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Economics and yield advantages of Sugarcane and Sugarbeet intercropping system in Northern Karnataka

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

Abstract
Field trials were conducted during two consecutive *kharif* seasons of 2010-11 and 2011-12 at 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. On the basis of results obtained from pooled analysis of two years data, Intercropping of Sugarcane + sugar beet (irrespective of sugar beet cultivars) in 1:2 and 1:3 RP recorded significantly higher net returns (Rs.196845 to 208766 ha^{-1} & Rs.184429 to 197398 ha^{-1} in 1:2 and 1:3 RP, respectively) but B:C was significantly higher in 1:1 RP (3.25 to 3.29). Similarly with respect to intercropping yield advantages, sugarcane + sugar beet (irrespective of sugar beet cultivars) in 1:2 and 1:3 RP recorded significantly higher sugarcane equivalent yield (SEY) (122.43 to 128.03 t ha^{-1} & 119.24 to 125.32 t ha^{-1} in 1:2 and 1:3 RP, respectively), LER (1.66 & 1.65to 1.67 in 1:2 and 1:3 RP, respectively), ATER (1.08 & 1.05 to 1.07 in 1:2 and 1:3 RP, respectively) and SPI (184.89 to 206.93 & 183.89 to 204.21 in 1:2 and 1:3 RP, respectively),when compared to 1:1 RP [(SEY:116.02 to 118.45 t ha^{-1}), (LER: 1.40 to 1.41),(ATER:1.00 to 1.01) and (SPI:160.30 to 185.06)].

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

Introduction
Sugarcane (*Saccharum officinarum* L.) is an important agro-industrial crop of tropical and sub-tropical regions of world and is cultivated in more than 110 countries. It is grown occupies in 26.09 million hectare with a production of 1, 842 million tonnes of cane (Anon., 2016). Sugarcane occupies an important position in Indian agriculture and plays a pivotal role in national economy by sustaining the second largest organized agro industry in the country next to textile. In India sugarcane 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 [3]. 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) [3]. In recent years sugarcane farming is facing serious challenges in terms of sustainability and is severely affected by multiple factors like climate change, escalating cost of production, labour scarcity, slashing sugar prices in the market, declining soil health *etc*. There is a little scope for increasing area under sugarcane due to heavy competition for food, fiber, oilseed, pulses *etc.* Therefore, the only alternative left is to increase the vertical production of sugarcane and sugar by finding out the efficient agronomic management practices. In recent years wider row planting technique (5 to 8 feet) is being popularized in tropical regions of sugarcane growing areas in India [1]. Planting cane in wider rows helps in mechanization of several field operations *viz*., inter cultivation, aftercare and harvesting, thereby not only increases the efficiency but also results in reducing the cost of production. Much of the space between two rows of sugarcane remains unutilized for an initial period of 100-120 days, because of its slow growth.

Due to the wider row spacing and initial slow growth rate of sugarcane, there is ample scope for intercropping in sugarcane. Much of the space between two rows of sugarcane remains unutilized for an initial period of 100-120 days, because of its slow growth. Due to the wider row spacing and initial slow growth rate of sugarcane, there is ample scope for intercropping in sugarcane. The major objectives of intercropping are to produce an additional crop, to optimize the use of natural resources and to stabilize the yield of crops [17]. The space available in between the wide row can be suitably used for growing component crops for increasing the total production per unit area.

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. The experiments conducted in the University of Agricultural sciences, Dharwad [12], 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 [5, 4] 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

A field experiment was conducted at Agricultural research station, Madhurakhandi (Northern dry zone of Karnataka) during the *kharif*-2010-11. 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 bee *et al.* :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}.

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 [9].

Production efficiency indices of intercropping systems

Land equivalent ratio (LER)

It is defined as the relative land area under sole crops that is required to produce the yields obtained in intercropping at the same level of management. LER was worked out by using the following formula given by Willey [17].

LER= La + Lb = Ya/Sa + Yb/Sb

Where,

La and Lb = LER for the crop 'a' and 'b'

Ya and Yb = Individual crop yields under intercropping

Sa and Sb = Individual crop yields under sole cropping

Area time equivalent ratio (ATER)

The limitation in the use of LER is the emphasis on the land area without consideration of time the field is dedicated to production. To correct this deficiency, the LER was modified by Hiebsch and Maccollum [7] to include the duration of time the crop was on the land from planting to harvest. This method is known as the area time equivalent ratio (ATER).

ATER was calculated by the formula evolved by Hiebsch and

Maccollum [7].

$$ATER = \frac{(RYa \text{ X } ta) + (RYb \text{ X } tb)}{T}$$

Where,
RY = Relative yield of species 'a' and 'b'
Yield of intercrop per hectare

$$RY = \frac{\text{Yield of intercrop per hectare}}{\text{Yield of monocrop per hectare}}$$

t = Duration (days) for species 'a' and 'b'
T = Total duration (days) of the intercropped system

Sugarcane equivalent yield (SEY, t ha^{-1})
The sugarcane equivalent yield of intercropping system was calculated by taking into account the yield of component crops (sugarcane and sugar beet) and the prevailing market price of both the crops. The sugarcane equivalent yield was calculated as

$$SEY \text{ (kg ha}^{-1}\text{)} = \text{Sugarcane yield (t ha}^{-1}\text{)} + \frac{\text{Sugar beet yield (t ha}^{-1}\text{)} \times \text{price of sugar beet (Rs. /tonne)}}{\text{Sugarcane price (Rs. /tonne)}}$$

System productivity index (SPI)
System productivity index (SPI) proposed by Odo [10], standardizes the economic yield of intercrops (secondary crop) in terms of the main (primary) crop yield. The SPI assists to identify the combination utilizing the growth resources most effectively and maintains a stable yield performance. It was calculated as

$$SPI = \frac{SA}{LB} \text{ x } Lb + Sa$$

Where,
SA and LB are mean yields of sole crops and Sa and Lb are their yields in intercropping system.
Fischer's method of analysis of variance was used for analysis and interpretation of the data as outlined by Gomez and Gomez [6]. The level of significance used in 'F' and 'T' tests was p=0.05. Critical differences were calculated wherever 'F' test was significant. Means were compared by Duncan Multiple Range Test (DMRT). The data were analysed statistically following computer package MSTAT-C and DMRT was used to determine the significant differences among the treatment means.

Results and Discussion

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.
Two years pooled data analysis revealed that there was 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 1).
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 Vashist [15] and Sanjay Kumar *et al* [13].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 (3.33 and 3.31, respectively) compared to 1:3 RP(3.07). 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 Porwal *et al*. [11].

Production efficiency indices of intercropping systems
Pooled analysis for two years revealed that, the data computed on intercropping indices like sugarcane equivalent yield (SEY), LER, ATER and SPI differed significantly due to sugar cane + sugar beet intercropping at different row ratio.
Among the different treatments, sugarcane (SC) + sugar beet (SB) (irrespective of cultivars) in 1:2 and 1:3 RP recorded significantly higher sugarcane equivalent yield (SEY) (122.43 to 128.03 t ha^{-1} & 119.24 to 125.32 t ha^{-1} in 1:2 and 1:3 RP, respectively) when compared to SC + SB in 1:1 RP (116.02 to 118.45 t ha^{-1}). Sole sugarcane (101.39 t ha^{-1}) and sugar beet [(44.64 t ha^{-1} (Avg. of all cultivars)] recorded significantly lower sugarcane equivalent yield. The higher SEY in SC + SB in 1:2 and 1:3 RP was due to higher yield and market price of both the crops. Significantly lower SEY was recorded in sole sugarcane and sugar beet on account of lower yield. These findings are in line with observations made by Sanjay Kumar *et al*. [13].
All the intercropping treatments recorded higher LER and ATER over sole cropping of either sugarcane or sugar beet. Among the intercropping system, irrespective of sugar beet cultivars SC + SB in 1:2 and 1:3 RP recorded significantly higher LER and ATER when compared to SC + SB in 1:1 row proportion (Table 2).The higher LER values in the intercropped treatments were due to higher yield of component crops in relation to their sole crops. This was evident by higher combined yield of both the crops per unit area. The higher combined yield in turn could be related to the fact that component crops differed in utilization of growth resources and converting them more efficiently into economic part leading to higher yield per unit area. Similar to LER, the higher ATER values in the above treatments indicate that both sugarcane as well as sugar beet were not only efficient in use of land but also efficient in use of time. The variations in ATER values in intercropping treatments could be attributed to higher productivity per unit area per unit time.
System productivity index (SPI) differed significantly due to intercropping of sugar beet cultivars with sugarcane at different row proportions (Table 2). Among the cropping system, irrespective of sugar beet cultivars, SC + SB in 1:2 and 1:3 RP recorded significantly higher SPI when compared

with SC + SB in 1:1 RP. The latter treatments recorded lowest SPI. This clearly indicates that growing of sugar beet as an intercrop in sugarcane in 1:2 and 1:3 RP helped to increase the total productivity of the system although the component crops were affected in intercropping system compared to sole stands. This was evident from the SEY data.

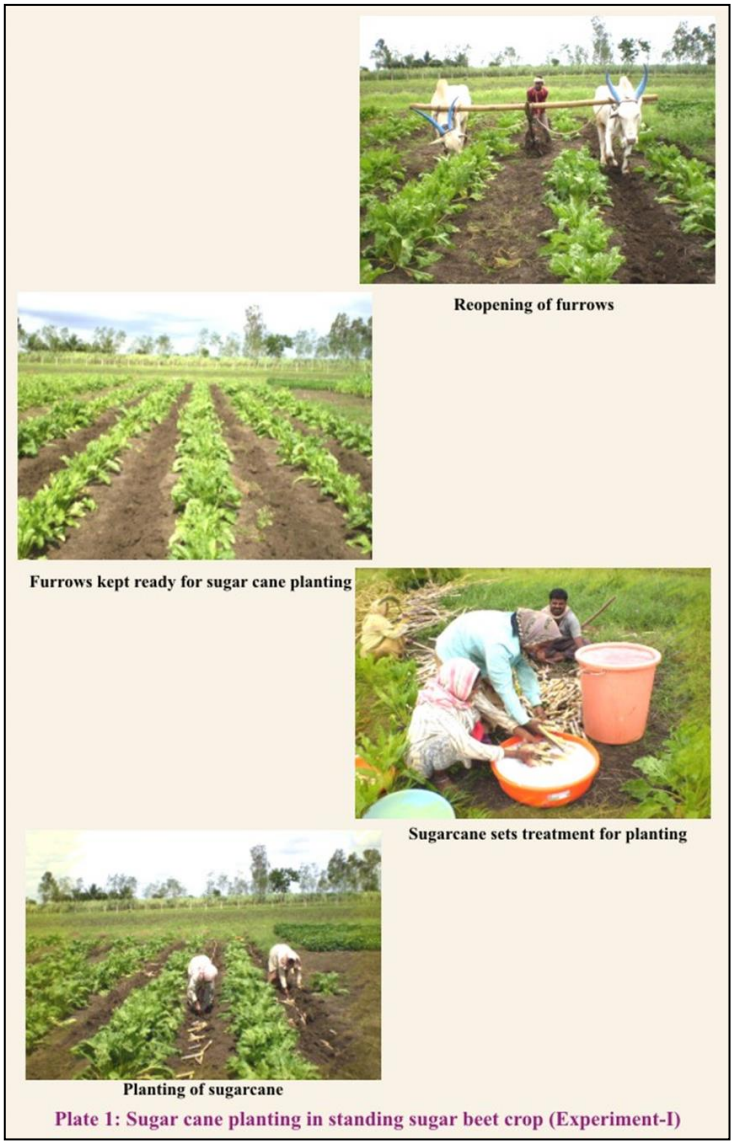

Plate 1: Sugar Cane planting standing sugar beet crop (Experiment-I)

Table 1: Yield and economics of sugarcane and sugar beet intercropping system (Pooled data of two years- 2010 and 2011)

Treatment	Yield (t ha^{-1})		Economics		
	Sugarcane	Sugarbeet	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 - Sole sugarcane (SC)	101.39a	-	237929d	159140c	3.02c-e
T_2 - Sole sugar beet cv. Cauvery	-	85.58a	115062e	70199d	2.56f
T_3 - Sole sugar beet cv. Shubhra	-	79.84ab	107355e	62492d	2.39fg
T_4 - Sole sugar beet cv. Magnolia	-	72.06bc	96884e	52021d	2.16g
T_5 - Sole sugar beet cv. Calixta	-	74.82bc	100595e	55732d	2.24g
T_6 - SC + SB cv. Cauvery (1:1 RP)	96.42a-c	38.54h	278034bc	193558ab	3.29a
T_7 - SC + SB cv. Cauvery (1:2 RP)	91.31b-e	64.21de	300603a	208766a	3.28ab
T_8 - SC + SB cv. Cauvery (1:3 RP)	86.18de	68.46cd	294345ab	197398ab	3.04b-e
T_9 - SC + SB cv. Shubhra (1:1 RP)	95.83a-d	35.98h	273273c	189116ab	3.25a-d
T_{10} - SC + SB cv. Shubhra (1:2 RP)	91.20b-e	59.95e-g	294611ab	203305ab	3.23a-d
T_{11} - SC + SB cv. Shubhra (1:3 RP)	87.17c-e	63.89d-f	290565a-c	194186ab	3.02de
T_{12} - SC + SB cv. Magnolia (1:1 RP)	97.65ab	32.62h	273076c	189337ab	3.26a-c
T_{13} - SC + SB cv. Magnolia (1:2 RP)	91.47b-e	54.16g	287430a-c	196845ab	3.18a-e
T_{14} - SC + SB cv. Magnolia (1:3 RP)	86.25de	57.72e-g	280039bc	184429b	2.93e
T_{15} - SC + SB cv. Calixta (1:1 RP)	96.75a-c	33.70h	272459c	188585ab	3.25a-d
T_{16} - SC + SB cv. Calixta (1:2 RP)	91.23b-e	56.18fg	289648a-c	198810ab	3.19a-d
T_{17} - SC + SB cv. Calixta (1:3 RP)	85.15e	59.96e-g	280448a-c	184559b	2.93e
S.Em±	3.32	2.70	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

Table 2: Yield advantages of sugarcane and sugar beet intercropping system Pooled data of two years- 2010 and 2011)

Treatment	Intercropping indices			
	Sugarcane equivalent yield (t ha^{-1})	Land equivalent ratio	Area time equivalent ratio	System productivity index
T_1 - Sole sugarcane (SC)	101.39d	1.00c	1.00b	-
T_2 - Sole sugar beet cv. Cauvery	48.93e	1.00c	1.00b	-
T_3 - Sole sugar beet cv. Shubhra	45.65e	1.00c	1.00b	-
T_4 - Sole sugar beet cv. Magnolia	41.20e	1.00c	1.00b	-
T_5 - Sole sugar beet cv. Calixta	42.78e	1.00c	1.00b	-
T_6 - SC + SB cv. Cauvery (1:1 RP)	118.45bc	1.41b	1.00b	160.30e
T_7 - SC + SB cv. Cauvery (1:2 RP)	128.03a	1.66a	1.08a	184.89a-c
T_8 - SC + SB cv. Cauvery (1:3 RP)	125.32ab	1.66a	1.06a	183.89a-c
T_9 - SC + SB cv. Shubhra (1:1 RP)	116.40c	1.40b	1.00b	167.52de
T_{10} - SC + SB cv. Shubhra (1:2 RP)	125.47ab	1.66a	1.08a	192.40a-c
T_{11} - SC + SB cv. Shubhra (1:3 RP)	123.70a-c	1.67a	1.07a	192.32a-c
T_{12} - SC + SB cv. Magnolia (1:1 RP)	116.30c	1.42b	1.01b	185.06a-d
T_{13} - SC + SB cv. Magnolia (1:2 RP)	122.43a-c	1.66a	1.08a	206.93a
T_{14} - SC + SB cv. Magnolia (1:3 RP)	119.24bc	1.66a	1.06a	204.21a
T_{15} - SC + SB cv. Calixta (1:1 RP)	116.02c	1.41b	1.00b	177.44c-e
T_{16} - SC + SB cv. Calixta (1:2 RP)	123.35a-c	1.66a	1.08a	200.21ab
T_{17} - SC + SB cv. Calixta (1:3 RP)	119.43a-c	1.65a	1.05a	196.93a-c
S.Em±	3.00	0.03	0.03	7.41

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, Sugarcane + sugar beet (irrespective of sugar beet cultivars) in 1:2 and 1:3 RP recorded significantly higher sugarcane equivalent yield, LER, ATER, SPI, total sugar yield, net returns when compared to 1:1 RP, but B:C was significantly higher in 1:1 RP.

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