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Effect of intercropping and planting methods on yield, nutrient content and uptake by sugarcane under lateritic soil of Konkan region

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Abstract
The present investigation entitled "Effect of Intercropping and Planting Methods on Yield, Nutrient content and Uptake by Sugarcane under Lateritic Soil of Konkan Region" was conducted at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *Suru* season of 2015. The trial was laid out in a randomized block design. There were seven treatments which were replicated thrice. The treatments mainly comprised of Sole sugarcane with 90 cm spacing (T_1), Sole PRS i.e. 60 x 60 – 120 cm (T_2), PRS + groundnut (T_3), PRS + sweet corn (T_4), PRS + cabbage (T_5), PRS + amaranthus (T_6) and PRS + green gram (T_7). Results revealed that treatment sole paired row planted sugarcane (60 x 60 –120 cm) produced yield as compared to the conventional method of planting (90 cm in furrows) under study. Among the different treatments of planting methods and intercropping systems, paired row planted sugarcane intercropped with green gram recorded highest cane yield (89.03 t ha^{-1}), highest number of millable canes (78251.67), green top yield (11.66 t ha^{-1}) and trash yield (9.15 t ha^{-1}). Under different intercropping systems, the intercrop sweet corn recorded highest yield (8277 kg ha^{-1}) and sugarcane equivalent yield (146.38 t ha^{-1}). The nutrient uptake by crop was significant with nitrogen and potassium, but it was non-significant in case of phosphorus uptake. The maximum nutrient uptake recorded when paired row planted sugarcane intercropped with green gram. On the basis of results obtained during study, it can be concluded that the paired row planting method of sugarcane found to be more beneficial and profitable than their conventional planting (90 cm). The combination of sugarcane intercropped with sweet corn in the paired row planted sugarcane (60 x 60 –120 cm) found to be more remunerative followed by sugarcane intercropped with cabbage.

Keywords: Sugarcane, intercropping, yield, nutrient content, uptake

Introduction
Sugarcane (*Saccharum officinarum* L.) is one of the most important commercial crops in India. Globally, India ranks second in area (20.4%) and production (18.6%) among sugarcane growing countries in World. In India, sugarcane is cultivated in an area of 5.04 million ha with production of 348.04 million tonnes of cane with average productivity of 69 t per ha (Anonymous., 2014) [2]. Sugarcane is one of the important crop in contributing to the country's economy and farmer's livelihood development. In India, sugar is a 550 billion rupees worth industry, supporting more than 50 million farmers. There is a growing demand for sugar in India. Sugarcane is the main cash crop of Maharashtra state. The state ranks IInd, Ist, and IVth in respect of area, total production of cane and cane yield per ha respectively. The average recovery of sugar in Maharashtra is the highest *i.e.* 11.85 per cent in the country which is because of favourable agro-ecological conditions, resulting in accumulation of more sugar in the cane.

Intercropping is one of the sure way of increasing production without much increase in the application of inputs. Intercropping refers to growing of two or more crops simultaneously on the same piece of land. This system gives crop intensification of both time and space. Apart from its advantages like diversification, labour distribution, maintenance of soil fertility, suppression of weeds, two major advantages are higher productivity and greater stability through utilization of solar energy, moisture and nutrients. Many successful intercropping systems have been evaluated through out of the world, to get maximum production from the small land holdings. Mono-cropping is less economical to meet the farmers need. The intercropping produces two crops in a year, but it also influence the yield and yield components of sugarcane by competing for nutrients and other environmental factors. Intercropping one or more crops with sugarcane is an appropriate approach of getting additional farm income besides the principle sugarcane crop. As sugarcane is planted at adequate row spacing and this inter-rows space practically remains vacant in early growth

stage which extends nearly four months where suitable short duration winter crops may be grown as intercrop that increase total yield, higher monitory return, and greater resource utilization and fulfils the diversified needs of the farmers. Intercropping in sugarcane with various short duration crops like cabbage, potato, mungbean etc. has been proven profitable in comparison to growing sugarcane as sole crop (Alam *et al*., 2000) [1].

Average size of land holdings of Indian farmers is decreasing day by day owing to constant increase in human population. Presently, the proportions of marginal, small and big farmers in the country is 58.0, 18.0 and 24.0 per cent respectively. Therefore, to meet the demand of food *viz*; cereals, pulses, oilseeds, vegetables, sugar, etc. for the ever increasing population, raising production of these crops is not possible due to limited availability of agricultural land and the only option is to increase the crop productivity on the available land. The productivity of land could be enhanced substantially by growing intercrops in the space left between sugarcane rows. Sugarcane crop remains in the field for a year or more and the space between sugarcane rows range from 70 to 90 cm providing ample chance for profuse weed growth which draws huge amount of nutrients and moisture from the soil. Hence, besides suppressing weeds in the inter-row spaces, additional production could be taken by growing suitable intercrops in between the cane rows. Some of the intercrops have been found to have no adverse effect on sugarcane yield. Konkan region is high rainfall zone having paddy as a principal traditional crop. After harvest of paddy and other hill millets, it is difficult to prepare land for plantation of pre-seasonal sugarcane. Konkan region is bestowed with assured rainfall with annual average 3500 mm. In spite of such huge rainfall, the region faces scarcity of water after mansoon. Thus, efficient use of water plays an important role for agricultural production in this region. This region has gained momentum in agro-tourism during last decade. Considering the commercial demand of sugarcane in this region, its productivity needs to be increase. Being a C_4 plant, physiologically it is one of the most efficient converters of solar energy into sugar among the cultivated plants. Sugarcane being a non-conventional crop for farmers in Konkan, most of them go for a traditional method of planting of sugarcane. So it has great scope in checking the modern methods of sugarcane planting in Konkan region with an additional inputs. While the information related to intercropping and planting methods on yield and nutrient uptake by sugarcane under lateritic soils of Konkan region is lacking Hence an attempt was made to study the Effect of intercropping and planting methods on growth, yield and quality of sugarcane under lateritic soil of Konkan region for sugarcane growers.

Material and methods

The present investigation "Effect of intercropping and planting methods on growth, yield and quality of sugarcane under lateritic soil condition" was conducted at Agronomy farm, Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during Suru season of 2015. The experiment was laid out in Randomized Block Design with three replications. The gross plot size is 6.3 m x 5.4 m and net plot size is 5.7 m x 4.8 m. The variety of Sugarcane - Co 8014 and intercrops Groundnut – TKG bold, Sweet corn – Sugar-75, Cabbage – Sent, Amaranthus – Konkan durangi, Green gram – Taiwan.

Treatment details

T1 – Sole sugarcane with 90 cm row spacing
T2 – Sole paired row sugarcane (60 x 60 cm – 120cm)
T3 – Paired row sugarcane (PRS) + Groundnut
T4 – Paired row sugarcane (PRS) + Sweet corn
T5– Paired row sugarcane (PRS) + Cabbage
T6 – Paired row sugarcane (PRS) + Amaranthus
T7 – Paired row sugarcane (PRS) + Green gram

Table 1: Fertilizers, seed rate and spacing.

Crop	N, P, K kg ha^{-1}	Seed rate ha^{-1}	Spacing
Sugarcane	250:115:115	30,000 setts	As per treatments
Groundnut	25:50:00	100 kg	30 x 15 cm
Sweet corn	200:60:60	20 kg	45 x 30 cm
Cabbage	120:60:60	50,000 seedlings	45 x 45 cm
Amaranthus	60:30:30	2.5 kg	20 cm line sowing
Green gram	25:50:00	20 kg	30 x 10 cm

Planting of sugarcane was done in paired row with 60 x 60 – 120 cm in dry soil in which 3 eye bud setts were placed in row and buried in soil at 5 cm depth. Planting of sugarcane in conventional method with 90 cm spacing was done by digging furrows at 15 cm depth and setts were planted in it. The six lines of sugarcane were maintained both in paired row as well as conventional planting. Intercrops were sown in 120 cm gap in between paired row and both sides of plots of sugarcane. The dibbling of groundnut and green gram seeds was done at 30 cm row spacing, where three rows were maintained in between gap of 120 cm and one row sown at both sides of plot, total eight number of rows in plot were maintained. In case of sweet corn, the seeds were dibbled at 45 x 30 cm spacing. Thus two rows were maintained between gaps of paired row and one row at both sides of each plot. Total number of six rows were accommodated in the plot. The cabbage seedlings were transplanted at 45 x 45 cm spacing in which two rows were maintained in between gaps of paired row and one row at both sides, thus total number of six rows were maintained. The amaranthus seeds were sown in line sowing at 20 cm row spacing where four lines were maintained in gap of paired rows and two rows at both the sides, the total lines being twelve per plot.

Fertilizer application

The recommended dose of fertilizer of sugarcane *viz.*, 250 kg per ha N, 115 kg per ha P_2O_5 and 115 kg per ha K_2O was used for field experiment. At the time of planting 10 per cent dose of N and entire dose of P_2O_5 and K_2O were applied by placement method just before planting of sugarcane crop. Remaining N were applied in three split doses @ 40, 10 and 40 per cent at an interval of six weeks from each preceding dose. In case of intercrops groundnut and green gram were fertilized with recommended dose of 25:50:00 kg per ha at the time of sowing whereas, sweet corn fertilized with 50 per cent recommended dose of N, 100 per cent P_2O_5 and K_2O as a

basal application just before sowing of crop and 50 per cent N as top dressing at 30 and 60 DAS. In case of cabbage the recommended dose split into 100 per cent P_2O_5 and K_2O as a basal application and N split into three doses such as at the time of transplanting and remaining at 20 and 40 DAP. Amaranthus was fertilized with recommended fertilizer dose 100 per cent at the time of sowing. As per recommendation time to time intercultural operations and plant protection measures was taken

Intercrops were harvested, uprooted, cleaned and subsequently fresh yield per net plot was recorded. Finally, it was presented on hectare basis. The sugarcane was also harvested at maturity by cutting at ground level. The green top and dry leaves of millable cane were separated from each other. Following observations were made at harvest. The weight of millable canes from each net plot was recorded separately with the help of platform balance and the cane yield per hectare was worked out. The weight of green tops and trash (dry leaves) per net plot was recorded and converted on hectare basis.

Soil analysis

The soil samples collected after harvest of sugarcane were used for determination of available nitrogen, phosphorus and potassium. The available nitrogen, phosphorus and potassium in soil at harvesting stage was determined by Alkaline potassium permanganate method (Subbaiah and Asija, 1956) [11] Bray's No. 1 method (Black, 1965) [3] and Flame photometry method (Jackson, 1973) [5] respectively.

Plant chemical analysis (N, P, K content and uptake)

The canes sampled for dry matter determination at harvest were utilized for chemical estimation. The dried samples were ground to fine powder (100 mesh) and about ten g of representative sample from the powdered material was preserved in suitably labelled brown paper bags for chemical estimation. The nitrogen, phosphorus and potassium content was determined by Microkjeldahl method, molybdovandate phosphoric acid method and flame photometric method, respectively. The uptake of nitrogen, phosphorus and potassium (kg ha^{-1}) was worked out by multiplying the percentage of these nutrients in cane with the corresponding dry yields of the respective constituent. The collected data during experiment was analyzed as per the procedure given by Panse and Sukhatme (1967) [7].

Results and Discussion

Effect of treatments on yield of sugarcane

Data pertaining to yield studies of sugarcane and intercrops is influenced by various treatments of planting methods and intercrops are presented in Table 2.

Number of millable canes (`000 ha^{-1})

The number of millable canes was significantly influenced by various treatments of planting methods and intercropping systems. Result revealed that, sugarcane planted with conventional spacing (90 cm in furrows) produced lower number of millable canes as compared to sole PRS (60 x 60 – 120 cm). In respect of intercropping systems, the number of millable canes was significantly higher in paired row planted sugarcane intercropped with green gram (T_7) *i.e.* 78251.67 which was at par with paired row planted sugarcane intercropped with groundnut (T_3) *i.e.* 74671.33 and sole paired row planting sugarcane (T_2) *i.e.* 73328.67 over rest of the treatments. The lowest number of millable canes was observed when paired row planted sugarcane intercropped with sweet corn (T_4) *i.e.* 66954.67.

Cane yield (t ha^{-1})

The data clearly indicated that sole paired row planted sugarcane intercropped with green gram (T_7) produced significantly superior in production of cane yield (89.03 t ha^{-1}) during investigation than the treatment T_1 and T_4 but it was remained identical with treatments T_3, T_5, T_2 and T_6 in descending order. However, among all the planting methods sole paired row planted sugarcane recorded comparatively higher but statistically equal cane yield per hectare with conventional planting (90 cm in furrows).

Green top yield (t ha^{-1})

From the data, it was observed that, the conventional planting (90 cm in furrows) of sugarcane obtained lower green top yield than sole paired row planting of sugarcane (60 x 60 – 120 cm). Among the different intercropping systems, the significantly highest yield of green tops was recorded by paired row planting sugarcane intercropped with green gram (T_7) i.e. 11.66 t per ha as compared to all other treatments. However, the significantly lowest green top yield obtained with treatment T_4 (PRS + sweet corn) *i.e.* 8.99 t per ha.

Trash yield (t ha^{-1})

The data clearly denoted that, the paired row planted sugarcane intercropped with green gram recorded significantly higher trash yield of 9.15 t per ha as compared with sugarcane planted at normal spacing (90 cm in furrows) and sole paired row sugarcane (60 x 60 – 120 cm) but it was remained at par with rest of the treatments. However, sole paired row sugarcane recorded relatively higher but statistically equal trash yield as compared to conventional planted sugarcane (90 cm in furrows).

The wider spacing recorded higher yield which is the ultimate result of increased accumulation of photosynthesis due to resource availability like sunlight, water and nutrients etc. Similar results were also reported by Singh *et al*., (2010) [10].

Intercrop yield (kg ha^{-1})

Amongst the different intercropping systems, sweet corn produced highest yield (8277 kg ha^{-1}). Next to sweet corn, cabbage intercropping system produce maximum yield (7715.33 kg ha^{-1}) which are followed by intercrops such as amaranthus (1826 kg ha^{-1}) and groundnut (844 kg ha^{-1}). The lowest intercrop yield (265 kg ha^{-1}) obtained in green gram than all other intercrops. It may be concluded from result that, the vegetable type of intercrops has economically more viable and gave maximum additional benefit as compare to seed type of intercrops. While, the intercrops like green gram and groundnut play a complementary role and helpful for maximum yield of main crop. The results corroborate with findings of Lithourgidis *et al*., (2011) [6].

Effect on nutrient content and uptake by sugarcane.

Data regarding total nutrient content and uptake of nitrogen, phosphorous and potassium by the sugarcane as influenced by different treatments of planting methods and intercrops are presented in Table 3.

Nutrient content (%) in sugarcane

Data regarding to the nutrient content of nitrogen, phosphorous and potassium content in the sugarcane after harvest indicated that the N, P and K content in sugarcane

after harvest failed to exert any significant effect due to various treatments of planting methods and intercropping systems. However, paired row planted sugarcane intercropped with green gram (T_7) recorded numerically higher values of N, P and K content in sugarcane.

Nutrient uptake by sugarcane (kg ha^{-1})

Total uptake of nitrogen (kg ha^{-1})

It is evident from the data presented in Table 3, the nitrogen uptake by sugarcane was significantly influenced by the various treatments. As compare with sole paired row planting (60 x 60 – 120 cm) and conventional planting (90 cm), the paired row spacing recorded maximum uptake than conventional method of planting. The data on uptake of N with different intercropping systems revealed that, the significantly highest uptake were recorded with the treatment T_7 (PRS + green gram) *i.e.* 198.93 kg per ha than the rest of the treatments except treatments T_3 and T_5 which were at par with each other. This is due to leguminous crops fix atmospheric nitrogen into available form which results maximum availability of nitrogen to crop and gets higher yield. Treatment T_4 (PRS + sweet corn) which was recorded lowest uptake than all other treatments *i.e.* 161.57 kg per ha.

Total uptake of phosphorus (kg ha^{-1})

Neither the planting geometry nor the intercropping systems significantly influenced the uptake of phosphorus per hectare by sugarcane after harvest. While, the maximum uptake of phosphorus were observed with the treatment T_7 (PRS + green gram) *i.e.* 15.17 kg per ha as compared to all other treatments. Amongst the various treatments, sole sugarcane with conventional planting (90 cm) recorded lowest phosphorus uptake *i.e.* 10.51 kg per ha.

Total uptake of potassium (kg ha^{-1})

The result showed marked influence of planting methods and intercrops on potassium uptake by sugarcane. However, numerically higher values of potassium uptake was recorded with sole paired row planting (60 x 60 – 120 cm) than the normal planting of sugarcane (90 cm). Data further revealed that, with different intercropping system, paired row planting sugarcane intercropped with green gram (T_7) recorded higher potassium uptake such as 289.47 kg per ha. As compared to other treatments, paired row planting of sugarcane intercropped with sweet corn (T_4) shows lower uptake of potassium *i.e.* 234.46 kg per ha.

The fertilizer use efficiency was marginally higher when sugarcane intercropped with green gram and groundnut. Similar type of results were also reported by Pawar and Bhosale (1987) [9] with different intercrops. The comparatively lowest uptake of nutrients were recorded when sugarcane intercropped with sweet corn. Sweet corn is voracious feeder of nutrients, that's why it compete with sugarcane for nutrients which results lowest uptake and adversely affecting on sugarcane growth. The significantly higher uptake was recorded with wide spacing of sugarcane (60 x 60 – 120 cm) over normal spacing (90 cm). Patel *et al*., (2014) [8] found similar types of result.

Effect on Availability of nutrient in soil.

The effect of different treatment on available nitrogen, phosphorus and potassium status kg per hectare of soil after harvest of sugarcane are presented in Table 4.

Available nitrogen in soil (kg ha^{-1})

Available nitrogen in soil after harvest of sugarcane remained unaffected due to various treatments of planting methods and intercrops. However, the maximum nitrogen available in soil after harvesting of sugarcane recorded in treatment T_3 (PRS + groundnut) *i.e.* 291.33 kg per ha. While treatment T_4 (PRS + sweet corn) recorded lowest nitrogen availability *i.e.* 283.77 kg per ha.

Available phosphorus in soil (kg ha^{-1})

Data regarding to available phosphorus in soil after harvesting of sugarcane revealed that, the various treatments of planting methods and intercrops was not influenced significantly on phosphorus availability in soil. The paired row planting sugarcane intercropped with groundnut recorded numerically maximum availability of phosphorus (13.35 kg ha^{-1}) as compared to rest of the treatments. The lowest availability of phosphorus in soil was recorded when paired row planting sugarcane intercropped with sweet corn (10.94 kg ha^{-1}).

Available potassium in soil (kg ha^{-1})

Differences in available potassium due to various methods of planting and intercrops were not remarkable and hence, found to be statistically non-significant. However, the maximum availability of potassium was recorded under treatment T_3 (PRS + groundnut) *i.e.* 264.34 kg per ha than rest of the treatments. The lowest potassium availability was recorded when sugarcane paired row planting with sweet corn *i.e.* 254.64 kg per ha.

Table 2: Yield of sugarcane and intercrops as influenced by various treatments of planting methods and intercropping systems.

Treat. No.	No. of millable canes (`000 ha^{-1})	Cane yield (t ha^{-1})	Green top yield (t ha^{-1})	Trash yield (t ha^{-1})	Intercrop yield (kg ha^{-1})	
					Economical yield	Biological yield
T_1:	67100	79.87	9.44	7.27	-	-
T_2:	73328.67	83.62	10.35	8.22	-	-
T_3:	74671.33	86.66	10.76	8.91	844	1055
T_4:	66954.67	75.96	8.99	6.81	8277	9930.40
T_5:	67503.67	85.76	10.52	8.20	7715.33	-
T_6:	67755.33	82.71	10.14	8.47	1826.33	-
T_7:	78251.67	89.03	11.66	9.15	265	-
S.E.±	2580.95	2.09	0.42	0.34	-	-
C.D. at 5%	7952.68	6.43	1.30	1.06	-	-
General mean	70795.04	83.37	10.26	8.14	-	-

Table 3: Plant nutrient content (%) and uptake (kg ha^{-1}) influenced various methods of planting and intercropping systems.

	Treatments	Nutrient content (%)			Nutrient uptake (kg ha^{-1})		
		N	P	K	N	P	K
T_1 :	Sole sugarcane - 90 cm	1.48	0.09	2.14	171.16	10.51	248.26
T_2 :	Sole PRS (60 x 60 – 120 cm)	1.49	0.11	2.16	183.21	12.91	264.89
T_3 :	PRS + Groundnut	1.50	0.12	2.17	190.94	14.92	276.83
T_4 :	PRS + Sweet corn	1.47	0.11	2.13	161.57	12.09	234.46
T_5 :	PRS + Cabbage	1.48	0.10	2.16	185.99	12.74	270.46
T_6 :	PRS + Amaranthus	1.49	0.11	2.18	180.29	12.82	264.50
T_7 :	PRS + Green gram	1.51	0.12	2.20	198.93	15.17	289.47
	S.E.+	0.02	0.01	0.02	4.28	1.88	5.85
	C.D. at 5%	N.S.	N.S.	N.S.	13.18	N.S.	18.02
	General mean	1.48	0.10	2.16	181.72	13.02	264.12

Table 4: Mean available N, P, K (kg ha^{-1}) in soil after harvest of sugarcane as influenced by various treatments of planting methods and intercropping systems.

	Treatments	Available N	Available P	Available K
T_1 :	Sole sugarcane - 90 cm	286.06	11.61	258.32
T_2 :	Sole PRS (60 x 60 – 120 cm)	289.06	11.98	259.45
T_3 :	PRS + Groundnut	291.33	13.35	264.34
T_4 :	PRS + Sweet corn	283.87	10.94	254.64
T_5 :	PRS + Cabbage	290.34	11.60	258.41
T_6 :	PRS + Amaranthus	288.32	11.57	259.70
T_7 :	PRS + Green gram	289.28	12.06	260.32
	S.E.+	1.77	0.48	1.75
	C.D. at 5%	N.S.	N.S.	N.S.
	General mean	288.25	11.87	259.31

Conclusion

On the basis of present investigation following broad conclusions can be drawn.

1. Intercropping with green gram and groundnut were obtain maximum yield in paired row planted sugarcane (60 x 60 – 120 cm).
2. Sweet corn crop is suitable for intercropping in paired row planted sugarcane.
3. The fertilizer use efficiency was marginally higher when sugarcane intercropped with green gram and groundnut

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