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ECONOMIC ANALYSIS OF SUGARCANE *(Saccharum officinarum* L.) INTERCROPPING WITH CANOLA (*Brassica napus* L.)

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A study to compare the sugarcane yield and economics of sugarcane intercropped with the different densities of canola was carried out during 2008-09. The experiment was laid in Randomized Complete Block Design. The treatments included two row sugarcane sole strip, two rows sugarcane strip and single row of canola, two rows each of sugarcane and canola, two rows sugar cane strip and three rows of canola; and sole canola. The sole sugarcane gave significantly maximum biological and stripped cane yield of 164.0 and 102.2 t ha^{-1}, respectively, over the intercropped plots. Yield components of the sugarcane were also significantly ($P<0.05$) affected by the different treatments. The highest number of millable canes (279.5 thousand canes per ha^{-1}), cane length (2.32 m) and stem girth (2.90 cm) was found in the sole sugarcane crop. Sugar recovery influenced non-significantly by different intercropped treatments; however, more sugar recovery (14.51%) was observed in the treatment with two rows each of sugarcane and canola. Comparing the economics of the treatments it was observed that treatment with two rows sugarcane sole strip gave benefit cost ratio of 2.29.
Keywords: *Saccharum officinarum*, canola, intercropping, sugar recovery

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is the major source of sugar in the world. Besides sugar it also contributes in other products of industry as chipboard and paper. The by-products of sugarcane are also valuable as ethanol is used as energy sources and filter cakes used as organic manure. In Pakistan sugar is the vital source of sugar and 'Gur' production. Sugarcane contributes to the 0.7% to GDP. It was grown on 1029 thousand hectares with production of 50045 tons (Ministry of Finance, 2010) during 2008-09. Pakistan is the 15th largest producer of sugar in the world, 5th largest in terms of area under sugarcane cultivation and 60th in yield (Rehman *et al*., 2010).

Many successful intercropping systems have been evaluated through out the world, to get maximum production from the small land holdings. The most common advantage of intercropping is the efficient use of the available resources by a mixture of crops having different rooting ability, height, canopy structure and nutrient requirements (Lithourgidis *et al*., 2011). Mono-cropping is less economical to meet the farmers need. Sugarcane can be intercropped with different crops, i.e. sunflower (*Helianthus annus* L.), canola (*Brassica napus* L.), wheat (*Triticum aestivum* L.) and berseem (*Trifolium alexendrium* L.). The intercropping produces two crops in a year, but it also influence the yield and yield components of sugarcane by competing for nutrients and other environmental factors. Gill (1995) and Cheema *et al*. (2002) have reported that the sugarcane yield increases with the wider spacing and using the improved production techniques. The present study was, therefore, carried out to investigate the effect of canola intercropping on the cane yield and economics of sugarcane.

MATERIALS AND METHODS

A study was carried out at Faculty of Agriculture, Gomal University, Dera Ismail Khan, KPK, Pakistan to investigate the influence of different planting densities of canola as an intercrop on the cane yield of sugarcane. Sugar cane was sown in two row strips (30/90 cm) on 10th September, 2008, while canola was intercropped in sugarcane on 8th November, 2008. The experiment was laid out in a randomized complete block design (RCBD) with plot size of 4.8 x 8 m having four replications. The NPK fertilizer in sugarcane @ 175:100:100 and NP fertilizers for Canola @ 90:60 were used. Sugarcane cultivar HSF-240 and canola variety Tower was planted. The treatments used were T_1 (two rows sugar cane strips), T_2 (two rows sugarcane strips + single row of canola), T_3 (two rows sugar cane strips + two rows of canola), T_4 (two rows sugar cane strips + three rows of canola) and T_5 (sole canola). The parameters studied during the period of experiment were biological yield of sugarcane, stripped cane yield, canola yield, number of millable canes, cane length and stem girth. Percent sugar recovery was determined by calculating the Brix (%), Sucrose content (Pol %) and Purity (%). Brix was determined by the Brix hydrometer and sucrose content by polarimeter.

$$\text{Purity (\%)} = \frac{\text{Pol}}{\text{Brix}} \times 100$$

$$\text{Sugar (\%)} = 1 + \frac{100\,(\text{Purity} - 4)}{\text{Purity}\,(100 - 40)} \times 100 \times \text{Pol (\%)} \times 60 \times 100$$

Where
Brix (%): Percentage of total soluble solids in cane juice.
Pol (%): Percentage of sucrose content in whole cane.
Purity (%): Percentage of pure sucrose in dry matter.
The economics for each treatment was calculated at the end of the experiment. Statistical analysis was carried out by using the procedure given by Steel *et al*. (1997). The physico-chemical analysis of soil, carried out before the experiment is expressed in Table 1.

Table 1. Soil characterization of experimental site

Characteristics	
Texture	Silty clay
pH	8.31
EC (dSm^{-1})	1.65
Ca + Mg (meq L^{-1})	7.90
OM (%)	0.64
N (%)	0.032
P (%)	7.3
K (%)	243
Zn (mg kg^{-1})	1.13
B (mg kg^{-1})	1.12

RESULTS AND DISCUSSION

***Yield of sugarcane and canola as influenced by various intercropping treatments*:** The biological and stripped cane yield of sugarcane was significantly ($P \leq 0.05$) affected by various treatments. The significantly maximum biological yield (164.0 t ha^{-1}) was recorded in two rows sole sugarcane strip followed by two rows sugarcane strips with single row canola. However, the lowest biological yield (116.2 t ha^{-1}) was noted in two rows sugarcane strips with three rows of canola (Table 2). Similarly the stripped cane yield was the highest in sole sugarcane (102.2 t ha^{-1}) which was significantly greater than the intercropped sugarcane. The greater yield of the sole sugarcane may be due to less competition for the nutrients and space which enhanced the potential of the cane during development stage. Nazir *et al.* (2002) reported that sugarcane yield was reduced by 21.8% with intercropping of brassica. Similarly greater yield of sole sugarcane crop over the intercropped has also been observed by Fareed (1990).
The canola seed yield was also variable and showed significant differences amongst various treatments ($P \leq 0.05$). Sole canola gave significantly the highest seed yield of 1960.46 kg ha^{-1} followed by that of three strips of canola. The lowest seed yield of canola was found in the single row canola. Zulfiqar *et al*. (2000) found significantly more seed yield of canola as sole crop compared with wheat intercropped. Akram *et al*. (2007) found higher seed yield of

Table 2. Yield of sugarcane and canola as affected by different spacing

Treatments	Biological yield of sugarcane (t ha^{-1})	Stripped cane yield (t ha^{-1})	Grain yield of canola (kg ha^{-1})
T1 Two rows sole sugarcane strips (control)	164.0 a	102.2 a	--
T2 Two rows sugarcane strips + single row of canola	136.77 b	89.02 b	633.33 c
T3 Two rows sugarcane strips + two rows of canola	135.2 bc	83.57 b	821. 87 bc
T4 Two rows sugarcane strips + three rows of canola	116.2 c	80.40 b	915.58 b
T5 Sole canola crop	--	--	1960.46 a
LSD	19.10	10.52	221.9

Different letter(s) in column showed significant difference at LSD 5%.

Table 3. Yield components of sugarcane as affected by various treatments

Treatments	No. of millable canes (000 ha^{-1})	Cane length (m)	Stem girth (cm)	Sugar recovery (%)
T1 Two rows sugarcane strips (control)	279.5 a	2.32 a	2.90 a	12.91
T2 Two rows sugarcane strips + single row of canola	271.3 b	2.07 b	2.77 b	13.73
T3 Two rows sugarcane strips + two rows of canola	263.4 c	2.02 b	2.79 b	14.51
T4 Two rows sugarcane strips + three rows of canola	261.6 c	1.98 b	2.60 c	12.97
LSD	6.751	0.1548	0.0947	N.S

Different letter(s) in column showed significant difference at LSD 5%.

canola alone than intercropped with sunflower. Ali *et al*. (2000) recorded the minimum number of fruiting branches in canola planted with three rows of wheat.

***Yield and quality components of sugarcane as influenced by various intercropping treatments*:** Different yield related traits of sugarcane including number of millable canes, cane length and stem girth were measured for each treatment (Table 3). The results indicated that all the parameters were significantly ($P \leq 0.05$) affected by various combinations. Sole sugarcane crop produced significantly the highest number of millable canes (279.5 thousand canes ha^{-1}) followed by treatments with two rows of sugarcane intercropped with one row of canola (T_2), two rows of sugarcane with two rows of canola (T_3) and two rows of sugarcane with three rows of canola (T_4). The increased number of millable canes in the sole crop may be due to more number of total tillers per m^{-2}. Similar results for millable canes have also been reported by Chatha *et al*. (2007) for wider row spaced sugarcane crop. Different number of millable canes per unit area at different planting densities has also been mentioned by Fareed (1990) and Bashir (1997) in their studies.

The cane length is an important yield component which contributes to the biomass of the plant. The cane length was also significantly influenced by various treatments and the longest stalks were observed in two rows sole sugarcane strips (2.32 m) followed by two rows sugarcane strips intercropped with two rows of canola which was statistically at par with the rest of the treatments (Table 3). Maqsood *et al*. (2005) findings also revealed similar results for the cane length using various cropping patterns. Stem girth also showed a significant impact of various treatments. The stem girth of 2.90 cm was measured in sole sugarcane, followed by two rows sugarcane strips with single row of canola (T_2) which was at par with two rows sugarcane strips with two rows of canola (T_3). The lowest stem girth of 2.60 cm was found in two rows sugarcane strip intercropped with three rows of canola. Similar results were obtained during the study on intercropping carried by Nazir *et al*. (1990).

The quality of the cane is determined by the sugar content recovery. There was no significant difference in the sugar recovery percentage among different treatments. These findings are in contrast with those of Ricuad and Cochran (1980) who reported that sucrose content increased by various intercropping patterns.

***Economics of various treatments*:** Adaptability of a system depends upon the cost benefit ratio of the system. The economics of various treatments showed that the highest total income of Rs. 166075.00 ha^{-1} was obtained from the treatment T_1 (Two rows sugarcane strips) with the highest cost benefit ratio of 2.29. Whereas the lowest total income of Rs. 33327 was obtained from the treatment T_5 (canola) and the lowest cost benefit ratio of 1.41. Al-Azad and Alam (2004) recorded greater benefit cost ratio for sole sugar cane than those intercropped with potatoes, onion, coriander, mustard and garlic. Rasool *et al*. (2011) reported maximum economic return of Rs. 156641 ha^{-1} when sugarcane was planted without intercropping, whereas, intercropping of sugarcane with wheat resulted in minimum return.

It is concluded from the results that the highest biological, cane yield, total income and cost benefit ratio was obtained in the sole sugarcane crop. The yield of sugarcane decreased significantly with the increased in the number of rows of canola.

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