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Evaluation of sugar beet varieties in intercropping with sugarcane in North Karnataka

Vishwanatha S, Shwetha BN, Koppalkar BG, Kavya BM, Hiremath SM and Patil PL

Abstract
Field trial was conducted during two consecutive *kharif* seasons of 2010-11 and 2011-12 at Agricultural Research Station (ARS), Madhurakhandi (Dist. Bagalkot), University of Agricultural Sciences, Dharwad to evaluate tropical sugar beet cultivars (Cauvery, Shubhra, Magnolia and Calixta) with different row proportions (1:1, 1:2 and 1:3) in sugarcane. There were seventeen treatment combinations laid out in randomised complete block design with three replications. Pooled analysis results indicated that sole sugarcane and sugarcane (SC) + sugar beet (SB) in 1:1 RP recorded significantly higher cane (101.39 and 96.67 (average of all cultivars) t ha^{-1}, respectively) and sugar (11.07 and 10.56 (average of all cultivars) t ha^{-1}, respectively) yield when compared to other intercropped treatments (SC + SB in 1:2 and 1:3 RP). Sole sugar beet cultivars Cauvery and Shubhra recorded significantly higher tuber (85.58 and 79.84 t ha^{-1}, respectively) and sugar (9.76 and 9.00 t ha^{-1}, respectively) yield than intercropped treatments. In intercropping system sugar beet cultivars Cauvery and Shubhra in 1:3 and 1:2 row proportions recorded significantly higher tuber and sugar yield than 1:1 RP. Sugarcane (SC) + sugar beet (SB) (cv. Cauvery) in 1:2 and 1:3 RP recorded significantly higher gross returns (Rs. 300603 and 294345 ha^{-1}, respectively) and net returns (Rs. 208766 and 197398 ha^{-1}, respectively) when compared to other treatments, but B:C was significantly higher in 1:1 RP(3.29).

Keywords: sugarcane, sugar beet, intercropping, cultivar, row proportion

Introduction
Sugar is an essential commodity and an integral part of the 'food chain' and the cheapest source of energy. More than 100 countries in the world produce sugar, 60 per cent of which comes from sugarcane growing countries while, the rest (40%) comes from sugar beet growing countries [9]. Sugarcane is cultivated in more than 110 countries and it is grown in 26.09 million hectare with a production of 1, 842 million tonnes of cane [3]. In India it is grown in an area of 4.92 million hectares with a production of 348 million tonnes and average productivity of 70.72 t ha-1. Among major sugarcane growing states in India, Karnataka occupies third position in area (0.45 million hectares), third rank in production (3.78 million tonnes) and fifth position in productivity (84.07 t ha -1) [4].

Sugar beet (*Beta vulgaris* L.) belongs to the family Chenopodiaceae, is considered as the second important sugar crop all over the world after sugar cane (*Sacchurum officinarum* L.). It is grown in 57 countries. Top fifteen sugar beet producing countries are Russian Federation, Ukraine, United States of America, Germany, France, Turkey, China, Poland, Egypt, United Kingdom, Iran (Islamic Republic of), Belarus, Netherlands, Italy and Belgium. Sugar beet is mainly produced in Europe and, to a lesser extent, in Asia and North America [10]. It contributes about 21.8 % of world sugar [2]. It is a biennial halophytic as well as Na- salts scavenger C3 plant containing up to 20 % sugar on fresh weight basis. The storage organ of this plant is usually called the root, of which 90% is actually root derived and the remaining 10% (the crown) is derived from the hypocotyls [20].Composition wise, a freshly harvested sugar beet root contains 75-76% water, 15-20 % sugars, 2.6% non-sugars and 4-6 % the pulp. Processing one ton of fresh sugar beet roots yields 121 kg sugar, 38 kg molasses (containing 18.2 kg sugar, 12.1 kg impurities and 7.8 kg water) and 50 kg of pulp.

Sugar beet being a new crop to Karnataka in order to promote its cultivation, it is often difficult to replace the existing sugarcane. One of the options is to grow it as an intercrop in sugarcane. Since sugarcane crop being relatively long duration with initial slow growth for 3-4 months which facilitates growing of intercrops with sugarcane by using temporal and spatial dimensions. This helps in effective use of both the natural and the applied nutrients thereby improving productivity and profitability of the system. Several short duration crops have been tried as intercrops in sugarcane under normal row spacing of 90 cm have proved beyond doubt the intercrops had deleterious effect on growth and yield of sugarcane in majority of the cases [17]. One of the recent agro techniques that can be employed to reduce the intercrop competition is the introduction of wide row spacing in sugarcane cultivation. Basically the concept of wide row spacing was developed to facilitate mechanical harvesting of the cane. This technique would greatly facilitate not only easy management of intercropping with minimal competition effects, but also provide enough space for greater population of intercrops to get higher productivity.

The experiments conducted in the University of Agricultural sciences, Dharwad [18], proved that the sugar beet can be cultivated in different agro-climatic zones of Karnataka under tropical condition with excellent yield potential. However, the information on growing of sugar beet as intercrop in sugarcane is meagre in the northern region of Karnataka. Many varieties of sugar beet have already emerged out and the suitability of these varieties in intercropping for northern region of Karnataka is yet to be identified. Thus, development of suitable intercropping system by evaluating the performance of sugar beet cultivars in different row proportions with wider spacing of sugarcane (150 cm) is need of the hour to increase the sugar production per unit area and net income of the farmer. Besides this, sugar beet as an intercrop in sugarcane helps to augment ethanol requirement. Research conducted by Chattha *et al*. [8] and Bahadar *et al*. [6] has clearly indicated that sugar beet with sugarcane will help to achieve the interim income per unit area, which will ultimately improve the economic status of growers and sugar industry. Thus, obviously sugar beet crop can not only be the supplement crop of sugarcane but also can be grown with the sugarcane. Keeping these points in to consideration field experiment was conducted for two consecutive *kharif* seasons of 2010-11 and 2011-12 to evaluate sugar beet cultivars (Cauvery, Shubhra, Magnolia and Calixta) with different row proportions (1:1, 1:2 and 1:3) in sugarcane.

Materials and Methods

Field experiments were conducted at Agricultural research station, Madhurakhandi (Northern dry zone of Karnataka) during the *kharif*-2010-11 and 2011-12. The experimental location is situated at 16^0 20'N latitude, 75^0 20'E longitude and at an altitude of 715 meters above mean sea level. The soil of the experimental plot was black clay loam having pH and electrical conductivity of 8.27 and 0.15 ds m^{-1}, respectively. The soil was low in available nitrogen (252 kg ha^{-1}), medium in available phosphorus (36.8 kg ha^{-1}) and high in available potassium (353 kg ha^{-1}). The distribution of rainfall was normal during the crop season (512.8 mm during 2010-11 and 301.9 mm during 2011-12). Other meteorological parameters such as temperature (minimum and maximum), relative humidity did not deviate much from the normal to influence the crop performance to a great extent.

The experiment consisted of sole sugarcane (T_1), sole sugar beet cv. Cauvery (T_2), sole sugar beet cv. Shubhra (T_3), sole sugar beet cv. Mangolia (T_4), sole sugar beet cv. Calixta (T_5), sugarcane (SC) + sugar beet (SB) cv. Cauvery in 1: 1 row proportion (RP) (T_6), SC + SB cv. Cauvery in 1: 2 RP (T_7), SC + SB cv. Cauvery in 1: 3 RP (T_8), SC + SB cv. Shubhra in 1: 1 RP (T_9), SC + SB cv. Shubhra in 1: 2 RP (T_{10}), SC + SB cv. Shubhra in 1: 3 RP (T_{11}), SC + SB cv. Mangolia in 1: 1 RP (T_{12}), SC + SB cv. Mangolia in 1: 2 RP (T_{13}), SC + SB cv. Mangolia in 1: 3 RP (T_{14}), SC + SB cv. Calixta in 1: 1 RP (T_{15}), SC + SB cv. Calixta in 1: 2 RP (T_{16}) and SC + SB cv. Calixta in 1: 3 RP (T_{17}). All seventeen treatments were laid out in randomised block design with three replications. The recommended dose of N, P_2O_5 and K_2O (kg ha^{-1}) for sugarcane was 250:75 :190 + FYM @ 25 t $ha^{-1}$and for sugar beet 120 :60 :90+ FYM @ 10 t ha^{-1}.

During both the years (2010-11 and 2011-12), the land was brought to fine tilth by initial ploughing once with tractor drawn plough and twice with cultivator. Later field was harrowed twice with bullock pairs, stubbles and weeds were removed from the field. Afterwards the raised beds (for sugar beet sowing) were formed by opening ridges and furrows at 150 cm distance (for sugarcane planting) with tractor mounted ridger and furrow opener. Sugar beet crop was sown with the onset of monsoon during both years (26/06/2010 & 14/07/2011). Sugar beet seeds were sown by hand dibbling in three different row proportions on raised bed. The germination, emergence and growth of sugar beet were satisfactory which ensured better crop growth and yield. In addition, sugar beet was irrigated based on crop need at an interval of 15 days. After two months of sowing of sugar beet on the raised bed, furrows which were meant open during sugar beet sowing were reopened by bullock drawn ridge former for planting of sugarcane without affecting standing sugar beet crop (Plate-1). Sugarcane was planted in the month of September during both the years and irrigated immediately after planting and crop was irrigated at monthly interval as a result sugarcane crop growth was normal. The seed rate for sugarcane crop was 4.5 t cane setts ha^{-1} while for sugar beet it was 3.6 kg of seeds ha^{-1}.

During both the years (2010-11 and 2011-12), full amount of recommended dose of phosphorous through diammonium phosphate and potassium through muriate of potash and 10 per cent N in sugarcane and 50 per cent N in sugar beet through urea were applied as basal. The remaining 90 per cent of nitrogen in sugarcane was top dressed with 20, 30 and 40 per cent at 6^{th}, 10^{th} and 14^{th} weeks after planting, respectively. In sugar beet rest half nitrogen was top dressed at 45 DAS. All the recommended plant protection measures were undertaken during the experimentation. All the biometric observations were recorded at different stages of crop growth for both crops. Need based plant protection measures were given against pests and diseases for both sugarcane and sugar beet. The sugar beet crop matured in five months and 15 days. Matured sugar beet tubers were harvested and topped manually. At the time of harvest, pre harvest irrigation was given for easy harvest. The sugarcane crop was harvested at the age of 11 month. The quality parameters for both sugarcane and sugar beet were determined as per the method of Meade and Chen [13].

Results and Discussion

Performance of sugarcane

Two years pooled data analysis revealed that sugarcane yield differed significantly due to intercropping of sugar beet cultivars in different row proportions (RP) (Table 1). Sole

sugarcane recorded significantly higher cane yield (101.39 t ha^{-1}) compared to intercropped treatments (85.15 to 97.65 t ha^{-1}). However, growing of sugarcane (SC) and sugar beet (SB) in 1:1 RP (irrespective of sugar beet cultivars) remained on par with sole sugarcane. Significantly lower sugarcane yield was recorded under 1:3 RP. Significantly lower cane yield was observed in 1:2 and 1:3 RP on account of greater competition exerted by higher population of sugar beet for various growth resources. The population of sugar beet was 66 and 100 per cent in 1:2 and 1:3 RP, respectively as compared to 1:1 R (33%).The results are in conformity with the findings of Mahadevaswamy [12] and Singh and Vashist [22], wherein they reported that cane yield obtained in sugarcane + onion in 1:1 RP was on par with sole sugarcane. Further, they reported that as the row proportions of onion increased from 1:2 to 1:4, there was significant reduction in yield of sugarcane. Results are in concurrence with the findings of Bahadar *et al*. [6] in sugarcane + sugar beet.

The higher cane yield in sole sugarcane and sugarcane (SC) + sugar beet (SB) in 1:1 RP (irrespective of sugar beet cultivars) was due to higher yield attributes namely number of millable canes (NMC) (83190 and 79032 (average of all cultivars) ha^{-1}, respectively) and single cane weight (1420 and 1345 (average of all cultivars) g plant^{-1}, respectively) (Table 1). The higher NMC and single cane weight in sole sugarcane and SC + SB in 1:1 RP(average of all cultivars) are the reflections of other yield attributing characters like length of internode (10.62 and 9.97 cm, respectively), diameter of cane (2.58 and 2.54 cm, respectively) and number of internodes (22.41 and 21.83, respectively) at harvest. The differences in yield components in sole sugarcane and SC + SB in 1:1 RP could be traced back to significant differences with regard to total dry matter production (TDMP) (438.74 and 430.78 (average of all cultivars) g plant^{-1}, respectively)(Table 1).The higher TDMP in sole sugarcane and SC + SB in 1:1 RP (average of all cultivars) was the cumulative effect of higher growth characters such as plant height (165.42 and 159.36 cm, respectively) at harvest and leaf area index (1.72 and 1.57, respectively) at peak stage of crop. On the contrary these values were significantly lower in SC + SB intercropping involving 1:2 and 1:3 RP.

Among the different quality parameters (brix, sucrose, commercial cane sugar per cent and sugar yield) studied, significant variations were observed only in sugar yield due to intercropping of sugar beet cultivars in different row proportions (Table 1). Sole sugarcane recorded higher sugar yield (11.07 t ha^{-1}) compared to intercropped treatments. However, intercropping of SC + SB in 1:1(average of all cultivars) (10.56 t ha^{-1}) and 1:2 RP (9.98 t ha^{-1}) recorded at par sugar yield to that of sole sugarcane. Significantly lower sugar yield was recorded in 1:3 RP (9.40 t ha^{-1}). The higher sugar yield in sole sugarcane, SC + SB in 1:1 and 1:2 RP was due to higher cane yield compared to SC + SB 1:3 RP. The results are in line with the findings of Mahadevaswamy [12] and Bahadar *et al*. [6].

Performance of sugar beet

Pooled analysis for two years revealed that, tuber yield of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions (Table 2). Sole cultivars Cauvery and Shubhra recorded significantly higher tuber yield (85.58 and 79.84 t ha^{-1}, respectively) than cultivar Calixta (74.82 t ha^{-1}). Significantly the lower tuber yield was recorded in cultivar Magnolia (72.06 t ha^{-1}). Similar results were also reported by Rajashekaran [16], Balakrishnan and Selvakumar [7], Salimath and Lamani [18] and Yekkeli [23].The economic yield is a function of dry matter production, efficiency to translocate photosynthates from assimilatory area of the source (leaf) and accumulate in tuber (sink). The higher tuber yield with sole Cauvery and Shubhra cultivars was due to improvement in yield attributing characters such as tuber weight (1181 and 1127 g plant^{-1}, respectively), tuber length (39.65 and 38.60 cm, respectively) and tuber girth (28.99 and 28.25 cm, respectively) (Table 2).The differences in yield components of sugar beet could be traced back to the differences in the total dry matter production (TDMP) (Table 2). Significantly higher TDMP was recorded in sole cultivars Cauvery (225.18 g plant^{-1}) and Shubhra (223.05 g plant^{-1}) than cultivars Calixta and Magnolia. The latter cultivar recorded lower TDMP (219.65 g plant^{-1}). The higher TDMP in sole cultivars Cauvery and Shubhra could also be related to higher photosynthatically active assimilatory surface area. Photosynthetic capacity of a plant depends upon plant height (Table 2) and leaf area index (Table 2) at peak stage of crop growth (120 DAS). These growth parameters enabled the plant to trap higher quantity of solar energy with higher leaf surface area to convert into chemical energy. This helps in accumulation of higher dry matter in the economic parts which in turn might have led to the higher tuber yield.

Among the intercropped treatments tuber yield increased significantly with increase in the rows of sugar beet from 1:1 to 1:3 in all the cultivars. Accordingly, significantly higher tuber yield was recorded in 1:3 RP (54.14 to 64.20 t ha^{-1}, Av. 62.50 t ha^{-1}) followed by 1:2 RP (54.16 to 64.21 t ha^{-1} Av. 58.62 t ha^{-1}). The lowest tuber yield was recorded in 1:1 RP (32.62 to 38.54 t ha^{-1} Av. 35.21 t ha^{-1}) (Table 2). The higher tuber yield of sugar beet in 1:3 RP was mainly due to higher plant population of sugar beet than 1:1 and 1:2 RP. The population of sugar beet in 1:3 RP was same as that of sole sugar beet (100 %) while the population of sugar beet in 1:1 and 1:2 RP was 33 and 66 %, respectively. In the present investigation, sugar beet in 1:3 RP recorded higher tuber yield although the various growth and yield attributes were significantly lower compared with sugar beet in 1:1 and 1:2 RP.

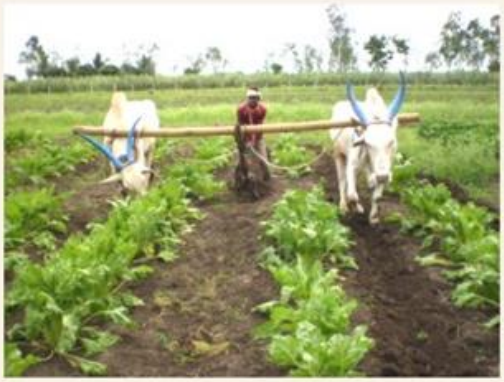
Similar to tuber yield, the sugar yield also showed significant variations among the intercropped treatments but was significantly lower compared to sole crop. Accordingly, significantly higher sugar yield was recorded in 1:3 RP (5.97 to 7.44 t ha^{-1}, Av. 6.61 t ha^{-1}) followed by 1:2 RP (5.50 to 6.90 t ha^{-1} Av. 6.10 t ha^{-1}). The lowest tuber yield was recorded in 1:1 RP (3.13 to 3.86 t ha^{-1} Av. 3.45 t ha^{-1}) (Table 2). The higher sugar yield of sugar beet in 1:3 RP was mainly due to higher tuber yield than 1:2 and 1:1 RP.

Economics of sugarcane + sugar beet intercropping system

Pooled analysis of the gross returns, net returns and benefit cost (B: C) ratio were influenced by intercropping of sugar beet cultivars with sugarcane depends upon the various factors such as any reduction in cane yield, yield of intercrop, cost of production and its market price. Significant differences were observed with respect to gross returns, net returns and B:C due to intercropping of sugar beet cultivars with sugarcane in different row proportions (Table 3). Among the different treatments, sugarcane (SC) + sugar beet (SB) (cv. Cauvery) in 1:2 and 1:3 RP recorded significantly higher gross returns (Rs. 300603 and 294345 ha^{-1}, respectively) and net returns (Rs. 208766 and 197398 ha^{-1}, respectively) when

compared to other treatments. The net returns recorded under 1:1 RP was comparable to that of 1:2 and 1:3 RP, though the tuber yield of sugar beet was significantly lower in former treatment which was compensated by the higher cane yield. The comparable net returns in above intercropped treatments could be attributed to variations in yield and cost of cultivation of component crops. The results corroborate the findings of Singh and Mehra [21], Singh and Vashist [22] and Sanjay Kumar *et al*. [19].The B:C of sugarcane and sugar beet intercropping system showed significant variations. Intercropping of sugarcane + sugar beet (cv. Cauvery) in 1:1 and 1:2 RP recorded significantly higher B:C (3.29 and 3.28, respectively) compared to 1:3 RP(3.04). While, significantly lower gross returns, net returns and B:C was recorded in sole sugarcane and sugar beet. The variations in B:C was due to variations in gross returns and cost of cultivation. The results obtained are in line with the work of Patil *et al*. [14] and Porwal *et al*. [15].

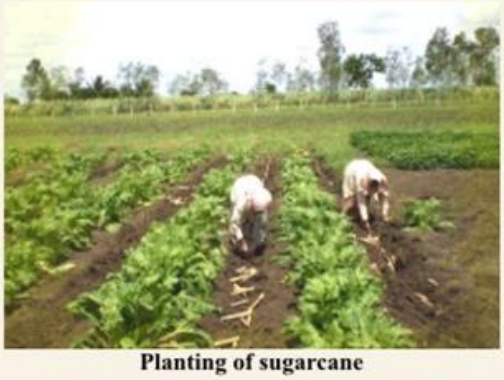
47



Reopening of furrows

Furrows kept ready for sugar cane planting

Sugarcane sets treatment for planting



Planting of sugarcane

Plate 1: Sugar cane planting in standing sugar beet crop (Experiment-I)

Table 1: Growth, yield and quality parameters of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions (Pooled data of two years- 2010 and 2011)

Treatment	Growth parameters			Yield parameters and yield						Quality parameters At harvest			
	Plant height (cm) At harvest	LAI At 270 DAP	TDMP At harvest (g plant^{-1})	NMC's (000 ha^{-1})	Cane weight (g plant^{-1})	Length of internode (cm)	Numberof internodes per plant	Diameter of cane (cm)	Cane yield (t ha^{-1})	Brix (%)	Sucrose (%)	CCS (%)	Sugar yield (t ha^{-1})
T_1 - Sole sugarcane (SC)	165.42a	1.72a	438.74a	83.19a	1420a	10.62a	22.41a	2.59a	101.39a	19.45a	16.26a	10.94a	11.07a
T_2 - Sole sugar beet cv. Cauvery	-	-	-	-	-	-	-	-	-	-	-	-	-
T_3 - Sole sugar beet cv. Shubhra	-	-	-	-	-	-	-	-	-	-	-	-	-
T_4 - Sole sugar beet cv. Magnolia	-	-	-	-	-	-	-	-	-	-	-	-	-
T_5 - Sole sugar beet cv. Calixta	-	-	-	-	-	-	-	-	-	-	-	-	-
T_6 - SC + SB cv. Cauvery (1:1 RP)	159.95ab	1.60a	429.88a-d	79.36ab	1360ab	10.03ab	21.98ab	2.54a	96.42a-c	19.43a	16.19a	10.87a	10.50ab
T_7 - SC + SB cv. Cauvery (1:2 RP)	150.47b-d	1.39bc	424.26b-d	74.57b-d	1250c-e	9.03c	20.85cd	2.45b	91.31b-e	19.42a	16.25a	10.93a	9.97ab
T_8 - SC + SB cv. Cauvery (1:3 RP)	143.83d	1.22cd	419.12cd	69.89d	1220de	8.78c	20.45d	2.44b	86.18de	19.41a	16.24a	10.92a	9.40b
T_9 - SC + SB cv. Shubhra (1:1 RP)	159.08a-c	1.56a	430.16a-c	77.11a-c	1350a-c	9.98ab	21.79a-c	2.55a	95.83a-d	19.43a	16.25a	10.93a	10.46ab
T_{10} - SC + SB cv. Shubhra (1:2 RP)	150.56b-d	1.38bc	424.18b-d	74.77b-d	1230de	9.22bc	20.66d	2.46b	91.20b-e	19.42a	16.22a	10.91a	9.97ab
T_{11} - SC + SB cv. Shubhra (1:3 RP)	144.90d	1.31cd	419.81cd	70.71cd	1210e	8.93c	20.20d	2.44b	87.17c-e	19.41a	16.24a	10.93a	9.53ab
T_{12} - SC + SB cv. Magnolia (1:1 RP)	158.93a-c	1.56ab	431.59ab	81.07ab	1330a-d	9.91ab	21.84a-c	2.54a	97.65ab	19.40a	16.22a	10.91a	10.68ab
T_{13} - SC + SB cv. Magnolia (1:2 RP)	151.12b-d	1.33c	424.08b-d	74.78b-d	1250b-e	9.46bc	21.12b-d	2.46b	91.47b-e	19.40a	16.24a	10.93a	10.02ab
T_{14} - SC + SB cv. Magnolia (1:3 RP)	146.07d	1.15d	419.47cd	70.12d	1210e	9.07c	20.92cd	2.43b	86.25de	19.37a	16.18a	10.88a	9.37b
T_{15} - SC + SB cv. Calixta (1:1 RP)	159.47ab	1.57a	431.51ab	78.59ab	1340a-c	9.95ab	21.73a-c	2.53a	96.75a-c	19.42a	16.22a	10.90a	10.57ab
T_{16} - SC + SB cv. Calixta (1:2 RP)	147.97cd	1.38c	424.58b-d	75.04b-d	1240c-e	9.26bc	20.57d	2.46b	91.23b-e	19.41a	16.25a	10.94a	9.97ab
T_{17} - SC + SB cv. Calixta (1:3 RP)	144.83d	1.31cd	418.72d	69.22d	1210e	9.03c	20.09d	2.43b	85.15e	19.38a	16.21a	10.91a	9.29b
S.Em±	3.82	0.06	3.83	2.32	0.04	0.28	0.36	0.02	3.32	0.61	0.51	0.34	0.48

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 2: Growth, yield and quality parameters of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane (Pooled data of two years- 2010 and 2011)

Treatment	Growth parameters			Yield parameters and yield				Quality parameters At harvest			
	Plant height (cm) At 120 DAS	LAI At 120 DAS	TDMP At harvest (g plant^{-1})	Tuber weight (g plant^{-1})	Tuber length (cm)	Tuber girth (cm)	Tuber yield (t ha^{-1})	Brix (%)	Sucrose (%)	CCS (%)	Sugar yield (t ha^{-1})
T_1 - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-	--	-
T_2 - Sole sugar beet cv. Cauvery	57.77a	7.63bc	225.18a	1181.07a	39.65a	28.99a	85.58a	22.81a	17.65a	11.38a	9.76a
T_3 - Sole sugar beet cv. Shubhra	57.16a	7.16de	223.05ab	1126.62ab	38.60ab	28.25ab	79.84ab	22.72a	17.49a	11.24a	9.00ab
T_4 - Sole sugar beet cv. Magnolia	56.40ab	7.09de	219.65b-d	1083.06a-d	37.30a-d	27.08a-e	72.06bc	22.47a	17.23a	11.05a	7.98b-d
T_5 - Sole sugar beet cv. Calixta	56.75ab	7.11de	221.14a-c	1104.84ab	37.95a-c	27.61a-d	74.82bc	22.62a	17.40a	11.18a	8.37bc
T_6 - SC + SB cv. Cauvery (1:1 RP)	56.12ab	4.80h	222.36ab	1101.87a-c	37.03a-e	28.04a-c	38.54h	21.23a	15.84a	9.99a	3.86h
T_7 - SC + SB cv. Cauvery (1:2 RP)	54.90ab	6.86ef	219.39b-d	1030.59b-e	35.34a-g	26.91a-e	64.21de	22.22a	16.85a	10.73a	6.90d-f
T_8 - SC + SB cv. Cauvery (1:3 RP)	53.05a-c	8.51a	216.53c-f	1007.82b-f	33.51d-g	25.39d-g	68.46cd	22.34a	17.00a	10.85a	7.44c-e
T $_9$ - SC + SB cv. Shubhra (1:1 RP)	55.32ab	4.78h	220.21b-d	1038.51b-e	36.12a-e	27.33a-e	35.98h	21.11a	15.65a	9.83a	3.54h
T_{10} - SC + SB cv. Shubhra (1:2 RP)	54.15ab	6.71f	217.21c-f	976.14c-g	34.06c-g	26.23b-g	59.95e-g	21.75a	16.38a	10.39a	6.24e-g
T_{11} - SC + SB cv. Shubhra (1:3 RP)	52.33bc	7.77b	214.45e-g	938.52e-g	32.67e-g	24.91e-g	63.89d-f	22.10a	16.66a	10.58a	6.76d-g
T_{12} - SC + SB cv. Magnolia (1:1 RP)	53.50ab	4.46h	216.80c-f	1008.81b-f	34.75b-g	26.17b-g	32.62h	20.74a	15.30a	9.58a	3.13h
T_{13} - SC + SB cv. Magnolia (1:2 RP)	51.98bc	6.34g	213.91e-g	942.48e-g	33.04d-g	24.94e-g	54.16g	21.30a	16.00a	10.14a	5.50g
T_{14} - SC + SB cv. Magnolia (1:3 RP)	48.46c	7.41cd	210.91g	880.11g	30.96g	23.82g	57.72e-g	21.57a	16.25a	10.31a	5.97fg
T_{15} - SC + SB cv. Calixta (1:1 RP)	54.26ab	4.70h	218.22b-e	1016.73b-f	35.48a-f	26.69a-f	33.70h	20.91a	15.47a	9.70a	3.27h
T_{16} - SC + SB cv. Calixta (1:2 RP)	53.21a-c	6.54fg	215.37d-g	962.28d-g	33.47d-g	25.48c-g	56.18fg	21.39a	16.12a	10.23a	5.76fg
T_{17} - SC + SB cv. Calixta (1:3 RP)	51.99bc	7.67bc	212.38fg	902.88fg	31.40fg	24.13fg	59.96e-g	21.92a	16.49a	10.46a	6.29e-g
S.Em±	1.67	0.12	1.67	43.60	1.53	0.91	2.70	0.93	0.70	0.44	0.46

Means followed by common letter do not differ significantly by DMRT @ p=0.05
Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 3: Economics of sugarcane and sugar beet intercropping system (Pooled data of two years- 2010 and 2011)

Treatment	Economics		
	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 - Sole sugarcane (SC)	237929d	159140c	3.02c-e
T_2 - Sole sugar beet cv. Cauvery	115062e	70199d	2.56f
T_3 - Sole sugar beet cv. Shubhra	107355e	62492d	2.39fg
T_4 - Sole sugar beet cv. Magnolia	96884e	52021d	2.16g
T_5 - Sole sugar beet cv. Calixta	100595e	55732d	2.24g
T_6 - SC + SB cv. Cauvery (1:1 RP)	278034bc	193558ab	3.29a
T_7 - SC + SB cv. Cauvery (1:2 RP)	300603a	208766a	3.28ab
T_8 - SC + SB cv. Cauvery (1:3 RP)	294345ab	197398ab	3.04b-e
T $_9$ - SC + SB cv. Shubhra (1:1 RP)	273273c	189116ab	3.25a-d
T_{10} - SC + SB cv. Shubhra (1:2 RP)	294611ab	203305ab	3.23a-d
T_{11} - SC + SB cv. Shubhra (1:3 RP)	290565a-c	194186ab	3.02de
T_{12} - SC + SB cv. Magnolia (1:1 RP)	273076c	189337ab	3.26a-c
T_{13} - SC + SB cv. Magnolia (1:2 RP)	287430a-c	196845ab	3.18a-e
T_{14} - SC + SB cv. Magnolia (1:3 RP)	280039bc	184429b	2.93e
T_{15} - SC + SB cv. Calixta (1:1 RP)	272459c	188585ab	3.25a-d
T_{16} - SC + SB cv. Calixta (1:2 RP)	289648a-c	198810ab	3.19a-d
T_{17} - SC + SB cv. Calixta (1:3 RP)	280448a-c	184559b	2.93e
S.Em±	7066	7066	0.08

Means followed by common letter do not differ significantly by DMRT @ p=0.05
Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Conclusion

The study revealed that, Sole sugarcane and sugarcane + sugar beet in 1:1 RP (irrespective of sugar beet cultivars) recorded significantly higher cane and sugar yield compared to sugarcane + sugar beet in 1:2 and 1:3 RP. Sole cultivars Cauvery and Shubhra recorded significantly higher tuber and sugar yield than intercropped treatments. In intercropping system cultivars Cauvery and Shubhra in 1:3 and 1:2 row proportions recorded significantly higher tuber and sugar yield than 1:1 RP. Sugarcane + sugar beet (irrespective of sugar beet cultivars) in 1:2 and 1:3 RP recorded significantly higher gross and net returns when compared to 1:1 RP, but B:C was significantly higher in 1:1 RP.

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