Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; SP6: 317-323

Vishwanatha S
Assistant Professor of Agrometeorology, Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

Shwetha BN
Assistant Professor, Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

Koppalkar BG
Professor and Head, Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

Kavya BM
M.Sc. scholar, India

Hiremath SM
Professor of Agronomy, Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India

Patil PL
Director of Research, University of Agricultural Sciences, Dharwad, Karnataka, India

Correspondence
Shwetha BN
Assistant Professor, Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

International Web-Conference
On
New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development
(21-22 June, 2020)

Productivity and feasibility of tropical sugar beet cultivars intercropping with sugarcane under different row proportions in Peninsular India

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

Abstract
The field experiment was carried out during 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. Results indicated that sole sugarcane and sugarcane (SC) + sugar beet (SB) in 1:1 RP recorded significantly higher cane (99.21 and 94.75 (average of all cultivars) t ha^{-1}, respectively) and sugar (10.73 and 10.26 (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 (82.47 and 76.95 t ha^{-1}, respectively) and sugar (9.38 and 8.65 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. 315802 and 310607 ha^{-1}, respectively) and net returns (Rs. 218446 and 207339 ha^{-1}, respectively) when compared to other treatments, but B:C was significantly higher in 1:1 RP(3.26).

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].

Sugarbeet (*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 sugarbeet 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. Sugarbeet 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 sugarbeet root contains 75-76% water, 15-20 % sugars, 2.6% non-sugars and 4-6 % the pulp.

Processing one ton of fresh sugarbeet 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 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

A field experiment was conducted at Agricultural research station, Madhurakhandi (Northern dry zone of Karnataka) during the *kharif*-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 (301.9 mm). 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}.

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 July. 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 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}.

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

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 (99.21 t ha^{-1}) compared to intercropped treatments (83.35 to 95.92 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) (8110 and 76767 (average of all cultivars) ha^{-1}, respectively) and single cane weight (1380 and 1310 (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 (10.38 and 9.72 cm, respectively), diameter of cane (2.55 and 2.50 cm, respectively) and number of internodes (21.88 and 21.33, 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) (431.27 and 423.90 (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 (163.03 and 157.77 cm, respectively) at harvest and leaf area index (1.61 and 1.48, 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 (10.73 t ha^{-1}) compared to intercropped treatments. However, intercropping of SC + SB in 1:1(average of all cultivars) (10.26 t ha^{-1}) and 1:2 RP (9.67 t ha^{-1}) recorded at par sugar yield to that of sole sugarcane. Significantly lower sugar yield was recorded in 1:3 RP (9.14 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

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 (82.47 and 76.95 t ha^{-1}, respectively) than cultivar Calixta (72.10 t ha^{-1}). Significantly the lower tuber yield was recorded in cultivar Magnolia (69.44 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 (1169 and 1115 g plant^{-1}, respectively), tuber length (38.43 and 37.40 cm, respectively) and tuber girth (28.10 and 27.37 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 (220.34 g plant^{-1}) and Shubhra (218.21 g plant^{-1}) than cultivars Calixta and Magnolia. The latter cultivar recorded lower TDMP (214.81 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 (55.62 to 65.97 t ha^{-1}, Av. 60.23 t ha^{-1}) followed by 1:2 RP (52.19 to 61.88 t ha^{-1} Av. 54.70 t ha^{-1}). The lowest tuber yield was recorded in 1:1 RP (31.43 to 37.14 t ha^{-1} Av. 33.92 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 (5.74 to 7.14 t ha^{-1}, Av. 6.35 t ha^{-1}) followed by 1:2 RP (5.28 to 6.62 t ha^{-1} Av. 5.85 t ha^{-1}). The lowest tuber yield was recorded in 1:1 RP (3.01 to 3.70 t ha^{-1} Av. 3.31 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

The economics of intercropping of sugar beet 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. 315802 and 310607 ha^{-1}, respectively) and net returns (Rs. 218446 and 207339 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 (3.26 and 3.24, respectively) compared to 1:3 RP(3.01). 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

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)	Number of 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)	163.03a	1.61a	431.27a	81.10a	1380a	10.38a	21.88a	2.55a	99.21a	19.33a	16.13a	10.84a	10.73a
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)	158.48ab	1.50a	422.45a-d	77.30ab	1320ab	9.76ab	21.46ab	2.50a	93.98a-d	19.31a	16.10a	10.82a	10.18ab
T_7 - SC + SB cv. Cauvery (1:2 RP)	147.77b-d	1.31bc	416.46b-d	72.83b-d	1210b-d	8.84cd	20.38b-d	2.42b	89.19b-e	19.30a	16.12a	10.84a	9.65ab
T_8 - SC + SB cv. Cauvery (1:3 RP)	142.79d	1.18cd	412.82cd	68.14d	1190cd	8.46d	19.96cd	2.40b	84.66de	19.30a	16.10a	10.82a	9.14ab
T_9 - SC + SB cv. Shubhra (1:1 RP)	157.01a-c	1.48a	423.66a-c	75.03a-c	1310a-c	9.72a-c	21.19a-c	2.51a	93.78a-d	19.31a	16.12a	10.84a	10.14ab
T_{10} - SC + SB cv. Shubhra (1:2 RP)	148.47b-d	1.29bc	417.04b-d	73.06b-d	1190b-d	9.05b-d	20.19b-d	2.41b	89.15b-e	19.30a	16.09a	10.81a	9.66ab
T_{11} - SC + SB cv. Shubhra (1:3 RP)	143.17d	1.22cd	413.26cd	68.94cd	1180d	8.71d	19.78d	2.39b	85.89c-e	19.29a	16.12a	10.84a	9.31ab
T_{12} - SC + SB cv. Magnolia (1:1 RP)	157.42ab	1.45ab	424.76ab	78.68ab	1300a-d	9.68a-c	21.38ab	2.50a	95.92ab	19.27a	16.09a	10.82a	10.40ab
T_{13} - SC + SB cv. Magnolia (1:2 RP)	149.36b-d	1.26c	417.31b-d	72.98b-d	1220b-d	9.25b-d	20.63b-d	2.41b	89.27b-e	19.28a	16.10a	10.83a	9.69ab
T_{14} - SC + SB cv. Magnolia (1:3 RP)	144.63d	1.07d	412.03d	68.40d	1200b-d	8.94b-d	20.44b-d	2.38b	84.64de	19.25a	16.05a	10.78a	9.12ab
T_{15} - SC + SB cv. Calixta (1:1 RP)	158.17ab	1.48a	424.73a-d	76.06ab	1310a-c	9.70a-c	21.29a-c	2.49a	95.30a-c	19.30a	16.09a	10.81a	10.32ab
T_{16} - SC + SB cv. Calixta (1:2 RP)	146.20cd	1.29bc	417.72b-d	73.23b-d	1210b-d	9.21b-d	20.09b-d	2.42b	89.34b-e	19.29a	16.12a	10.84a	9.67ab
T_{17} - SC + SB cv. Calixta (1:3 RP)	142.35d	1.28c	411.74d	68.06d	1170d	8.84cd	19.65d	2.39b	83.35e	19.26a	16.08a	10.81a	9.01b
S.Em±	3.84	0.06	3.76	2.25	0.05	0.31	0.47	0.03	3.30	0.61	0.50	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

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	55.68a	7.28bc	220.34a	1169.14a	38.43a	28.10a	82.47a	22.79a	17.62a	11.35a	9.38a
T_3 - Sole sugar beet cv. Shubhra	55.08ab	6.81de	218.21ab	1115.24ab	37.40ab	27.37ab	76.95ab	22.70a	17.46a	11.21a	8.65ab
T_4 - Sole sugar beet cv. Magnolia	54.36a-c	6.74de	214.81b-d	1072.12a-c	36.14a-d	26.24a-e	69.44c	22.45a	17.20a	11.02a	7.67b-d
T_5 - Sole sugar beet cv. Calixta	54.69a-c	6.76de	216.30a-d	1093.68ab	36.77a-c	26.75a-c	72.10bc	22.60a	17.37a	11.15a	8.02bc
T_6 - SC + SB cv. Cauvery (1:1 RP)	54.09a-c	4.57h	217.52a-c	1090.74ab	35.89a-d	27.18ab	37.14g	21.21a	15.81a	9.97a	3.70i

T_7 - SC + SB cv. Cauvery (1:2 RP)	52.91a-c	6.52ef	214.55b-g	1020.18b-d	34.24a-d	26.08a-e	61.88de	22.20a	16.82a	10.71a	6.62d-f
T_8 - SC + SB cv. Cauvery (1:3 RP)	51.12a-d	8.07a	211.69d-i	997.64b-e	32.48d-g	24.61c-g	65.97cd	22.32a	16.97a	10.82a	7.14c-e
T_9 - SC + SB cv. Shubhra (1:1 RP)	53.32a-c	4.55h	215.37b-d	1028.02b-d	35.01a-e	26.49a-d	34.67g	21.09a	15.62a	9.81a	3.40i
T_{10} - SC + SB cv. Shubhra (1:2 RP)	52.18a-c	6.36f	212.37c-h	966.28c-f	33.00c-g	25.42b-f	57.77ef	21.73a	16.36a	10.37a	5.98f-g
T_{11} - SC + SB cv. Shubhra (1:3 RP)	50.43b-d	7.33b	209.61f-i	929.04d-f	31.66e-g	24.14e-g	61.58de	22.08a	16.64a	10.55a	6.48er-g
T_{12} - SC + SB cv. Magnolia (1:1 RP)	51.56a-c	4.23h	211.96c-h	998.62b-e	33.67b-g	25.36b-g	31.43g	20.73a	15.27a	9.56a	3.01i
T_{13} - SC + SB cv. Magnolia (1:2 RP)	50.10cd	5.99g	209.07gi	932.96d-f	32.02d-g	24.17d-g	52.19f	21.29a	15.98a	10.11a	5.28h
T_{14} - SC + SB cv. Magnolia (1:3 RP)	46.46d	6.97cd	206.07i	871.22f	30.00g	23.09g	55.62ef	21.56a	16.23a	10.29a	5.74f-h
T_{15} - SC + SB cv. Calixta (1:1 RP)	52.29a-c	4.47h	213.38b-g	1006.46b-e	34.39a-f	25.87a-e	32.47g	20.90a	15.44a	9.68a	3.14i
T_{16} - SC + SB cv. Calixta (1:2 RP)	51.28a-c	6.20fg	210.53e-i	952.56c-f	32.44d-g	24.70c-g	54.15f	21.38a	16.10a	10.21a	5.52gh
T_{17} - SC + SB cv. Calixta (1:3 RP)	50.11cd	7.24bc	207.54hi	893.76ef	30.43fg	23.39fg	57.78ef	21.90a	16.47a	10.43a	6.04f-h
S.Em±	1.67	0.12	1.67	42.87	1.44	0.81	2.49	0.93	0.70	0.44	0.36

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

Treatment	Economics		
	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 - Sole sugarcane (SC)	248026e	166109c	3.03a-c
T_2 - Sole sugar beet cv. Cauvery	123709f	76814d	2.64de
T_3 - Sole sugar beet cv. Shubhra	115422f	68527d	2.46ef
T_4 - Sole sugar beet cv. Magnolia	104165f	57270d	2.22f
T_5 - Sole sugar beet cv. Calixta	108154f	61259d	2.31f
T_6 - SC + SB cv. Cauvery (1:1 RP)	290675b-d	201495ab	3.26a
T_7 - SC + SB cv. Cauvery (1:2 RP)	315802a	218446a	3.24ab
T_8 - SC + SB cv. Cauvery (1:3 RP)	310607ab	207339ab	3.01a-c
T_9 - SC + SB cv. Shubhra (1:1 RP)	286452d	197618ab	3.22ab
T_{10} - SC + SB cv. Shubhra (1:2 RP)	309527a-c	212747ab	3.20ab
T_{11} - SC + SB cv. Shubhra (1:3 RP)	307089a-d	204436ab	2.99bc
T_{12} - SC + SB cv. Magnolia (1:1 RP)	286956cd	198575ab	3.25ab
T_{13} - SC + SB cv. Magnolia (1:2 RP)	301455a-d	205456ab	3.14a-c
T_{14} - SC + SB cv. Magnolia (1:3 RP)	295036b-d	193217b	2.90cd
T_{15} - SC + SB cv. Calixta (1:1 RP)	286954cd	198428ab	3.24ab
T_{16} - SC + SB cv. Calixta (1:2 RP)	304574a-d	208302ab	3.16ab
T_{17} - SC + SB cv. Calixta (1:3 RP)	295043a-d	192922b	2.89cd
S.Em±	7962	7962	0.09

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.

Acknowledgement

The authors acknowledged to Agricultural Research Station (ARS), Madhurakhandi (Dist. Bagalkot), University of Agricultural Sciences, Dharwad Karnataka for facilitate conducting the field experiment.

References

1. Ahlawat IPS, Omprakash, Saini GS. Scientific crop production in India. Aman Publishing House, Meerut, 2002, 576p.
2. Anonymous. Hand Book of Agriculture (Published by Indian Council of Agricultural Research, New Delhi – 110 012), 2013.
3. Anonymous. Ministry of Agriculture, Govt. of India, 2016a, www.indiastat.com
4. Anonymous. Ministry of Agriculture, Govt. of India, 2017, www.indiastat.com
5. Anonymous, 2011. www.faostat.fao.org/site/567/page105

67/anchor2013.
6. Bahadar K, Sadiq M, Subhan M, Khan AU, Khan P, Khan D. Production potential of sugar beet intercropping with sugarcane under various planting geometry system. Pakistan Sugar J. 2007; 22(1):76-81.
7. Balakrishnan A, Selvakumar T. Evaluation of suitable tropical sugar beet hybrids with optimum time of sowing. Sugar Tech. 2009; 11(1):65-68.
8. Chattha AA, Grawal M, Fayyaz A. Feasibility of sugarcane, sugarbeet intercropping in central Punjab. Pakistan. Sugar J. 2003; 28(6):65-67.
9. Leilah AA, Badawi MA, Said EM, Ghonema MH, Abdou MAE. Effect of planting dates, plant population and nitrogen fertilization on sugar beet productivity under the newly reclaimed sandy soils in Egypt. Scientific J. King Faisal Univ., (Basic and Applied Sciences). 2005; 6(1):95-110.
10. Kumar R, Pathak AD. Recent trend of sugarbeet in world. Souvenir- IISR-Industry Interface on Research and Development Initiatives for Sugarbeet in India, 28-29 May, Sugarbeet Breeding Outpost of IISR IVRI Campus, Mukteswar-263138, Nainital. Organised by Indian Institute of Sugarcane Research (ICAR) and Association of Sugarcane Technologists of India, 2013, 46-47p.
11. Mahadevaswamy M, Martin GJ. The productivity and feasibility of onion (*Allium cepa* var. *Aggregatum*) intercropping under normal and wide row sugarcane in tropical India. Sugarcane Intl. 2002, 25-29p.
12. Mahadevaswamy M. Studies on intercropping of aggregatum onion (*Allium cepa* var. *aggregatum*) in wide spaced sugarcane. *Ph. D., Thesis* submitted to Tamil Nadu Agric. Univ. Coimbatore (India), 2002.
13. Meade GP, Chen ICP. Cane sugar handbook 9th Edn. John Willey and Sons INC. New York, 1977.
14. Patil PB, Mathad JC, Rajanna KM, Patil SS, Pujari BT, Goudreddy BS. Growth, yield and economics of sugarcane intercropped with vegetables. Farming System. 1991; 1:27-34.
15. Porwal MK, Dhakar LL, Bhatnagar GS. Economics of intercropping with autumn sugarcane in command area of southern Rajasthan, Indian J. Agron. 1994; 39:392-396.
16. Rajashekharan M. Effect of drip fertigation on growth, yield and quality of tropical sugar beet. *M. Sc*. (*Agri) Thesis*, submitted to Tamil Nadu Agricultural University, Coimbatore, India, 2007.
17. Roodagi LI, Itnal CJ, Khandagave RB. Influence of planting system and intercrops on sugarcane tillering and yield. Indian Sugars. 2005; 50(9):605-609.
18. Salimath PM, Lamani KD. Evaluation of sugarbeet varieties in northern Karnataka. Proc. Sugarbeet as alternate feedstock for sugar, ethanol, biogas (Electricity, CNG & cooking) held on 26th March 2010 at Chancexy pavilion, Bangalore, 2010.
19. Sanjay Kumar, Singh SS, Adesh Singh. Production potential of winter vegetables as intercrops in autumn planted sugarcane under valley conditions of Uttarakhand. Progressive Hort. 2011; 43(1):54-58.
20. Shrivastava AK, Shukla SP, Sawnani A. Useful products from sugarbeet. Souvenir- IISR-Industry Interface on Research and Development Initiatives for Sugarbeet in India, 28-29 May, Sugarbeet Breeding Outpost of IISR IVRI Campus, Mukteswar-263138, Nainital. Organised by Indian Institute of Sugarcane Research (ICAR) and Association of Sugarcane Technologists of India, 2013, 43-45p.
21. Singh A, Mehra SP. Yield and economics of various sugarcane based intercropping systems. *J. Res., Punjab* Agric. Univ. 1995; 32:259-64.
22. Singh A, Vashist KK. Rabi onion-intercropping in autumn planted sugarcane. Sugar Tech. 2004; 6(1&2):101-102.
23. Yekkeli NR. Intercropping of sugar beet with sugarcane under different spacing regimes, Proc. of 9th Joint Conv. of STAI and SISSTA, 2010, 222-227.