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Effects of tillage practices and fertility levels on crop growth, yield and quality of sugarcane (*Saccharum officinarum* L.) under South Gujarat conditions

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Abstract
Field experiments were conducted during rabi season of 2017-2018 and 2018-2019 at College farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari to study the "Effects of tillage practices and fertility levels on growth, yield and quality of sugarcane (Saccharum officinarum L.) under South Gujarat conditions". Total sixteen treatment combinations consisting of four treatment of tillage practices T_1: Cultivation with cultivator, T_2: Sub soiling (45 cm depth & at 2 m distance in square) + Cultivation with cultivator, T_3: Deep ploughing (22.5) + Cultivation with cultivator T_4: Rotavator + Cultivation with cultivator and four treatment of fertilizer levels F_1: 75% RDN (187.5 N kg/ha), F_2: 100% RDN (250 N kg/ha), F_3: 125% RDN (312.5 N kg/ha), F_4: 150% RDN (375 N kg/ha) was laid out in Split Plot Design with three replications. The sugarcane cultivar used in the study was Co N 13073.
Germination of sugar cane setts at 30 & 45 DAP and girth of millable cane at harvest were not differed significantly during both the years due to different tillage practices. While, plant height, number of tillers, number of internode, single cane weight, millable cane length and millable canes per hectare were found significantly higher under treatment the T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator). While, treatment having cultivation with cultivator (T_1) recorded significantly lower growth parameters and yield attributes than rest of the treatments during both the years as well as in pooled result.
The results of present investigation further revealed that growth and yield attributing characters, *viz g*ermination of sugar cane setts and girth of millable cane at harvest were not differs significantly during both the years due to different fertilizer levels. While, plant height, number of tillers, number of internode, single cane weight, millable cane length, millable canes per hectare, cane yield were found significantly higher under the treatment 125% RDN (F_3) followed by the fertility level 150% RDN (F_4). However, treatment 75% RDN (F_1) recorded lowest value of all growth parameters and yield attributes during both the years as well as in pooled analysis.
Treatment T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator) registered maximum gross realization (₹ 4,87,243/ha) and net realization (₹ 3,79,832/ha) with B:C ratio of 3.54. While, the lowest gross realization (₹ 3,73,651/ha) and net realization (₹ 2,70,240/ha) with B: C ratio of 2.61 was obtained under T_1 (Cultivation with cultivator) treatment. The highest gross realization (₹ 4,72,537/ha), net-realization (₹ 3,69,535/ha) and B:C ratio (3.52) were obtained with the treatment F_3 (125% RDN). While, the lowest gross realization (₹ 3,78,049/ha), net realization (₹ 2,70,755/ha) and B:C ratio (2.62) was obtained under the treatment F_1 (75% RDN).

Keywords: Sugarcane, tillage, fertility levels, growth, cane yield and economics

Introduction
Sugarcane is one of the most important industrial cash crops in both tropical and subtropical region of the world and a major export product of many developing countries. Sugarcane cultivation in India dates back to the Vedic period. The earliest mention of sugarcane cultivation is found in Indian writings of the period 1400 to 1000 B.C. It is a principal raw material for sugar industry as world's 77% sugar comes from sugarcane. It is the main source of sugar, jeggari (gur) and brown sugar (khandsari). About two-thirds of the total sugarcane produced in India is consumed for making gur and khandsari and only one third of it goes to sugar factories. It also provides raw material for manufacturing alcohol. In most countries where sugarcane is cultivated, there are several foods and popular dishes derived directly from

it, addition to sugar production, it is raw material for paper, alcohol, plywood, industrial enzyme and animal feed.

Sugarcane is a deep rooted crop. Hence, effective exploitation of soil from deeper layers is important for harnessing potential crop productivity and/or quality. Preparatory tillage operations are usually carried by harrow and rotavator. However, the depth of tillage is confined to 10-15 cm. Repeated operations by harrowing confining to constant depth over long period results in formation of hard pan in plough sole. The presence of hard/compact layer in subsoil leads to restricted water infiltration thereby bringing many chemical and biological changes. During rainy season and/or on watering field temporary anaerobic conditions persist in root zone which adversely affects the plant growth. Further, compact layer in subsoil limits vertical root growth, which subsequently reduces nutrients and water uptake by the crop.

Among several factors, fertilizer is responsible for satisfactory vegetative growth and better production of sugarcane crop. The nutrients should be supplied according to crop needs at different physiological stages of the growth. The higher cane yield (109.4 t/ha) was recorded under the treatment 125% RDF followed by treatment 100% RDF (250-125-125 NPK kg/ha). The increased cane yield could be due to positive and significant correlation with number of millable cane per hectare, plant height, millable cane length, single cane weight and number of internodes per cane during both the years. However, higher dose of N promoting growth parameters might be due to fact that the net assimilation rate of the N fed to plants was accelerated due to increase in chlorophyll content and the absorbed N helped in the formation of food reservoir due to higher photosynthetic activity, which increases the growth character

Methodology

The field experiment was conducted on plot number D-15 and B-6 of the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during 2017-2018 and 2018-2019**.** Campus is geographically located at 20º57' N latitude and 72º54' E longitude at an altitude of 10 meters above the mean sea level. Data on soil analysis revealed that soil of experimental plot was clay in texture. The soil of the both plots (on an average of both years) was medium in available nitrogen (269.85 kg/ha), medium in available phosphorus (27.7 kg/ha) and fairly rich in available potassium (372.65 kg/ha) and slightly alkaline in reaction (8.01).

The experimental field was prepared by tractor drawn implements. The subsoiling, deep ploughing and rotavator practice was carried out in the month November-December during both the years as per treatment details. Ridges and furrows were opened at a distance of 100 cm with the help of tractor drawn ridger. Plots were laid out as per the plan given in Fig. 3: during both the years. The essential channels required to irrigate the plots were opened with the help of tractor drawn ridger.

A common dose of 125 kg P_2O_5 ha^{-1} and 125 kg K_2O ha^{-1} in the form of single super phosphate and murate of potash, respectively, were applied uniformly to all the experimental plots prior to planting and it was mixed with the soil. Whereas, nitrogen was applied in the form of urea in all treatments in four splits as 15 per cent at the time of planting, 30 per cent at 45 days after planting, 20 per cent at 90 days after planting and 35 per cent before final earthing-up *i.e.*150 days after planting fertilizer were manually applied uniformly in all the experimental unit during both the year as per the treatments.

Two eye budded setts obtained from sugarcane varieties (CoN 13073) were used @ 50,000 per hectare. Two eye budded setts were planted in furrows after treating with 0.1 per cent solution each of Emisan and Melathion for control of fungal and insect infestation. The planting was done using seed rate of 50,000 two eye bud setts *i.e.* planting 100 cm between rows. The setts were arranged in the field and covered with soil in wet planting method. Tube well having good quality water was used for irrigation. During the entire growth period 14 irrigations were given during 2017-18 and 2018-2019 with 20-22 days interval in winter and 15- 18 days interval in summer season, respectively.

Results and Discussion

Growth parameter

The data on germination count, plant height and number of tillers at periodical interval are presented in Table 1. The data clearly revealed that the number of tillers per meter row length was found to be increased progressively up to 135 DAP then after it was decreased. It may be due to competition among tillers for light, nutrients, air and moisture. Tillers are able to take all these parameters easily become well in growth. Total plant dry matter accumulation in leaf blade, leaf sheath and stalk at harvest are presented in Table 1.

Effect of tillage practices

The data presented in Table 1 revealed that tillage practices did not exert any significant influence on the germination of sugarcane setts at 30 and 45 days after planting during pooled analysis. Treatment T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator) resulted numerically higher emergence 59.1 and 70.8% at 30 and 45 DAP, respectively.

The different tillage practices significantly influenced plant height. At 90, 180, 270 DAP and harvest maximum plant height was recorded with treatment T_2 (Sub soiling 45 cm depth & at 2m distance in square + Cultivation with cultivator) being statistically at par with treatment T_3 (Deep ploughing (22.5 cm) + Cultivation with cultivator) during both the years. However, in pooled analysis, plant height in treatment T_2 was statistically at par with treatment T_3 at 270 DAP and at harvest only.

Tillage practices significantly influenced the number of tillers per meter row length in sugarcane at all the stages of observation during both the years and in pooled analysis. Significantly higher number of tillers (17.3, 22.3 and 16.3) were recorded under the treatment T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator at 90 DAP) during in pooled analysis.

Different tillage practices significantly affected the periodical dry matter accumulation by plant. Significantly higher dry matter accumulation at harvest (54.7 t ha^{-1}) were observed in the treatment T_2 (Sub soiling 45 cm depth & at 2m distance in square + Cultivation with cultivator) during both the year as well as in pooled analysis, respectively. Treatment T_1 (Cultivation with cultivator) recorded the lowest dry matter accumulation at harvest during in combined analysis.

Effect of fertility levels

A perusal of data presented in Table 1 indicated that germination percentage at 35 and 45 days after planting were not affected significantly due to different nitrogen fertility levels during both the years of study and in pooled analysis. However, numerically higher germination per cent was found

with treatment F_3 *i.e.* 125% RDN (312 kg N / ha.) at both the stage during individual and combine of two years.

Treatment 125% RDN (F_3) recorded significantly higher plant height at 90 DAP, 180 DAP, 270 DAP and at harvest during both the year as well as in pooled analysis. It was found statistically at par with the 150% RDN (F_4) during individual and combine of two years at 180 DAP, 270 DAP and at harvest. Treatment 75% RDN (F_1) and 100% RDN (F_2) significantly inferior to the other fertility levels during both the year of study and in pooled analysis.

Significant variations in the number of tillers per meter row length were observed due to different fertility levels at 90 DAP, application of 125% RDF (F_3) recorded significantly higher number of tillers per meter row length in pooled analysis, At 135 DAP, number of tillers per meter row length were found significantly higher under the treatment F_3 (125% RDN) in pooled analysis, respectively. Significantly higher number of tillers per meter row at 180 DAP were observed under the treatment F_3 (125% RDN) in pooled analysis, respectively. However, it was statistically at par with treatment (F_4) 150% RDN during the pooled data.

At all periodical stages, dry matter accumulation of total dry matter at harvest found significantly higher under 125% RDN (F_3) which was found statistically at par with 150% RDN (F_4). The lowest dry matter accumulation was observed under the treatment of 75% RDN (F_1) at all periodical stages during both the individual year as well as in pooled analysis.

Interaction effect

The interaction between tillage practices and fertility levels with respect to Germination count, plant height, number of tiller per meter row length and periodical dry matter yield was non-significant during in combined analysis

Table 1: Effect of tillage practices and fertility levels on growth parameter of sugarcane

Treatment	Germination count		Plant height (cm)				Number of tiller per meter row length			Plant dry matter accumulation (t/ha)
	30 DAP	45 DAP	90 DAP	180 DAP	270 DAP	At harvest	90 DAP	135 DAP	180 DAP	
Tillage practices (T)										
T_1	53.7	65.2	55.4	163.9	219.3	289.3	12.2	14.1	11.7	40.8
T_2	59.1	70.8	65.4	188.8	250.7	335.7	17.3	22.3	16.3	54.7
T_3	56.8	67.6	59.9	174.6	238.4	322.3	15.3	19.8	14.5	50.1
T_4	55.9	67.6	58.3	169.4	228.7	296.4	14.4	18.6	13.5	48.2
SEm ±	1.08	1.12	1.25	3.43	4.23	9.89	0.40	0.49	0.41	1.07
CD (P=0.05)	NS	NS	3.86	10.56	13.05	34.23	1.23	1.51	1.26	3.30
CV%	9.41	8.06	10.3	9.64	8.85	11.04	13.22	12.83	14.3	10.8
Fertility levels (F)										
F_1	53.9	65.5	49.6	146.5	207.1	281.0	12.8	14.9	12.2	38.7
F_2	56.8	68.2	57.6	167.3	230.7	301.4	14.8	18.9	13.9	49.3
F_3	57.8	69.7	68.1	194.2	260.5	336.7	16.4	21.2	15.4	54.9
F_4	57.0	67.7	63.4	188.7	248.8	322.7	15.1	19.7	14.4	50.9
SEm ±	1.02	1.08	1.17	2.88	4.66	12.10	0.38	0.44	0.39	1.06
CD (P=0.05)	NS	NS	3.32	8.18	13.26	35.32	1.09	1.25	1.12	3.01
CV%	8.84	7.82	9.57	8.09	9.75	13.50	12.6	11.46	13.7	10.7
Interaction (T x F)										
SEm ±	2.92	2.17	2.33	5.76	9.33	24.20	0.77	0.88	0.78	2.11
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Yield and yield attributes

The observations related to millable cane height, number of millable cane per meter row, number of internode per millable cane, girth of cane, number of millable cane, singal cane weight and cane yield of sugarcane crop were recorded at harvest only during both the years and the data are presented in Table – 2

Effect of tillage practices

Maximum number of millable canes per meter row length was observed with treatment T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator). This was largely attributed to more number of sugarcane tillers per meter row length, more efficient utilization of moisture, nutrients and solar energy with less inter plant and intra plant competition

The differences in individual single cane weight can be attributed to the variation in cane length and cane girth. Higher millable cane length, number of internode per millable cane, single cane weight and cane girth were recorded under treatment T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator) during both the years and combined analysis. The higher millable cane length, number of internodes, single cane weight and cane girth under tillage practices treatment T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator) may be due to better utilization of available nutrient and moisture under better soil structure development.

During both the years, sugarcane crop exhibited significant variations in cane yield owing to execution of different tillage practices treatment. An increase in yield was observed with increasing intensity of tillage. Crop grown under the most intense tillage *i.e.* treatment T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator) exhibited significantly higher cane yield (131.7 t/ha) as compared to treatment T_1 Cultivation with cultivator) in sugarcane during pooled analysis. Such increase in cane yield was due to higher individual cane weight and number of millable canes. Crop grown under treatment T_2 (Sub soiling 45 cm depth & at 2 m distance in square + Cultivation with cultivator) had 19.4 per cent more of millable canes and 14.6 per cent cane weight than that of treatment T_1 (Cultivation with cultivator) in pooled analysis.

Effect of fertility levels

Significantly higher millable cane length, number of millable cane per meter row length and number of internodes were observed higher under the treatment 125% RDN (F_3) during both the years as well as in pooled analysis. It might be due to better morpho-physiological development of crop in terms of higher LAI, number of tillers per metre row length under this treatment. Millable cane, number of millable cane per meter row length and number of internodes were found significantly lower with 75% RDN (F_1) during two consecutive years and in pooled analysis, respectively. However, different fertility levels did not exert their significant effect on girth of millable cane at harvest during both the years.

The data pertaining to number of millable cane per hectare as affected by various fertility levels was found significant at harvest during both the years. 125% RDN (F_3) recorded significantly higher number of millable canes per hectare at harvest which were remained at par with 150% RDN (F_4) during in pooled analysis. However, significantly the lowest numbers of millable canes per hectare were observed under the treatment 75% RDN (F_1) at harvest during both the years of investigation and in pooled analysis, respectively. The enhanced fertility status and more tillering which converting into higher number of millable canes also contributed to more cane yield.

Single cane weight differs significantly due to different fertility levels during both the years. Significantly higher single cane weight was observed under the treatment 125% RDN (F_3) and it was remained at par with 150% RDN (F_4) during in pooled analysis and lowest single cane weight was observed under treatment 75% RDN (F_1).

It was observed from the data (Table 2) that, higher cane yield were recorded under fertility level 125% RDN (F_3). The cane yield is a product of growth and yield components. The increased cane yield in fertility levels (F_3) and (F_4) could be due to positive and significant correlation with number of millable cane per hectare, plant height, millable cane length, single cane weight and number of internodes per cane during both the years.

Interaction effect

The interaction between tillage practices and fertility levels with respect to millable cane height, number of millable cane per meter row, number of internode per millable cane, girth of cane, number of millable cane, singal cane weight and cane yield was non-significant during in combined analysis

Table 2: Effect of tillage practices and fertility levels on yield attributes and yield component of sugarcane

Treatments	Millable cane length (cm)	Number of Millable cane per meter row	Number of internode per Millable cane	Girth of cane (cm)	Number of millable cane (ha)	Single cane weight (kg)	Cane yield (t/ha)
Main : Tillage practices(T)							
T_1	199.9	8.27	18.57	8.63	82708	1.10	101.0
T_2	249.4	11.19	22.92	8.91	111897	1.42	131.7
T_3	232.3	10.60	21.87	8.65	106016	1.28	123.8
T_4	217.4	9.74	20.76	8.53	97358	1.14	109.4
SEm ±	6.89	0.30	0.51	0.16	3009	0.03	3.09
CD (P=0.05)	21.2	0.93	1.57	NS	9272	0.12	13.5
CV%	15.0	13.40	13.2	8.89	14.82	15.3	13.0
Sub : Fertility levels (F)							
F_1	195.4	8.20	18.53	8.36	81654	1.18	102.2
F_2	222.3	9.83	21.36	8.64	98140	1.14	115.9
F_3	244.6	11.3	22.61	8.98	112859	1.34	128.3
F_4	236.7	10.5	21.62	8.72	105326	1.28	119.5
SEm ±	5.80	0.30	0.56	0.22	3017	0.04	2.67
CD (P=0.05)	16.5	0.86	1.59	NS	8579	0.11	7.60
CV%	12.6	12.9	12.6	12.4	14.86	15.2	11.2
Interaction (T x F)							
SEm ±	11.6	0.60	1.12	0.44	6034	0.07	5.34
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

Conclusion

From the two years of experimentation, it can be concluded that sub soiling 45 cm depth & at 2 m distance in square + cultivation with cultivator or deep ploughing (22.5 cm) + cultivation with cultivator along with 125% RDN (312.5 kg N/ha) was found beneficial for securing higher cane yield, infiltration rate and economic returns under south Gujarat condition.

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