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Productivity of Sugarcane-based Sequential Intercropping System Suitable for Central Telangana Zone

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ABSTRACT

A field study was conducted at Agricultural Research Station, Basanthpur, Telangana, India during 2015 and 2017 to determine the suitability and productivity of year-long intercropping with short duration summer crops followed by ginger in sugarcane. The summer vegetable crops viz., green gram, tomato, watermelon, bitter gourd, bottle gourd, ridge gourd and keera were intercropped along with sugarcane. Following the harvest of summer crops, ginger seedlings were transplanted during May on the raised beds. The results of the study revealed that intercropping sugarcane with early summer vegetable crops of 75 to 90 days duration *viz*., watermelon and gourds followed by ginger in sequence reported yield advantage of 25 to 85 t ha^{-1} over sole sugarcane and proved to be a highly productive cropping system of sugarcane and best suitable for Central Telangana Agro-climatic Zone. The most profitable sequential intercropping for sugarcane followed the order-Sugarcane+bitter gourd-ginger (223.07 t ha^{-1})>watermelon-ginger (220.05 t ha^{-1})>ridge gourd-ginger (204.59 t ha^{-1})>bottle gourd-ginger (183.78 t ha^{-1})>keera-ginger (174.56 t ha^{-1})>tomato-ginger (169.22 t ha^{-1})>green gram-ginger (162.09 t ha^{-1}). Under adequate irrigation facility, a yearlong sequence intercropping in sugarcane with short duration crops during the initial four months followed by a long duration intercrop that comes up well under partial shade conditions can sustain sugarcane cropping system with intermittent income and no adverse effect on the main crop yield.

KEYWORDS: Ginger, intermittent income, sequence intercropping, sugarcane, summer intercrops

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1. INTRODUCTION

Sugarcane accounting to second largest organized agro-industry of India (Harender et al., 2021) is extended in 5.00 million hectares with a production and productivity of 77.6 t ha^{-1} and 377.76 mt, respectively (Anonymous, 2021b). It is meeting 32.6 mt of sugar requirement of the country (Anonymous, 2019). In Telangana; it extends in 0.22 lakh hectares with production and productivity of 17.51 lakh tonnes and 79.59 tonnes ha^{-1}, respectively (Anonymous, 2021a)

Sugarcane is characteristically a long duration one-time income generating crop. Due to its sluggish initial growth, it lends ample scope for intercropping of short duration, high value and mid-season income generating crops for economic security (Shukla et al., 2018). Further, with introduction of high tillering and yielding varieties, the practice of adopting wider row spacing in sugarcane has increased (Chitkala Devi et al., 2005). Sugarcane exhibited physiological and environmental plasticity with respect to yield at wider row spacings (Garside et al., 2009). This also permitted intercropping without adversely affecting crop's yield and thus increasing the overall productivity and profitability of the system (Islam and Islam, 2016, Shen et al., 2018, Endrizal et al., 2021). Rajula Shanthy and Muthusamy (2012) reported higher cane yield (20–30 t ha^{-1}) at a spacing of 150 cm due to high tillering and low tiller mortality. Gopalasundaram et al. (2012) also indicated that wide row spacing of 150 cm is preferable for sugarcane-based intercropping systems and that soybean and black gram could be raised as profitable intercrops. Intercropping has the potential to increase total system productivity, monetary returns, and resource utilization in long duration crops such as sugarcane (Dhaliwal, 2018, Kaur et al., 2016, Islam and Islam, 2018, Li et al., 2012, Ramouthar et al., 2013). Hence, there is a need to diversify the sugarcane cropping system through introduction of intercrops and by adjusting crop geometry.

In Telangana, sugarcane planting starts from December and extends until March. The crop completes germination in about five weeks from planting and attains the stage of canopy closure by 15th week after planting. Since the underutilized growth resources prevail only for a short time, the intercrops selected should be of dwarf stature with a compact canopy and short duration. Hence, short duration legumes, oilseeds and vegetables of 70 to 90 days duration are most suitable intercrops in main season planted sugarcane (Kumar et al., 2015, Dhaliwal, 2018) to tap the resources during early growth period and yield intermittent income (Singh and Uppal, 2015).

Further, there is a scope of intercropping in sugarcane for its entire duration by introducing shade loving crops like ginger after the harvest of summer intercrops during May-June. On system basis, cropping of sugarcane with summer intercrops initially and later by ginger in sequence can be a remunerative sugarcane based intercropping system. The sustainability of sugarcane cropping system by intercropping longer duration with two consequent intercrops was also proved by Hossain et al. (2003) where sugarcane intercropped with potato followed by sesame produced highest yield of cane, potato and sesame. Similar studies were reported by Abdul Rehman and Jamshaid (2014), Alam et al. (2015), Ayele et al. (2014), Ganapati (2015), Khan et al. (2012), Khippal et al. (2016), Singh et al. (2021), SU Li-rong et al. (2017), Yang et al. (2015), Zarekar et al. (2018) where intercropping of sugarcane with cereals/legumes/vegetables was found to increase system yield without effecting the main crop yield besides improving soil microbiome, nutrient status and overall sustainability of the system. Hence, the present investigation was conducted on similar terms, to study the suitability and productivity of year-long intercropping in sugarcane under the agroclimatic conditions of Central Telangana Zone.

2. MATERIALS AND METHODS

The study was conducted at Agricultural Research Station, Basanthpur, located at 17° 47' 52.55" N Latitude and 77°32' 37.77" E longitude and at an altitude of 626 m amsl. The study was conducted during the Eksali of 2015 and 2017. The sugarcane crop was sown in the months of February and March during 2015 and 2017, respectively. The variety of sugarcane sown was Co 87025, as it is highly suitable for intercropping and mechanization, producing more no. of tillers and dry matter accounting for higher yields under compensated crop density conditions. The field experiment was laid out in randomized block design in three replications under the drip irrigation method on red laterite soils. The treatments comprised of the following intercrops – Sugarcane+Green gram-Ginger, Sugarcane+Tomato-Ginger, Sugarcane+Watermelon-Ginger, Sugarcane+Bitter gourd-Ginger, Sugarcane+Ridge gourd-Ginger, Sugarcane+Bottle gourd-Ginger, Sugarcane+Keera-Ginger. Initially, all the summer intercrops (*viz.*, Green gram, Tomato, Watermelon, Bitter gourd, Ridge gourd, Bottle gourd and Keera) were sown along with Sugarcane (Figure 1). Later, after the harvest of summer intercrops, ginger was sown between the sugarcane rows (Figure 2). The sole sugarcane was planted at a row spacing of 150 cm and each furrow accommodated a single row of three budded sugarcane setts placed end to end. On the other hand, to compensate for plant population, the intercropped sugarcane was planted in two rows in a single opened furrow as depicted in figure 1 and 2. Each furrow was of 30 cm width and along the two edges throughout the length of the

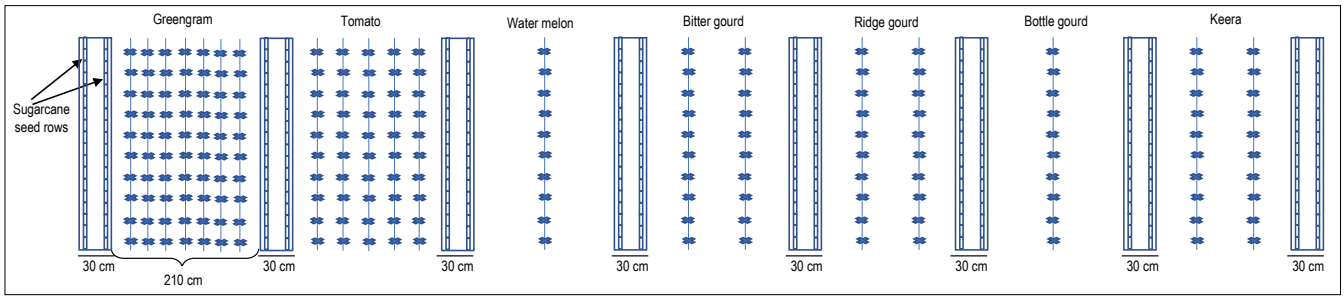

Figure 1: Sugarcane intercropping with early summer intercrops

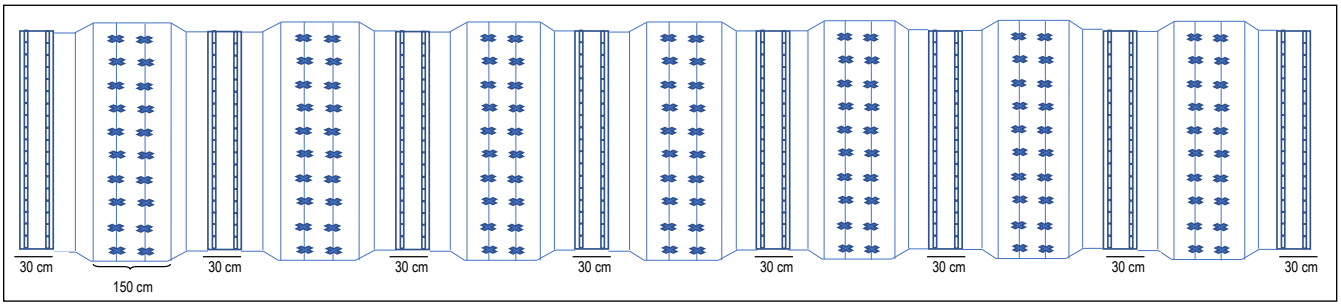

Figure 2: Sugarcane intercropped with ginger in sequence to summer intercrops. The flat beds of summer intercrops were converted to raised beds to plant ginger

furrow the three budded sugarcane setts were planted end to end. The distance between two sugarcane furrows was 210 cm which was used for sowing the summer intercrops. The number of rows of summer intercrops accommodated in the inter-row spacing of sugarcane were – Green gram–7 rows (spacing–30 cm×10 cm), Tomato–5 rows (45×30 cm^2), Watermelon–1 row (2×0.3 m^2), Bitter gourd–2 rows (1.5×0.6 m^2), Ridge gourd-2 rows (1.5×0.6 m^2), Bottle gourd-1 row (2×0.75 m^2); and Keera-2 rows (1.5×0.5 m^2) in the respective treatment fields. After the harvest of summer intercrops, inter-row space between sugarcane (210 cm) was made into a raised bed having a width of 1.5 m and a height of 15 cm. On these raised beds, ginger was transplanted in two rows with spacing of 45×15 cm^2. The sole ginger was also sown on raised beds accommodating two rows, with similar spacing. The fertilizers to the crops were applied as per the recommended doses, specific to each crop. The number of tillers of sugarcane were recorded at 75 and 120 DAT while the number of millable canes, plant height, cane girth and single cane weight were recorded at harvest. A note of number of tillers per plant, number of rhizomes per clump, fresh and dry rhizome weights were also made at harvest of ginger. The cane, individual intercrop and ginger yields were recorded after the harvest of respective crops. The individual intercrops and ginger yields were converted to sugarcane equivalent yield by taking in to account the existing per unit market price. The experimental data was subjected to statistical analysis following the procedure for randomised block design as outlined by Panse and Sukhatme (1967). The significance was tested by "F" test at 5% level of probability (Snedecor and Cochran, 1967). Critical difference was worked out for the effects which were significant.

3. RESULTS AND DISCUSSION

The data on sugarcane intercropping with early summer intercrops, in sequence with ginger, was presented in tables 1 to 3 and discussed in detail here under.

3.1. Yield attributes of sugarcane

The yield attributes of sugarcane were noted in terms of tiller count, the number of millable canes, plant height at harvest, single cane weight and cane girth. An overview of two-year pooled data indicated that the tiller count of sugarcane noted at 75 and 120 DAT was significantly highest in the sole crop (90.1 and 182.7×10^3 ha^{-1}, respectively). Among the intercrop combinations, sugarcane intercropped with watermelon alone showed the highest tiller count at both the stages *viz.,* 75 and 120 DAT (Pooled: 62.6 and 132.2×10^3 ha^{-1}, respectively). The results obtained in the present study were in contrast to Gana and Busari (2003) who observed that the cane intercropped with watermelon suffers in tiller number. Probably a single row of watermelon between sugarcane furrows might not pose enough competition to suppress the growth of sugarcane resulting in a better tiller number in this combination than the other crops. However, the tiller number of sugarcane in all the intercrop combinations was less by 30.53 to 44.60% at 75 DAT and 27.62 to 38.85% at 120 DAT compared to sole sugarcane crop.

The plant height at harvest was maximum (310.1 cm) in the sole crop than the intercropped sugarcane. Similar to the tiller count, the number of millable canes in sugarcane also was maximum (105.4×10^3 ha^{-1}) in sole sugarcane compared to the intercropped sugarcane. Among the intercrop combinations, sugarcane+watermelon recorded a significantly higher number of millable canes (71.6×10^3 ha^{-1}). The plant height of intercropped sugarcane had shown a variation of 8.07 to 14.39% from the sole sugarcane, while the number of millable canes varied from 32.08 to 41.15% (Table 1). The decrease in tiller number, millable canes and plant height of sugarcane in the intercropped sugarcane may be attributed to the competition between the sugarcane setts rather than by the intercrops. Planting intercropped sugarcane in dual rows in a single furrow unlike sole sugarcane might have caused competition between the setts, resulting in reduced plant height and number of millable canes. These results are contradictory to those obtained by Khandagave (2010) who reported no alteration in the number of millable canes and cane yield due to dual of single row planting of sugarcane. The decrease in plant height of intercropped sugarcane on the other hand was marginal in relation to sole sugarcane.

Table 1: Growth of sugarcane as affected by intercropping with early summer intercrops in sequence with ginger (Pooled data of two years)

Intercropping systems	Tiller population ('000 ha)		Plant height at harvest (cm)	No. of millable canes ('000 ha)	Single cane weight (kg)	Girth (cm)
	75 DAT	120 DAT				
Sugarcane+greengram-Ginger	53.31	115.69	272.01	65.23	1.08	2.75
Sugarcane+tomato -Ginger	49.89	111.72	269.35	62.05	1.07	2.76
Sugarcane+watermelon-Ginger	62.56	132.23	285.33	71.61	1.21	2.93
Sugarcane+bittergourd-Ginger	59.79	127.87	273.05	69.38	1.10	2.77
Sugarcane+ridgegourd-Ginger	58.72	123.56	272.37	67.75	1.04	2.75
Sugarcane+bottlegourd-Ginger	55.27	117.53	265.74	66.54	1.00	2.72
Sugarcane+keera-Ginger	56.72	121.89	271.63	65.93	1.09	2.78
Sole sugarcane	90.05	182.69	310.09	105.43	1.42	3.09
Sole ginger	-	-	-	-	-	-
SEm±	0.98	0.99	9.91	0.98	0.01	0.09
CD (p=0.05)	2.10	2.12	21.26	2.1	0.02	0.19

The single cane weight and girth (Table 1) of sugarcane was maximum in sole sugarcane (1.42 kg and 3.09 cm), while among the intercrop combinations, the sugarcane with watermelon recorded significantly highest single cane weight and cane girth (1.21 kg and 2.93 cm). The data indicates that the variation in cane girth was only 5.12 to 11.97% and the single cane weight differed by 14.79 to 29.58 percent under the intercropping system than sole sugarcane. This variation might have aroused due to intensive planting of sugarcane in furrows under intercropping system than that in the sole crop. Further a comparison of sole and intercropped sugarcane with regards to growth and quality studied in terms of plant height, no. of millable canes, cane girth and single cane weight indicated <50% variation for the above parameters. Non-exhaustive and dwarf nature of the intercrops and residual effect of the additional fertilizers as well as cultural practices and irrigation applied to companion crops on sugarcane (Hossain et al., 2003) had minimised the competition for resources and hence lesser difference. These results are in close conformity with Muhammad et al. (2000).

3.2. Yield attributes of ginger

The tiller number per plant (27.26) and rhizome number per clump (14) of ginger were significantly highest in sole compared to intercropped ginger (Table 2). The intercropped ginger was effective in growth when intercropped in sequence to watermelon with higher tiller (19.00) and rhizome (29.60) number. Similar, to the tiller and rhizome count, the fresh (220.25 g) and dry rhizome (103.99 g) weights of ginger were significantly highest in the sole crop. Whereas, in the intercropped ginger, due to maximum tiller and rhizome number, the fresh (142.10 g) and dry (61.84 g) weights of ginger also were highest when raised in sequence to watermelon alone (Table 2).

3.3. Yield of sugarcane

Sugarcane yield when raised as a sole crop obviously recorded the highest (2015: 146.55; 2017: 127.5; and Pooled data: 137.03 t ha^{-1}) than that of the intercropped

Table 2: Growth of ginger as affected by intercropping with early summer intercrops in sequence with ginger (Pooled data of two years)

Intercropping systems	No. of tillers plant^{-1}	No. of rhizomes clump^{-1}	Fresh rhizome weight (g)	Dry rhizome weight (g)
Sugarcane+greengram-Ginger	15.83	28.77	128.36	49.75
Sugarcane+tomato -Ginger	13.41	20.70	114.07	46.94
Sugarcane+watermelon-Ginger	19.00	29.60	142.10	61.84
Sugarcane+bittergourd-Ginger	16.94	26.95	128.19	56.54
Sugarcane+ridgegourd-Ginger	15.67	24.43	124.2	54.11
Sugarcane+bottlegourd-Ginger	14.94	23.97	116.86	48.93
Sugarcane+keera-Ginger	13.21	20.59	111.85	46.73
Sole sugarcane	-	-	-	-
Sole ginger	27.26	44.14	220.25	103.99
SEm±	0.86	0.68	3.42	1.92
CD (p=0.05)	1.84	1.46	7.33	4.12

combinations which were in agreement with findings of Azad and Alam (2004); and Nazir et al. (2002). Higher millable canes, single cane weight and cane girth had resulted in higher cane yield in sole sugarcane. The cane yield of intercropped sugarcane ranged from 79.83 to 92.94 t ha^{-1} and 65.21 to 81.25 t ha^{-1} during 2015 and 2017, respectively with the highest being recorded by the intercrop combination of sugarcane+watermelon (Table 3). This may be attributed to the highest millable canes and single cane weight observed under this combination. The pooled mean of two years also indicated the highest productivity of sugarcane to be in combination with watermelon (87.10 t ha^{-1}) (Table 3). Keshavaiah and Chandrappa (2014) also related higher number of tillers for higher yield of sugarcane

Table 3: Yield of Sugarcane, intercrops and ginger as affected by intercropping with early summer intercrops in sequence with ginger

Intercropping systems	Cane yield (t ha^{-1})			Summer intercrop yield (t ha^{-1})			Ginger yield (t ha^{-1})			Total sugarcane equivalent yield (t ha^{-1})		
	2015	2017	Pooled	2015	2017	Pooled	2015	2017	Pooled	2015	2017	Pooled
Sugarcane+greengram-Ginger	Mean	65.21	74.52	0.32	0.24	0.28	5.27	3.29	4.28	178.2	145.4	161.9
Sugarcane+tomato -Ginger	79.83	70.21	75.02	5.33	4.79	5.06	4.13	3.72	3.93	163.9	174.2	169.0
Sugarcane+watermelon-Ginger	92.94	81.25	87.10	8.52	7.88	8.20	5.03	4.12	4.56	203.1	237.3	220.0
Sugarcane+bittergourd-Ginger	89.79	76.25	83.02	4.87	6.48	5.68	4.83	3.89	4.36	205.3	240.3	223.2
Sugarcane+ridgegourd-Ginger	88.86	74.79	81.83	5.63	5.29	5.46	4.78	3.84	4.31	194.9	213.9	204.5
Sugarcane+bottlegourd-Ginger	84.65	68.13	76.39	7.14	6.69	6.92	4.54	3.42	3.98	181.9	185.5	183.6
Sugarcane+keera-Ginger	86.56	68.33	77.45	5.18	4.38	4.78	4.21	3.46	3.84	167.2	181.2	174.0
Sole sugarcane	146.5	127.5	137.03	-	-	-	-	-	-	146.6	127.5	137.0
Sole ginger	-	-	-	-	-	-	22.39	17.86	20.13	344.4	435.1	389.9
SEm±	-	-	-	-	-	-	-	-	-	23.71	72.5	34.8
CD (p=0.05)	-	-	-	-	-	-	-	-	-	10.32	25.0	11.5

(167.67 t ha^{-1}) in sugarcane+vegetable intercropping system. This system with the advantage of shorter intercrop duration did not coincide with the active tillering stage of main crop (sugarcane) and being leguminous crop had fixed the atmospheric nitrogen which complimented and supplemented to the sugarcane crop by enhancing its growth and productivity. However, vegetable crops like onion, bhendi, tomato have negative effect on the cane tillering and yield. The supressing effect of companion crops similar to present study also reported by Saini et al. (2003), who as well indicated that intercropping of radish, turnip and palak with autumn planted sugarcane has decreased the cane yield by 5.1, 7.4 and 11.5%, respectively over pure cane. The results of the present study corroborated the above findings.

3.4. Yield of intercrops

Among the summer (short duration) intercrops, watermelon registered the highest yield (2015: 8.52; 2017: 7.88; and Pooled data: 8.20 t ha^{-1}) compared to other crops. The next best intercrop was bottle gourd (2015: 7.14; 2017: 6.69; and Pooled data: 6.92 t ha^{-1}). On the other hand, the rhizome yield of sole ginger was maximum (2015: 22.39; 2017: 17.86; and Pooled data: 20.13) compared to the intercropped ginger. Among the different intercrop sequences, the ginger raised in sequence to green gram (5.27 t ha^{-1}) during 2015 and the ginger raised in sequence to watermelon (2017: 3.98) during 2017 and the pooled data (Pooled: 4.50 t ha^{-1}) recorded maximum rhizome yield (Table 3).

3.5. Sugarcane equivalent yield

The year-long sequential intercropping in sugarcane reported a yield advantage of 25.06 to 86.04 t ha^{-1} over the sole sugarcane. The most profitable sequential intercropping for sugarcane followed the order - Sugarcane+bitter gourd-ginger (223.07 t ha^{-1}) > watermelon-ginger (220.05 t ha^{-1})> ridge gourd-ginger (204.59 t ha^{-1})>bottle gourd-ginger (183.78 t ha^{-1})>keera-ginger (174.56 t ha^{-1})>tomato-ginger (169.22 t ha^{-1})>green gram-ginger (162.09 t ha^{-1}). Of the different sugarcane–summer crops-ginger combinations, intercropping sugarcane with bitter gourd/watermelon followed by ginger was highly potential sustaining the system yield (Table 3).

3. CONCLUSION

Intercropping in sugarcane is efficacious when an appropriate crop with proper management practices is followed, provided the effect of intercrop on cane yield is given prime importance. The detailed study suggested that intercropping sugarcane with early summer intercrops of 75–90 days duration *viz*., gourds or watermelon followed by ginger in sequence was a highly productive cropping system suitable to the Central Telangana Agroclimatic Zone with a yield advantage of 25–85 t ha^{-1} over sole sugarcane crop.

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