC gave more than 6 % and 13 % higher stripped cane yield and CGR than all intercrop treatments. Higher values of LER was noted in SC + Wheat than other treatments. Maximum net return was obtained in SC + Potato as compared with other intercrops and sole SC, while maximum BCR was noted in sole SC. Based on economics, it is recommended that resource poor farmers grow only sole sugarcane while resource rich farmers prefer to grow SC + Potato due to high returns.

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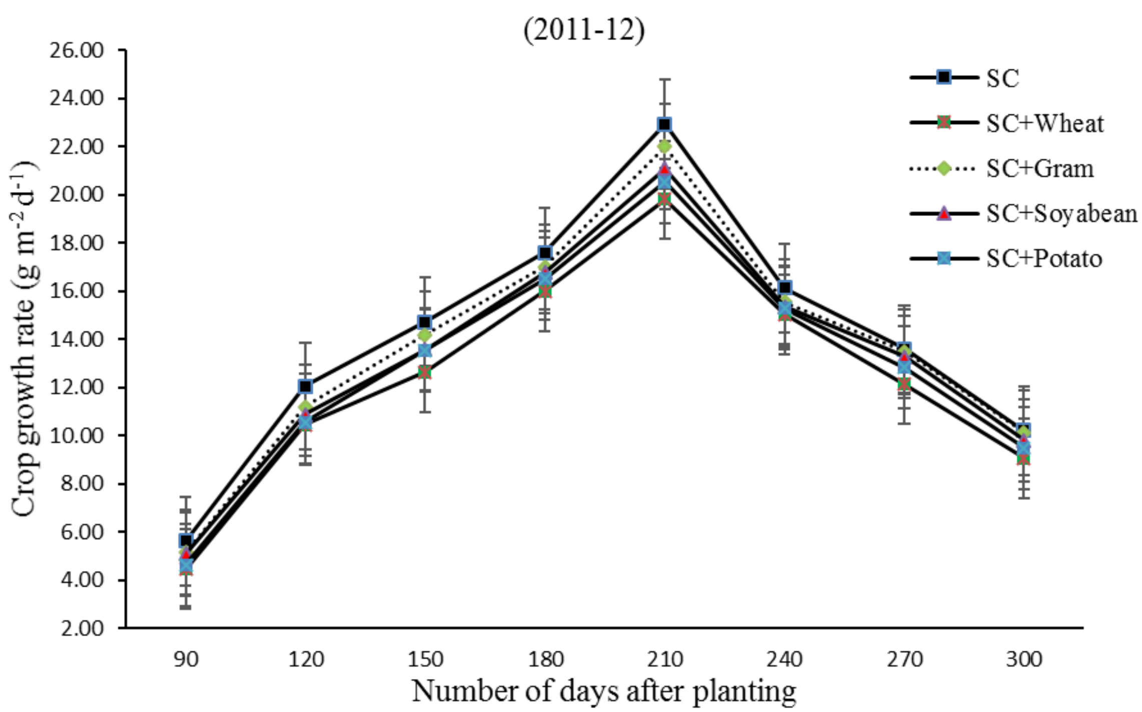

Figure-1: Periodic changes in crop growth rate of sugarcane in response of different intercropping

Table-1: Effect of different intercrops on growth and yield of triple row strip sugarcane

Intercropping	Number of millable canes (m^{-2})	Cane stem diameter (cm)	Un-stripped cane yield (t ha^{-1})	Stripped cane yield (t ha^{-1})	Land equivalent ratio
Sole SC	14.3 a	2.08 a	121.8 a	102.4 a	1.0
SC + Wheat	13.4 c	1.96 e	113.6 e	96.3 e	1.61
SC + Gram	13.9 b	1.99 c	118.5 b	99.7 b	1.56
SC + Soybean	13.3 d	1.97 d	116.1 d	96.5 d	1.55
SC + Potato	13.2 e	2.01 b	116.9 c	98.1 c	1.53
LSD $p \leq 0.05$	0.014	0.001	0.021	0.027	

SC = Sugarcane. SC + Wheat = Sugarcane-wheat intercropping. SC + Gram = Sugarcane-gram intercropping. SC + Soybean = Sugarcane-soybean intercropping. SC + Potato = Sugarcane-potato intercropping.

Table-2: Economics of various intercrop combination in September sown sugarcane

Intercropping	Gross income (Rs. ha^{-1})	Total Cost (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	Benefit cost ratio
Sole SC	448175	83054	365121	5.40
SC + Wheat	537335	103572	433763	5.18
SC + Gram	532823	100899	431924	5.28
SC + Soyabean	508199	98120	410079	5.17
SC + Potato	556021	105777	450244	5.25