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System Productivity and Economics of Seasonal Sugarcane Based Intercropping Systems under different Farming Practices

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Abstract: A field experiment was carried out at Agricultural Research Station, Hukkeri (Dist. Belagavi) during 2019-20 to study the productivity and economics seasonal sugarcane based intercropping systems. The experiment was laid out in split-split plot design with three farming practices in main plot such as M_1: recommended package of practices (RPP), M_2: organic farming (OF) and M_3: natural farming (NF); in sub plots two spacings *viz*., S_1: 60-180-60 cm × 60 cm (paired row planting) and S_2: 240 cm × 60 cm (wide row planting) and in sub-sub plots three intercropping systems were taken *viz*., I_1: sugarcane + onion *fb* turmeric, I_2: sugarcane + onion + cowpea + coriander + green chilli and I_3: sole sugarcane. Results revealed that, RPP recorded a significantly higher NMC (73.04 thousand ha^{-1}), cane yield (93.8 t ha^{-1}) and net returns (₹ 244855 ha^{-1}) than organic farming and natural farming practices. Between two spacings, paired row planting recorded significantly higher NMC (83.77 thousand ha^{-1}), cane yield (100.9 t ha^{-1}) and net returns (₹ 214718 ha^{-1}) than wide row planting. Among the intercropping systems, sugarcane + onion *fb* turmeric recorded significantly higher sugarcane equivalent yield (170.3 t ha^{-1}) and net returns (₹ 277556 ha^{-1}) than other intercropping systems.

Keywords: Intercropping systems, Farming practices, Natural farming, Organic farming, Sugarcane

Sugarcane (*Saccharum* spp. hybrid complex) is an important commercial crop in tropical and subtropical regions of the world and is cultivated in more than 115 countries and grown over an area of 26.27 million hectares with a production of 1907.02 million tonnes and productivity of 72.59 t ha^{-1} (Anonymous 2020). Sugarcane plays a pivotal role in the national economy by sustaining the second-largest agro-industry in the country next to textile. To meet the growing demand for sugar and energy by 2050 India, need to produce around 630 million tonnes of sugarcane with a recovery of 11.5 per cent having average productivity of 105.0 t ha^{-1} (Anonymous 2015). In the wake of the green revolution, agriculture is heavily dependent on fertilizers and chemicals. Their imbalanced and indiscriminate usage is leading to increased soil, water, environmental pollution, and health hazards. Organic farming emerged as an alternative agricultural system in the 20th century and addresses self-reliance in food production, rural development, and conservation of natural ecosystems. The green revolution has bought about debt and despair among the farming community due to the increased cost of cultivation and with specified ingredients and processes, organic farming is also becoming difficult. To overcome the ill-effects of conventional agriculture and make technology feasible for adoption by economically poor and marginal farmers is by adopting natural farming (Palekar 2006). Natural farming (NF) is a grassroots peasant movement that is trying to improve India's capacity to produce its own food by farming with nature and ending farmers' reliance on purchased inputs and credit and is a holistic agricultural practice that reduces commercial expenditure and market dependency of farmers by avoiding the use of external inputs (Smith et al 2020). It is seen as a way of overcoming the inability of many poor farmers to access improved seed and manufactured agrochemicals (Palekar 2006). In India, presently farmers are adopting wide row spacing (120 to 180 cm) in sugarcane than the existing 90 cm row spacing which is being popularized. Sugarcane, being a long duration with initial slow growth nature much of the space between two rows remains unutilized for an initial period of 100-120 days. In addition, sugarcane generates income only once in a year due to its long crop duration. So, this situation provides ample opportunity for intercropping in sugarcane which increases the total production per unit area (Nadiger et al 2017). Increased crop yield often observed in intercrops compared to sole crops has been attributed to enhanced resource use (Szumigalski and Van 2008). Therefore, the inclusion of short duration, high value and midseason income-generating intercrops is the need of the hour to provide economic security and maximise farm productivity in sugarcane. Crop diversification increases resource use efficiency, reduces production costs and improves or maintains soil quality in intensive agriculture systems (Singh et al 2021). In this view, the study was undertaken to investigate the influence of natural, organic, and conventional farming practices (RPP) on the productivity and economics of sugarcane based intercropping systems.

MATERIAL AND METHODS

Experimental site: Field experiment was carried out at Agricultural Research Station, Hukkeri in Belagavi district of Karnataka which is situated in the Northern Transition Zone of Karnataka (Zone 8) lies 16° 13' 48.00'' North latitude, 74° 35' 59.99'' East longitude and at an altitude of 631 m above mean sea level (MSL). The monthly mean annual rainfall of the experimental site was 650.1 mm (2004-2018). During the crop growing season, the rainfall received was excess by 48.39 per cent during the year 2019 compared to the mean annual rainfall of the experimental site (630.0 mm). The total rainfall received during the entire crop growth period was 964.7 mm. Sufficient rainfall was received for sugarcane crop growth. The soil of the experimental site was medium black clay in texture having a slightly alkaline pH (8.20) with normal electrical conductivity (0.283 dSm^{-1}). The soil had medium in organic carbon content (0.68 %), low in available nitrogen (241.2 kg ha^{-1}), medium in available P_2O_5 (38.54 kg ha^{-1}) and high in available K_2O (433.6 kg ha^{-1}).

Experimental details: The experiment was laid out in split-split plot design with three farming practices in main plot namely M_1:Recommended package of practices, M_2:Organic and M_3: Natural farming; two planting methods in sub plots *viz*., S_1: paired row planting (PRP: 60-180-60 cm × 60 cm) and S_2: wide row planting (WRP: 240 cm × 60 cm) in which three intercropping systems were introduced *viz*., sugarcane + onion *fb* turmeric (I_1), sugarcane + onion + cowpea + coriander + green chilli (I_2) and sole sugarcane (I_3) in sub-sub plots. A total of eighteen treatment combinations were replicated thrice (Table 1).

Transplanting of settling and sowing of intercrops: Furrows were opened at 60 cm apart and settlings of ssugarcane cultivar Co 86032 of 25 days old were transplanted on 9th March 2019. Settlings were transplanted in furrows with paired row plating (S_1: 60-180-180 cm × 60 cm) and wider row planting (S_2: 240 cm × 60 cm). Intercrops were sown on both sides of furrows opened at 60 cm distance provided between sugarcane planted rows. Sowing of intercrops in the five-tier model (Fig. 1, 2). The onion was planted on both sides of sugarcane furrows, cowpea and green chilli were planted alternatively on the sides of furrows and coriander was sown in the middle of furrows. After harvesting onion in intercropping system I_1, the land was levelled with the help of small tractor (power tiller) and furrows were opened at 60 cm apart between the wide row, then turmeric rhizomes were dibbled on the sides of furrows at 20 cm apart.

Harvest of sugarcane, intercrops, and yield: Sugarcane was harvested on 23rd January 2019 to the ground level, detrashed, bundled and stacked before recording the plot yield. Intercrops were harvested from the net plot at physiological maturity and harvestable maturity yield were converted in kg ha^{-1}. Intercrop yields were computed as sugarcane equivalent yields. Sugarcane Equivalent Yield (SEY) is a simple expression in intercropping to compare the economics of intercrops by converting grain/seed/economic part *etc.* in terms of gross returns/net returns for valid comparison. The economics was worked out from prevailing market prices of inputs and outputs for different treatments.

Statistical analysis: The data recorded during the investigation were compiled and analysed for statistical significance by Microsoft excel as per the analysis of variance for the spilt-split plot design. Fisher's method of analysis of variance as described by Gomez and Gomez (1984) was adopted for the purpose. Standard error of mean and coefficient of variability have been worked out for a set of observations under each character at p=0.05 to interpret the significance.

RESULTS AND DISCUSSION

Sugarcane yield and yield parameters: Number of millable canes (NMC) and cane yield were significantly influenced by different farming practices, spacings, intercropping systems and their interactions (Table 2). RPP recorded significantly higher NMC (73.04 thousand ha^{-1}) and cane yield (93.8 t ha^{-1}) as compared to organic farming and natural farming. Higher yield under RPP was mainly due to the integrated use of different sources of the nutrients which comprises FYM @ 25 t ha^{-1}, 250:75:190 kg $N:P_2O_5:K_2O$ ha^{-1}, micronutrients *viz*., $FeSO_4$ and $ZnSO_4$ @ 25 kg ha^{-1} and biofertilizers *viz*., *Azospirillum* and PSB @ 10 kg ha^{-1}, which is a well-established system for meeting the sugarcane crop's nutrient demands. Higher single cane weight (1.45 kg) under RPP was due to higher millable cane height (240.3 cm), number of internodes (18.99), internodal length (12.39 cm) and cane diameter (3.13 cm) (Table 1). Increased cane yield was attributed to these entire yield attributing parameters in RPP. Similar results were reported by earlier scientist that among the nutrient management practices, RPP recorded significantly higher yield attributes are mainly due balanced nutrition in the form of chemical fertilizers along with FYM and biofertilizers (Kuri and Chandrashekara 2015, Shridevi et al 2016, Nooli et al 2019). Cane yields were lower with organic farming and natural farming due to a lack of readily available

Table 1. Yield parameters of sugarcane as influenced by different farming practices, spacings and intercropping systems

Treatments	Yield parameters of sugarcane															
	Millable cane height (cm)				Number of internodes cane^{-1}				Internodal length (cm)				Cane diameter (cm)			
	RPP	OF	NF	Mean S	RPP	OF	NF	Mean S	RPP	OF	NF	Mean S	RPP	OF	NF	Mean S
S: Row Spacings (cm)		M × S				M × S				M × S				M × S		
S_1: 60-180-60 cm × 60 cm (PRP)	238.9	222.4	208.2	223.2	18.57	17.97	17.60	18.04	12.38	12.08	11.61	12.02	3.12	3.03	2.84	3.00
S_2: 240 cm × 60 cm (WRP)	241.7	225.5	211.8	226.3	18.10	17.63	17.08	17.61	12.39	11.98	11.71	12.03	3.14	3.04	2.86	3.01
I: Intercropping systems		M × I		Mean I		M × I		Mean I		M × I		Mean I		M × I		Mean I
I_1: Sc + O - T	240.1	225.1	211.8	225.7	18.57	17.97	17.60	18.04	12.59	12.19	11.71	12.16	3.16	3.04	2.83	3.01
I_2: Sc + O + Cp + Co + GC	229.7	217.1	202.8	216.6	18.10	17.63	17.08	17.61	12.35	11.97	11.55	11.96	3.01	2.96	2.80	2.92
I_3: Sole sugarcane	251.0	229.7	215.3	232.0	20.30	18.77	18.13	19.07	12.22	11.92	11.71	11.95	3.23	3.11	2.91	3.08
		M × S × I		S × I		M × S × I		S × I		M × S × I		S × I		M × S × I		S × I
S_1: 60-180-60 cm × 60 cm (PRP) I_1	237.0	225.1	210.1	224.1	18.53	17.80	17.47	17.93	12.45	12.30	11.69	12.15	3.16	3.05	2.82	3.01
I_2	229.5	215.5	200.5	215.1	18.00	17.53	17.00	17.51	12.40	11.95	11.41	11.92	3.00	2.93	2.79	2.91
I_3	250.1	226.7	214.0	230.3	20.33	18.40	18.07	18.93	12.28	12.00	11.72	12.00	3.21	3.12	2.90	3.08
S_2: 240 cm × 60 cm (WRP) I_1	243.1	225.1	213.5	227.2	18.60	18.13	17.73	18.16	12.73	12.08	11.73	12.18	3.16	3.02	2.85	3.01
I_2	230.0	218.8	205.2	218.0	18.20	17.73	17.17	17.70	12.30	12.00	11.68	11.99	3.02	2.99	2.82	2.94
I_3	251.9	232.7	216.5	233.7	20.27	19.13	18.20	19.20	12.15	11.85	11.70	11.90	3.25	3.10	2.91	3.09
M: Farming practices	240.3	224.0	210.0		18.99	18.12	17.61		12.39	12.03	11.66		3.13	3.03	2.85	
Source of variations				C. D. (p=0.05)				C. D. (p=0.05)				C. D. (p=0.05)				C. D. (p=0.05)
M - Farming practices				12.14				0.98				0.51				0.161
S - Spacings				NS				NS				NS				NS
I - Intercropping systems				9.84				0.80				NS				NS
M × S				NS				NS				NS				NS
M × I				NS				NS				NS				NS
S × I				NS				NS				NS				NS
M × S × I				NS				NS				NS				NS

M: Main plot (Farming practices)
M_1: Recommended package of practices (RPP)
M_2: Organic farming (OF)
M_3: Natural Farming (NF)

S: Sub plot (Row spacings)
S_1: PRP - Paired row planting (60-180-60 cm × 60 cm)
S_2: WRP - Wide row planting (240 cm × 60 cm)

I: Sub sub plot (Intercropping systems)
I_1: Sugarcane + Onion – Turmeric (Sc + O - T)
I_2: Sugarcane + Onion + Cowpea + Coriander + Green Chilli (Sc + O + Cp + Co + GC)
I_3: Sole sugarcane

Table 2. Yield parameters, yield and sugarcane equivalent yield of seasonal sugarcane as influenced by different farming practices, spacings and intercropping systems

Treatments	Yield parameters of sugarcane															
	Number of milable canes (000' ha^{-1})				Single cane weight (kg $cane^{-1}$)				Cane yield (t ha^{-1})				Sugarcane equivalent yield (t ha^{-1})			
	RPP	OF	NF	Mean S	RPP	OF	NF	Mean S	RPP	OF	NF	Mean S	RPP	OF	NF	Mean S
S: Row Spacings (cm)		M × S				M × S				M × S				M × S		
S_1: 60-180-60 cm : 60 cm (PRP)	92.56	83.74	75.03	83.77	1.44	1.40	1.26	1.37	120.0	101.2	101.2	100.9	163.6	141.8	117.4	141.9
S_2: 240 cm × 60 cm (WRP)	53.53	47.82	40.13	47.16	1.45	1.42	1.27	1.38	67.6	57.2	57.2	56.3	128.0	110.6	91.7	110.1
I: Intercropping systems		M × I		Mean I		M × I		Mean I		M × I		Mean I		M × I		Mean I
I_1: Sc + O - T	76.14	70.18	58.82	68.38	1.46	1.41	1.28	1.38	98.4	85.7	85.7	83.7	194.9	172.8	143.1	170.3
I_2: Sc + O + Cp + Co + GC	61.69	52.84	48.74	54.42	1.40	1.37	1.24	1.33	77.0	59.6	59.6	62.3	136.9	113.4	99.3	116.4
I_3: Sole sugarcane	81.30	74.31	65.18	73.60	1.49	1.44	1.28	1.40	105.9	92.4	92.4	89.9	105.9	92.4	71.3	89.9
		M × S × I		S × I		M × S × I		S × I		M × S × I		S × I		M × S × I		S × I
S_1: 60-180-60 cm × 60 cm (PRP) I_1	96.49	90.69	76.41	87.86	1.46	1.40	1.27	1.38	127.1	113.1	86.4	108.9	206.3	187.5	151.6	181.8
I_2	79.00	66.89	62.89	69.59	1.39	1.36	1.23	1.33	97.3	73.7	66.2	79.1	149.1	121.0	108.5	126.2
I_3	102.2	93.64	85.78	93.87	1.48	1.43	1.28	1.40	135.5	116.9	92.3	114.9	135.5	116.9	92.3	114.9
S_2: 240 cm × 60 cm (WRP) I_1	55.79	49.68	41.23	48.90	1.46	1.43	1.28	1.39	69.7	58.4	47.7	58.6	183.6	158.1	134.7	158.8
I_2	44.38	38.80	34.60	39.26	1.40	1.37	1.24	1.34	56.7	45.4	34.5	45.5	124.1	105.9	90.0	106.7
I_3	60.42	54.98	44.57	53.32	1.50	1.45	1.29	1.41	76.3	67.8	50.3	64.8	76.3	67.8	50.3	64.8
M: Farming practices	73.04	65.78	57.58		1.45	1.41	1.27		93.8	79.2	62.9		145.8	126.2	104.6	

Source of variations	C. D. (p=0.05)	C. D. (p=0.05)	C. D. (p=0.05)	C. D. (p=0.05)
M - Farming practices	3.39	0.082	4.27	4.1
S - Spacings	2.42	NS	2.87	2.7
I - Intercropping systems	2.99	0.056	3.58	4.2
M × S	4.19	NS	4.97	4.7
M × I	5.04	NS	6.02	7.0
S × I	4.23	NS	5.06	5.9
M × S × I	7.33	NS	8.76	10.2

See Table 1 for details

nutrients from organic sources which takes time to mineralize and made available to the crop (Durai and Devaraj 2003).

The superiority of cane yield under organic farming over natural farming was attributed to the application of 100 per cent organics equivalent to RDN through FYM + VC + EPM 1/3rd each and biofertilizers like *Azosprillum* and PSB @ 10 kg ha^{-1} along with the foliar application of *panchagavvya* as well as soil application of *jeevamrutha* resulted in higher sugarcane yield. The increase in cane yield under organic farming was to the extent of 25.91 per cent over natural farming (Table 2). This might be due to the application of FYM, vermicompost as well as press mud which is a good source of nutrients *viz.*, organic carbon (34.19 %), nitrogen (2.0 %), phosphorus (1.55 %), potassium (2.85 %) and micronutrients (Fe, Zn, Cu and Mn) (Sinha et al 2014). In organic farming, the application of carbonic substrate through organic manures coupled with soil application of *jeevamrutha* which was congenial for microbial growth (Vinay et al 2020a) lead to better mineralization of organic matter and further increased the availability of essential nutrients coupled with foliar nutrition with *panchagavya* lead to better growth and yield attributes of sugarcane. The lower yield was observed in natural farming due to fact that external application of fertilizer as well as organic manures are avoided which led to insufficient nutrient supply from soil to sugarcane crop which is huge biomass producing as well as nutrient demanding crop throughout its growth stages. Hence, undernourished crops resulted in poor growth and yield attributes finally reducing cane yield. Significantly higher number of millable canes (83.77 thousand ha^{-1}) and cane yield (100.9 t ha^{-1}) were recorded under PRP (60-180-60 cm × 60 cm) compared to WRP (240 cm × 60 cm). The increase in the yield was to the extent of 79.21 per cent over wide row planting (WRP). Higher cane yield with PRP attributed to significantly higher number of millable canes than WRP (Table 2). Higher NMC's were the main reason for higher cane yield under the PRP of sugarcane. Sarala et al (2014) also observed that sugarcane planting with paired rows at 75/105 cm recorded better yield attributes like number of millable canes and cane yield compared to wider row planting.

The wide row spacings of sugarcane give ample opportunity for the intercrops which leads to crop intensification and increase the system productivity. The significantly higher number of millable canes (73.60 thousand ha^{-1}) were recorded under sole sugarcane as compared to

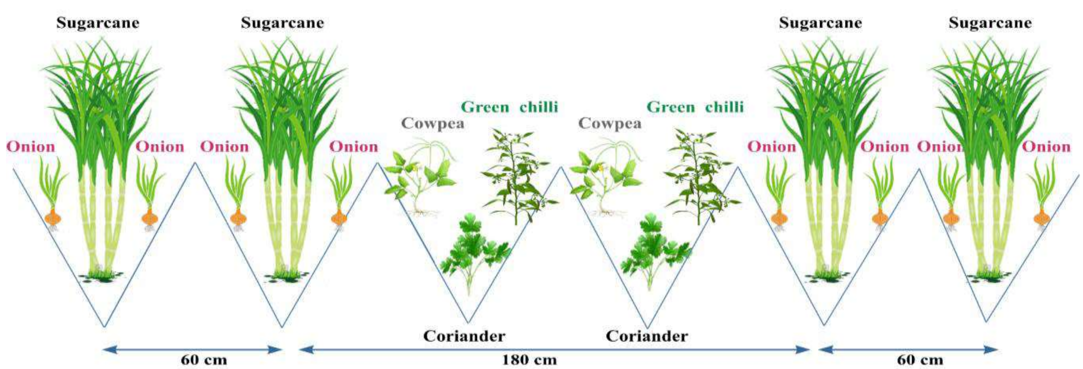

Fig. 1. Planting pattern in 60-180-60 cm × 60 cm paired row planting

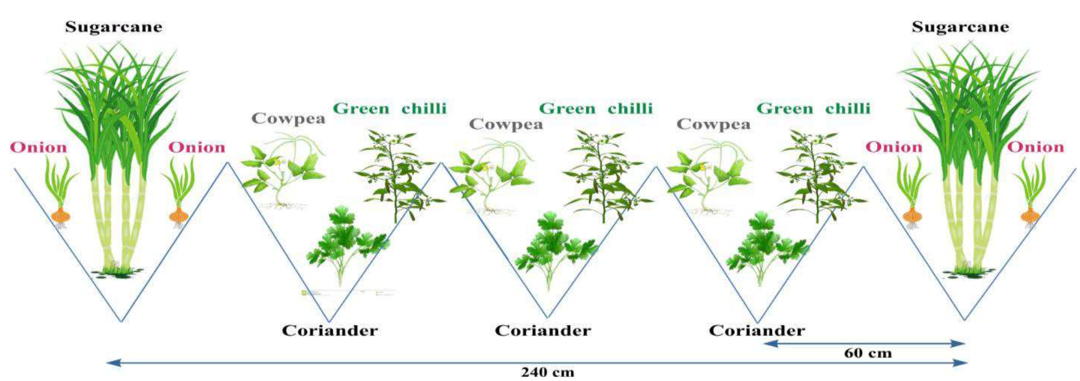

Fig. 2. Planting pattern in 240 cm × 60 cm wide row planting

sugarcane + onion *fb* turmeric (I_1) and sugarcane + onion + cowpea + coriander + green chilli (I_2). The extent of reduction in cane yield was least (7.40 %) in sugarcane + onion *fb* turmeric (I_1) and as compared to 44.30 per cent in sugarcane + onion + cowpea + coriander + green chilli (I_2) than sole sugarcane. Results are in line with El-Gergawi and Abdalla (2000) found that higher yield with sugarcane + sweet potato; and Mahadevaswamy (2001) in sugarcane + onion. Significantly superior cane yield under sole sugarcane was due to the absence or least of competition for natural resources as compared to intercropping involving component crops. However, cane yield recorded with intercropping of sugarcane + onion *fb* turmeric (I_1) was comparable to that of sole sugarcane due to the least competition by onion in the early growth stages of sugarcane. Among the interaction effects of farming practices with different spacings and intercropping, RPP + PRP + sole sugarcane ($M_1S_1I_3$) recorded significantly higher NMC (102.19 thousand ha^{-1}) and cane yield (135.5 t ha^{-1}) than other interactions. However, interaction of RPP with PRP of sugarcane + onion *fb* turmeric ($M_1S_1I_1$)was on par with RPP + PRP + sole sugarcane ($M_1S_1I_3$). The significantly lower NMC and sugarcane yield were recorded under natural farming with WRP of sugarcane + onion + cowpea + coriander + green chilli ($M_3S_2I_2$). Significantly higher NMC recorded with recommended package of practices with paired row planting of sole sugarcane might be due to higher cane population coupled with better nutrient management as per RPP lead to reduced tiller mortality over other treatment combinations. It was due to the better availability of growth resources like water, nutrients, air, better cultural practices in wider plant geometry with no intercrop competition might have helped the plants to exhibit their full potential and produced higher yields than other treatment combinations with intercrops (Nadige et al 2017).

Sugarcane equivalent yield (SEY) of sugarcane based intercropping systems: Sugarcane equivalent yield (SEY) differed significantly due to different farming practices, spacings, intercropping systems and their interactions (Table 2). Among the farming practices, recommended package of practices (RPP) resulted in significantly greater SEY (145.8 t ha^{-1}) compared to organic farming and natural farming practices. The greater SEY was mainly due to maximum sugarcane and intercrop yield under recommended package of practices than with organic farming and natural farming practices. It is also due to the higher price of intercrops with higher yield levels thereby higher sugarcane equivalent yield. The extent of increase in SEY under RPP over organic farming was 15.53 per cent and 39.38 per cent over natural farming. The lower sugarcane equivalent yield is attributed to natural farming mainly due to a drastic reduction in sugarcane and intercrop yield. Different spacings significantly influenced sugarcane equivalent yield (SEY). Significantly higher SEY was recorded with PRP of sugarcane (141.0 t ha^{-1}) compared to WRP. The higher SEY in PRP of sugarcane to the extent of 28.06 per cent over WRP. It was mainly due to higher sugarcane yield under PRP of sugarcane by higher NMC compared to WRP. Even though higher intercrop yields under wider space (240 cm) are unable to compensate for reduced yield under WRP in the form of sugarcane equivalent yield as compared to PRP of sugarcane. Among the intercropping systems tested, sugarcane + onion *fb* turmeric (I_1) recorded significantly higher SEY (170.3 t ha^{-1}) as compared to intercropping of sugarcane + onion + cowpea + coriander + green chilli (I_2) (116.4 t ha^{-1}) and sole sugarcane (I_3). The higher SEY under sugarcane + onion *fb* turmeric (I_1) to the extent of 46.30 per cent over sugarcane + onion + cowpea + coriander + green chilli (I_2) and 89.43 per cent over sole sugarcane (I_3). The higher SEY was mainly due to higher sugarcane and intercrop yield as well as the higher market price of the produce. Lower SEY under intercropping of sugarcane + onion + cowpea + coriander + green chilli (I_2) was mainly due to lower sugarcane and intercrop yields which were attributed to reduced NMC, cane diameter, single cane weight due to smothering effect by spreading nature of cowpea on sugarcane and other component crops. Similar observations reported by Khandagave (2010). The interaction of RPP with PRP of sugarcane + onion *fb* turmeric ($M_1S_1I_1$) recorded significantly higher SEY (206.3 t ha^{-1}) as compared to other treatment combinations. The higher sugarcane equivalent yield in RPP with PRP of sugarcane + onion *fb* turmeric ($M_1S_1I_1$) was mainly due to higher cane and intercrop yield as well as the higher market price of sugarcane, onion and turmeric crops. Kumar et al (2011) reported that higher sugarcane equivalent yield was recorded with the sugarcane + onion intercropping system.

Economics of sugarcane based intercropping system: The cost of cultivation (COC) of sugarcane was very high in organic farming (₹ 212896 ha^{-1}) and it was least in natural farming (₹ 119500 ha^{-1}) (Fig. 3). The reduction in the cost of cultivation in natural farming to the extent of 23.72 per cent over RPP and 43.86 per cent over organic farming. It was mainly due to lower input costs in natural farming. The higher cost of cultivation in organic farming was mainly due to the high cost involved in supplementation of nutrients through bulky organic manures (FYM, vermicompost and enriched press mud) equivalent to nitrogen (250 kg N ha^{-1}) requirement of sugarcane. Among the farming practices, RPP resulted in significantly higher gross returns (₹ 401529 ha^{-1}), net returns (₹ 244855 ha^{-1}) and B:C ratio (2.51) than organic and natural

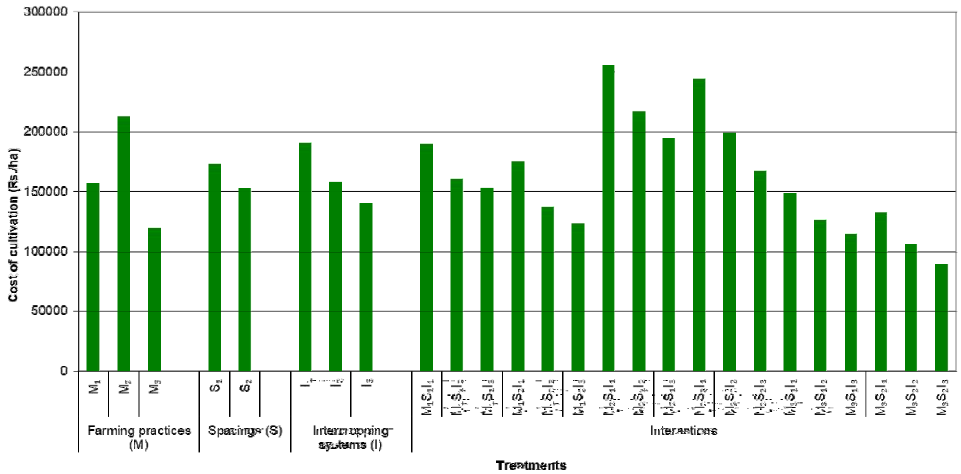

Fig. 3. Cost of cultivation of seasonal sugarcane based cropping systems as influenced by different farming practices, spacings and intecropping systems

Table 3. Economics of seasonal sugarcane based cropping systems as influenced by different farming practices, spacings and intecropping systems

Treatments		Economics of seasonal sugarcane											
		Gross returns (₹ ha^{-1})				Net returns (₹ ha^{-1})				B:C ratio			
		RPP	OF	NF	Mean S	RPP	OF	NF	Mean S	RPP	OF	NF	Mean S
S: Row spacings (cm)			M × S				M × S				M × S		
S_1: 60-180-60 cm × 60 cm		450403	390336	323326	388022	282491	168116	193547	214718	2.66	1.74	2.46	2.29
S_2: 240 cm × 60 cm		352655	304759	252715	303377	207219	101188	143495	150634	2.36	1.46	2.23	2.02
I: Intercropping systems			M × I		Mean I		M × I		Mean I		M × I		Mean I
I_1: Sc + O - T		536032	475244	393619	468299	353610	225611	253446	277556	2.94	1.90	2.81	2.55
I_2: Sc + O + Cp + Co + GC		377274	313356	274418	321683	228089	105211	158285	163862	2.53	1.50	2.36	2.13
I_3: Sole sugarcane		291279	254042	196025	247115	152866	73134	93832	106611	2.07	1.38	1.88	1.78
			M × S × I		S × I		M × S × I		S × I		M × S × I		S × I
S_1: PRP	I_1	567245	515659	416874	499926	377805	260420	268770	302331	2.99	2.02	2.81	2.61
	I_2	411275	333793	299408	348159	250140	116762	172956	179953	2.55	1.54	2.37	2.15
	I_3	372687	321556	253697	315980	219529	127165	138917	161870	2.43	1.65	2.21	2.10
S_2: WRP	I_1	504820	434830	370365	436671	329415	190802	238122	252780	2.88	1.78	2.80	2.49
	I_2	343274	292920	249429	295207	206039	93659	143615	147771	2.50	1.47	2.36	2.11
	I_3	209871	186529	138353	178251	86204	19102	48748	51351	1.70	1.11	1.54	1.45
M: Farming practices		401529	347548	288021		244855	134652	168521		2.51	1.60	2.35	
Source of variations					C. D. (p=0.05)				C. D. (p=0.05)				C. D. (p=0.05)
M - Farming practices					11403				11403				0.05
S - Spacings					7421				7421				0.05
I - Intercropping systems					11435				11435				0.07
M × S					12853				12853				0.09
M × I					19248				19248				0.12
S × I					16172				16172				0.10
M × S × I					28011				28011				0.17

See Table 1 for details

farming practices (Table 3) and were mainly attributed to higher sugarcane equivalent yield. Tyagi *et al*. (2011), Shridevi *et al*. (2016) and Kuri and Chandrashekar (2015) also observed that RPP recorded maximum gross and net returns. The, PRP (60-180-60 cm × 60 cm) recorded significantly higher gross returns (₹ 388022 ha^{-1}), net returns (₹ 214718 ha^{-1}) and B:C ratio (2.29) than WRP (240 cm × 60 cm). The additional net returns with PRP to an extent of 42.54 per cent over WRP could be due to the higher yield under PRP (Table 3). Among the intercropping systems, significantly higher gross returns (₹ 468299 ha^{-1}), net returns (₹ 277556 ha^{-1}) and B:C ratio (2.25) were recorded with sugarcane + onion *fb* turmeric (I_1) as compared I_2 and I_3. This could be due to significantly higher sugarcane equivalent yield (170.3 t ha^{-1}) under intercropping of sugarcane + onion *fb* turmeric (I_1) than other intercropping systems. The extent of increase in SEY in I_1 over I_2 was 46.30 per cent and 89.43 per cent over sole sugarcane (I_3). It was attributed to the higher market price for onion and turmeric crops and the higher yield of sugarcane in these intercropping systems. The reduction in SEY in intercropping of sugarcane + onion + cowpea + coriander + green chilli (I_2) was mainly due to a lower yield of sugarcane and intercrops due to the smothering effect of cowpea. In the present investigation interaction of recommended package of practices with PRP of sugarcane + onion *fb* turmeric resulted in significantly higher gross returns (₹ 567245 ha^{-1}), net returns (₹ 377805 ha^{-1}) and B:C ratio (2.99) than other interactions (Table 3). It could be due to higher cane and intercrop yield and higher market prices for onion and turmeric crops.

CONCLUSIONS

Finally, it can be concluded that paired row planting of sugarcane + onion *fb* turmeric under RPP resulted in higher sugarcane equivalent yield, gross returns, net returns and B:C ratio. However, cost of cultivation of sugarcane can be reduced by adopting natural farming to the extent of 23.72 per cent over RPP and 43.86 per cent over organic farming. Natural farming with intercropping of sugarcane + onion *fb* turmeric under paired row planting resulted in higher sugarcane equivalent yield and net returns than sole sugarcane under recommended package of practices.

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