Indian J. Agric. Res., 49 (3) 2015: 222-228
Print ISSN:0367-8245 / Online ISSN:0976-058X

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.ijarjournal.com

Effect of planting methods on growth pattern and productivity of sugarcane varieties

J.M.L. Gulati*, Ch Sunmarg, Kar, Jitendra Behra, S.N. Jena and Subhrasini Lenka

Department of Agronomy,
College of Agriculture (OUAT), Bhubaneswar, Odisha-751 003, India.
Received: 17-12-2014 Accepted: 18-04-2015 DOI: 10.5958/0976-058X.2015.00034.7

ABSTRACT

Results from an experiment consisting of 4 planting methods and 8 varieties of sugarcane revealed that cane yield under small pit method of planting (120cm x60cm spacing with 3 settlings per pit) was significantly the highest (149.5 t ha^{1}) and registered an increase to the tune of 5.7, 9.9, and 16.2 % over those of Mega pit (150cm x 150cm 15 settlings per pit), Trench method (30cm width x 30cm depth with 12 settlings per pit) and conventional method (15cm width 15cm depth with 12 settlings per pit) of planting.The corresponding per cent increase with respect to number of milliable cane was 11.6, 16.0 and 22.7 %. Among the varieties, variety 87A298 recorded significantly the highest cane yield of 147.67 t ha^{-1} while variety CO 86V96 recorded highest number of millable canes (105.3). The growth parameters under small pit method were also higher as compared to other methods. It also registered maximum net return (Rs.178430ha^{-1}) and per day productivity (443.6 kg ha^{-1}). However, the B-C ratio was the highest (2.30) under conventional method of planting.

Key words: Conventional, Mega pit, Planting methods, Small pit, Trench.

INTRODUCTION

Sugarcane is one of the most productive plant species known in terms of dry matter production as it potentially produces from 41 to 65 t of dry matter ha^{-1} year $^{-1}$ (Cheeroo-Nayamuth, *et al*, 2000).In India the crop is cultivated in an area of 4.2 million hectares producing nearly 290 million tonnes of cane with an estimated requirement of 625 million tonnes by the year 2020 (Sundara, 1998). Limited horizontal expansion of sugarcane area due to industrialization of cultivable lands, the vertical growth by adopting effective crop management techniques is the option left (Manimaran *et al*, 2009). Physiologically, sugarcane being C_4 plant, is one of the most efficient converters of solar energy into sugar and during the peak growth period it has the potentiality to produce around half a tonne of dry matter ha^{-1} day $^{-1}$ (Yadav, 1991). However, such performance of the crop depends upon establishment methods and types of genotype as it is directly influenced by amount of harvestable solar radiation and crop stand. In recent years pit method of planting has been reported to produces higher proportion of thick and heavy primary shoot, contributing more to final population and the yield (Bajelan and Nazir ,1993.,and Yadav *et al.*,1997 and Kumar,2012). Further, planting techniques do not perform uniformly across the situation and are location specofic as indicated by Mohammed *et al*, (1996) and Yadav and Kumar (2005). Differential response of sugarcane to planting technique is attributed to soil moisture storage and its depletion rate (Dhawan *et al*, 1997 and Singh, 2002). Bhullar *et al*.(2002) advocated that planting method should provide enough opportunity to conserve soil moisture to facilitate settling establishment.

Planting technique- genotype interaction is an important consideration for realising the potential of a genotype as the ultimate number of millable stalk which a genotype is able to carry depends upon a set of environment that a planting method provides. Keeping this in view the present study was carried out.

MATERIALS AND METHODS

The field experiment was carried out at Agronomy Research Farm, Orissa University of Agriculture &Technology, Bhubaneswar (20º 15' N latitude and 85º 52' E longitude with an altitude of 25.9 m above mean sea level) during 2011-12. The experimental site falls under the East and South Eastern Coastal Plain Agro-climatic Zone of Odisha having sub humid climate with unimodel rainfall pattern. A total of 1640.9 mm rain was recorded during the crop growing season in 108 rainy days with highest (215.3mm) in 35th and 36th standard meteorological week. The maximum

*Corresponding author's e-mail: jml.gulati@gmail.com.

temperature ranged between 25.6 to 39.1 ^{0}C and was recorded in 2nd and 12th standard week whereas minimum temperature ranged between14.2 to 27.2^{0}C (51st and 20th standard week). The average morning and afternoon relative humidity during the growth period was 90.2 and 55.2% with a range of 71-97 % and 22-94 %, respectively .The bright sunshine hours ranged within 0.7 to 8.9 hr day^{-1} with an average of 5.8 hr day^{-1}. The mean evaporation and wind velocity during crop growing season was 4.4 mm day^{-1} and 4.4 km hr^{-1} with a range of 1.9 to 8.4 mm day^{-1} and 1.9 to 8.4 km hr^{-1}, respectively (Table.1) Soil of the experimental site was well drained upland having sandy loam surface and loamy sand subsurface with low water holding capacity. The pH of the soil was 5.9 and it contained 3.9 g kg^{-1} organic carbon and 215.34 -54.26 - 105.62 kg ha^{-1}. N, P_2O_5, K_2O, respectively. The experiment was laid out in a split plot design with three replications to study the effect of different planting methods on sugarcane varieties. The main plots comprised of four treatments *viz.* M_1- Mega pit (150cmx150cm, spacing, 30cm depth,15 settling per pit), M_2- Small pit (120cmx 60cm spacing 30cm depth with three settlings per pit), M_3- Trench method (spacing-30cm width x 30cm depth, 12 settlings with paired systems of planting), M_4- Conventional (spacing-15cm width x 15cm depth, 12 settlings with end to end planting). The sub plots consisted of eight varieties such as V_1- CO-86V96, V_2- CO-93A145, V_3- 87A298, V_4- CO-62175, V_5- COOR-05-346, V_6-COOR-03-152, V_7- COOR-04-152, V_8- COOR-06-346. The nursery raised settlings were transplanted under different planting methods on 23.03.2013 as per specification and the crop was raised by adopting recommended package of practices. The economics was calculated as per prevailing prices.

RESULTS AND DISCUSSION

Effect of planting methods: Canes were significantly the longest under small pit method (M_2) during all the stages of growth except during early stage of 2 months when mega pit method (M_1) had longest cane (56.0cm). Significantly the tallest plants of 327.6 cm length were produced under small pit method establishing its superiority over M_1, M_3 and M_4 by a margin of 2.9, 4.1 and 5.9%, respectively (Table 2a). Data further revealed that rate of increase was the maximum during initial stage of 2-4 months (123.3%) and decreased thereafter to 3.2 % between 8 months to harvest irrespective of planting methods (Fig 1). Higher values under M_2 can be attributed to variation in early vigour as indicated by higher values in percent increase rate. Bull (2000) also observed that stem elongation is initially rapid and it slows down approximately 120 days after planting. Number of shoots per unit area ("000 ha) increased with time until 8 months of the growth and M_1 produced significantly more number of shoots at all the dates of observation(Table 2a and Fig.2). Similarly, number of nodes (16.9) and number of leaves (17.7) per cane at harvest were also the highest under M_2 with an increased margin of 5.6, 13.3 and 4.1% and 17.0, 10.9 and 22.7%, respectively over M_1, M_3 and M_4 treatments. More number of nodes and leaves were associated with plant height (Table 2b).Rate of increase was identical with that of other characters (Fig 3 & 4) Significantly the maximum cane yield of 149.5 t ha-1(Table 3) was recorded with M_2 which was significantly superior by 5.7, 9.9 and 16.2 % over M_1, M_3, and M_4 treatments, respectively. The increase in yield was associated with more number of millable cane (118.9 thousands ha $^{-1}$) which declined to 102.5, 97.7 and 83.3 thousand ha $^{-1}$ under M_1, M_3 and M_4 respectively. Yadav *et al* (1990) explained that in pit method of planting the proportion of primary shoots, which are thicker and heavier, in the final cane population was more than in conventional planting method. Similarly, per day productivity was also significantly the maximum in M_2 (443.6 kg ha^{-1}). However, conventional planting (M_4) produced significantly the heaviest single cane (Table 3). Singh *et al* (2008) has also reported higher yield and yield characters under ring method of planting with *Sacchurum* hybrid complex under sub tropical climate of Lucknow. Bell and Garside (2005) from their study reported that weight of stalk and millable cane population together account for more than 98 % of the variation in cane yield. Bhullar, (2008) concluded that precise planting technique is important for improving sugarcane productivity as it plays a crucial role in sustaining higher number of millable canes. Thus, better spacing under small pit treatment (M_2) with resultant reduction in competition in nutrient use and increased utilization of space and light led to greater number of millable canes and hence the higher cane yield.

Effect of varieties: All the plant growth parameters showed increasing trend up to maturity though with declining rate irrespective of varieties with maximum rate during early phase of growth (Table 2a, 2b and Fig.1). Significantly the longest cane length of 336.9 was measured with variety V_3 at harvest which was at par with V_2 (331.3 cm). Maximum number of shoots (123 thousand ha^{-1}) were noted at 8th month of observation which was on par with those of V_1, V_5, V_6 and V_8. Chattha, *et al* (2007) reported that tillering is an important yield attributing character and is controlled by genetic and environmental factors. Similarly numbers of nodes per plant were the maximum in V_3 (16.8) which were at par with V_7 while there was no significant difference in number of leaves between V_2 and V_3. Single cane weight (1.43 kg) and per day productivity (433.6 kg ha^{-1}) was significantly higher in V_2.

TABLE 1: Weekly meteorogical data during crop growing period

Std. Met week	Date 2011-12	Rainfall (mm)	No. of rainy days	Evaporation (mm d^{-1})	Atm. temp. (^{0}C)		Relative humidity %		BSH (h d^{-1})	Wind Velocity (km/hr)
					Max.	Min.	FN	AN		
12	19-25 Mar	0	-	6	35.1	24.4	87	53	8.0	6.0
13	26-01 April	0	-	6.4	35.4	24.7	92	50	6.3	6.4
14	02-08 April	2.8	1	5.9	34.9	23.7	92	50	6.1	5.9
15	09-15 April	0	-	7.3	37.6	23.8	84	35	6.8	7.3
16	16-22 April	11.0	3	7.1	37.6	25.4	84	49	6.6	7.1
17	23-29 April	7.3	2	7.2	35.3	22.8	86	44	8.2	7.2
18	30-06 May	29.2	4	7.0	36.9	24.0	86	51	8.7	7.0
19	07-13 May	12.0	1	7.7	38.4	26.4	94	46	7.4	7.7
20	14-20 May	97.0	1	7.1	38.4	27.2	88	56	7.6	7.1
21	21-27 May	5.8	2	7.5	35.7	26.3	89	62	6.9	7.5
22	28-03 June	5.1	2	8.4	37.3	26.5	85	56	8.9	8.4
23	04-10 June	29.7	1	7.3	36.4	26.3	89	62	5.1	7.3
24	11-17 June	91.7	5	5.5	34.4	24.8	89	69	1.6	5.5
25	18-25 June	36.7	7	3.6	34.0	25.3	91	64	3.2	3.6
26	25-1 July	37.4	6	3.7	34.1	24.8	93	70	2.3	3.7
27	2-8 July	79.2	6	2.6	32.3	24.7	93	81	1.2	2.6
28	9-15 July	67.1	3	3.4	33.9	26.0	92	78	6.1	3.4
29	16-22 July	144.0	7	2.0	31.5	25.1	96	89	1.2	2.0
30	23-29 July	53.4	3	3.1	32.8	25.5	91	76	6.0	3.1
31	30-5 Aug	57.7	5	3.4	34.1	25.8	92	71	5.9	3.4
32	6-12 Aug	113.6	5	2.5	31.8	25.6	96	85	0.4	2.5
33	13-19 Aug	17.5	4	3.3	32.7	25.4	95	79	3.9	3.3
34	20-26 Aug	89.6	6	3.0	31.9	25.1	96	84	3.5	3.0
35	27-2 Sept	215.3	7	1.9	30.6	24.7	96	92	2.9	1.9
36	3-9 Sept	215.3	7	1.9	30.2	24.6	97	94	0.7	1.9
37	10-16 Sept	42.2	4	3.2	31.5	24.9	96	81	3.3	3.2
38	17-23 Sept	78.9	4	2.6	30.8	24.6	96	81	2.3	2.6
39	24-30 Sept	0	-	3.9	33.5	25.1	89	61	7.6	3.9
40	1-7 Oct	44.5	1	4.3	34.0	24.3	91	65	6.9	4.3
41	8-14 Oct	7.2	3	5.0	33.7	24.7	93	68	7.3	5.0
42	15-21 Oct	2.5	1	4.2	33.7	23.4	88	57	7.3	4.2
43	22-28 Oct	2.8	1	3.8	32.5	22.0	90	48	7.2	3.8
44	29-4 Nov	0	-	3.9	32.6	18.4	87	37	8.4	3.9
45	5-11 Nov	0	-	3.8	33.2	17.6	90	35	8.7	3.8
46	12-18 Nov	0	-	3.3	32.4	17.2	94	44	7.3	3.3
47	19-25 Nov	0	-	3.2	31.6	17.7	85	38	7.5	3.2
48	26-02 Dec	0	-	3.1	31.2	18.1	86	44	6.8	3.1
49	03-09 Dec	0	-	3.4	30.9	16.0	91	38	5.5	3.4
50	10-16 Dec	0	-	3.6	30.1	16.8	84	42	5.2	3.6
51	17-23 Dec	0	-	3.5	27.9	12.3	78	31	6.6	3.5
52	24-31 Dec	0	-	3.3	26.9	16.0	71	41	3.8	3.3
1	01-07 Jan	4.6	1	3.3	30.8	20.2	92	57	5.5	3.3
2	08-14 Jan	39.8	2	3.0	25.6	15.3	89	58	4.5	3.0
3	15-21 Jan	0	-	3.4	29.5	14.2	94	43	9.2	3.4
4	22-28 Jan	0	-	3.4	29.0	15.3	93	49	5.4	3.4
5	29-04 Feb	0	-	3.5	28.1	14.5	85	36	6.2	3.5
6	05-11 Feb	0	-	3.9	32.0	15.3	85	36	8.2	3.9
7	12-18 Feb	0	-	4.0	31.4	19.6	92	57	6.0	4.0
8	19-25 Feb	0	-	4.3	36.1	17.3	92	22	8.7	4.3
9*	26-04 Mar	0	-	4.2	37.1	20.6	91	33	6.8	4.2
10	05-11 Mar	0	-	5.7	36.7	22.5	94	37	7.2	5.7
11	12-18 Mar	0	-	5.6	36.0	21.9	94	35	5.9	5.6
12	19-25 Mar	0	-	6.1	39.1	23.7	94	32	7.4	6.1
13	26-01 April	0	-	5.9	38.8	23.5	92	31	6.5	5.9

TABLE 2a: Effect of planting methods and variety on growth attributes of Sugarcane in different months (M)

Treatments	Plant Height (cm)					Shoot no('000/ha)			
	2 M	4 M	6 M	8 M	At H.	2 M	4 M	6 M	8 M
M_1	56.0	122.7	213.9	308.5	318.5	64.1	102.6	119.7	137.5
M_2	54.8	124.2	225.8	315.6	327.6	55.2	119.3	125.8	129.9
M_3	55.0	121.8	209.0	307.6	314.6	49.3	93.9	105.3	112.7
M_4	53.5	120.6	199.4	299.3	309.3	39.7	78.6	87.3	95.3
SE(m)±	0.34	0.54	2.38	1.54	1.05	0.46	1.23	1.41	1.50
CD(0.05)	1.2	1.9	8.2	5.3	3.6	1.6	4.3	4.9	5.2
V_1	58.3	128.0	228.2	327.2	336.9	59.4	110.3	118.1	123.6
V_2	53.5	120.3	228.3	321.5	331.3	50.5	96.1	105.2	113.3
V_3	54.8	122.3	219.2	308.8	318.5	52.8	99.8	112.8	123.3
V_4	56.7	125.4	186.7	295.8	305.5	49.1	93.8	104.4	114.9
V_5	58.1	127.7	212.5	306.0	315.8	50.7	96.4	109.4	121.9
V_6	50.6	115.7	215.4	310.4	320.2	50.0	95.3	110.3	120.8
V_7	52.4	118.5	200.0	295.6	305.3	49.0	93.6	103.6	114.1
V_8	53.9	120.9	205.8	296.8	306.6	55.3	103.8	112.3	119.1
SE(m)±	0.94	1.51	2.98	3.88	3.07	1.33	1.47	2.24	2.41
CD(0.05)	2.7	4.3	8.5	11.0	8.7	3.8	4.2	6.3	6.8
M within V									
SE(m)±	2.54	4.06	8.58	10.49	8.26	3.58	4.26	6.24	6.72
CD(0.05)	7.3	11.6	NS	30.0	23.6	10.2	12.5	18.1	19.5
V within M									
SE(m)±	1.89	3.02	5.97	7.75	6.14	2.66	2.94	4.47	4.82
CD(0.05)	5.3	8.5	NS	22.0	17.4	7.5	8.3	12.7	13.7

TABLE 2b: Effect of planting methods and variety on growth attributes of Sugarcane in different months (M)

Treatments	No of Nodes					No of Leaves				
	2 M	4 M	6 M	8 M	At H.	2 M	4 M	6 M	8 M	At H.
M_1	2.8	6.5	12.1	15.5	16.0	3.7	7.9	13.2	16.4	15.6
M_2	2.9	6.8	12.3	16.2	16.9	3.8	8.1	15.1	18.4	17.7
M_3	2.5	6.3	11.8	15.3	15.8	3.6	7.7	12.8	15.9	15.1
M_4	2.8	6.0	10.8	14.8	15.2	3.6	7.8	11.6	14.7	13.9
SE(m)±	0.06	0.12	0.21	0.33	0.27	0.08	0.12	0.21	0.32	0.33
CD(0.05)	0.2	0.4	0.7	1.1	0.9	NS	NS	0.7	1.1	1.1
V_1	2.7	6.3	11.1	15.3	15.8	3.8	8.1	13.0	16.1	15.3.
V_2	3.0	6.8	12.5	15.8	16.3	3.9	8.2	15.1	18.4	17.7
V_3	3.3	7.2	12.3	16.2	16.8	4.0	8.3	14.9	18.1	17.4
V_4	2.5	6.0	9.8	15.0	15.5	3.5	7.6	12.6	15.8	15.0
V_5	2.6	6.2	10.8	14.2	14.8	3.8	8.0	11.6	14.7	13.9
V_6	2.5	6.0	12.3	14.8	15.3	3.2	7.2	12.6	15.7	14.9
V_7	2.5	6.0	12.3	16.3	16.8	3.3	7.4	12.6	15.7	14.9
V_8	2.9	6.6	13.0	15.9	16.4	3.9	8.3	13.1	16.2	15.4
SE(m)±	0.10	0.17	0.31	0.49	0.51	0.10	0.17	0.26	0.82	0.44
CD(0.05)	0.30	0.50	0.90	1.40	NS	0.30	0.50	0.70	2.30	1.20
M within V										
SE(m)±	0.28	0.49	0.87	1.38	1.41	0.28	0.48	0.76	2.22	1.25
CD(0.05)	0.80	1.40	2.50	4.00	4.10	0.80	1.40	2.20	NS	3.70
V within M										
SE(m)±	0.20	0.35	0.62	0.98	1.03	0.20	0.34	0.53	1.64	0.88
CD(0.05)	0.60	1.00	1.80	2.80	2.90	0.60	1.00	1.50	NS	2.50

Brix values remained unaffected due to various varieties. Variety V_3 produced significantly higher cane yield (147.67 t ha^{-1}). While the lowest cane yield (127.90 t ha^{-1}) was obtained with variety V_5 (Table 3). Similar yield differences in cane due to varieties has also been reported by Kumar *et al.* (2012**).**

Two factor interactions between method of establishment and variety was also the significant and the highest cane yield of 189.0 t ha^1 was recorded with variety V_3 when planted under small pit method (Fig 5). Variation in yield due to planting methods and variety are in accordance with the findings of

TABLE 3: Effect of planting methods and variety on yield and other characters of sugarcane.

Treatment	Brix value(%)	Single cane weight(kg)	Number of millable canes (000 ha^{-1})	Cane yield (t ha^{-1})	Days to maturity (Days)	Per day productivity (kg ha^{-1})
M_1	19.79	1.27	102.5	141.5	337.2	419.1
M_2	19.54	1.14	118.9	149.5	336.6	443.0
M_3	19.79	1.27	97.7	136.1	338.2	402.7
M_4	19.50	1.37	83.3	128.7	340.2	378.5
SE(m)±	0.235	0.029	1.45	1.62	0.20	4.84
CD(0.05)	NS	0.10	5.00	5.6	0.7	16.7
V_1	19.25	1.20	105.0	140.3	328.8	426.5
V_2	19.92	1.43	95.0	147.0	338.6	433.6
V_3	19.50	1.32	105.3	147.7	345.4	428.0
V_4	19.67	1.36	96.7	144.6	371.3	389.8
V_5	19.83	1.12	103.7	127.9	324.7	393.5
V_6	19.75	1.13	102.5	128.0	312.3	410.0
V_7	19.58	1.35	95.8	139.1	363.8	382.1
V_8	19.75	1.18	100.8	136.1	319.6	425.3
SE(m)±	0.396	0.035	2.35	2.17	0.33	6.23
CD(0.05)	NS	0.10	6.70	6.1	0.9	17.6
M within V						
SE(m)±	1.100	0.102	6.54	6.17	0.92	17.84
CD(0.05)	NS	0.30	18.90	18.0	2.7	52.2
V within M						
SE(m)±	0.792	0.071	4.70	4.33	0.66	12.45
CD(0.05)	NS	0.20	13.3	12.3	1.9	35.3

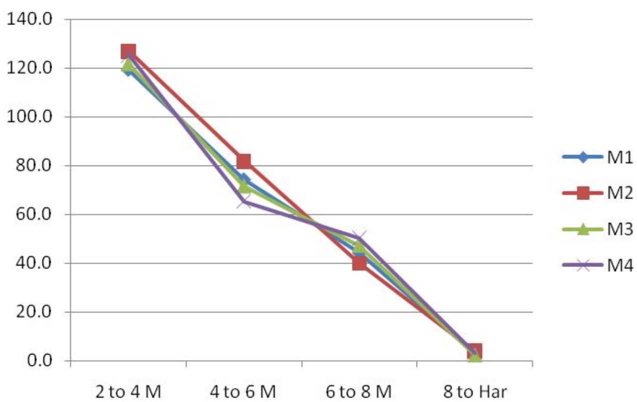

FIG 1: Percentage increase in plant height as influenced by planting methods

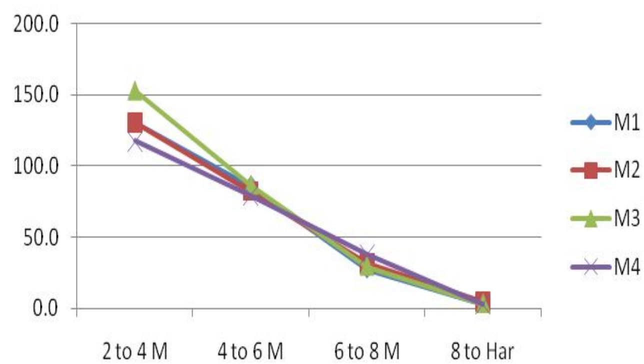

FIG 3: Percentage increase in node number as influenced by planting methods

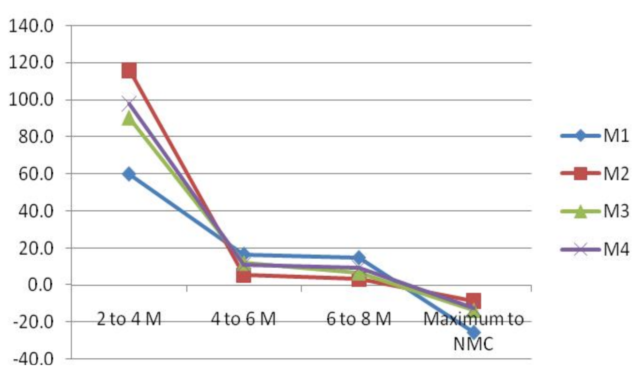

FIG 2: Percentage increase in shoot number as influenced by planting methods

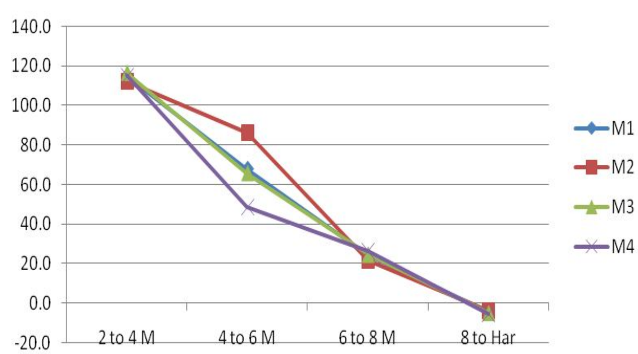

FIG 4: Percentage increase in leaf number as influenced by planting methods

Bhullar (2002) and Islam, *et al* ,(2011). The highest significant positive correlation(r= 0917**) was observed between cane yield and single cane weight (Table 4). Multiple regressions and the equation developed was

$$Y= -181.038+0.048\ X_1 +1.439^{**}\ X_2 +126.38^{**}\ X_3 \quad (R^2 = 0.992)$$

Where: Y= Cane yield, t ha^{-1}, X_1: Cane length, cm, X_2: Number of millable cane ("000 ha), X_3: Single cane weight, kg

Economic: Data on economics revealed that planting of sugarcane in small pits incurred highest expenditure to the tune of Rs.1,61,055 ha^{-1} higher by 6.0, 9.2 and 25.4 % over mega pit, trench method and conventional method of planting, respectively (Table 5). The increase was mainly due to number of labourers employed for various operations. Bhullar *et al*. (2008) observed that human labour and tractor hour were the two major components that accounted for differences in the cost of cultivation among the planting methods. In spite of highest cost of cultivation, the small pit method could registered maximum net return of Rs1,78,430 ha^1 followed by conventional method. Similar higher return with ring method has also been reported by Singh *et al*. (2013). However, conventional method of planting recorded highest benefit – cost ratio (2.30) than small pit method (2.05) as next in order indicating that the conventional method engages lesser number of human labour which was a key component in determining the cultivation cost and thus, may be more suitable and adoptable by the resource poor farmers.

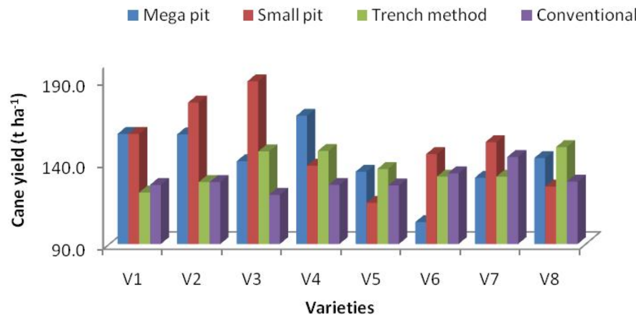

FIG 5: Interaction effect of planting methods and variety on cane yield

TABLE 4: Correlation Matrix of growth and cane yield at harvest

Character	Shoot height	Shoot number	Single cane weight	Cane yield
Shoot height	1.000			
Shoot number	0.346	1.000		
Single cane weight	0.017	-0.459	1.000	
Cane yield	0.198	-0.086	0.917**	1.000

TABLE 5: Economics of sugar cane as influenced by planting methods

Method of planting	Cost of cultivation, (Rs/ha)	Cane yield, (t/ha)	Gross Return, (Rs./ha)	Net return, (Rs./ha)	B-C ratio
Mega Pit	1,51,429	141.5	3,04,225	1,52,796	2.01
Small Pit	1,61,055	157.9	3,39,485	1,78,430	2.11
Trench method	1,46,236	136.2	2,92,615	1,46,377	2.00
Conventional method	1,20,121	128.7	2,76,705	1,56,584	2.30S

REFERENCES

Bajelan, B. and Nazir, N.S. (1993).Effect of fertility variation and planting pattern on growth, yield and quality of sugarcane. *International Journal of Tropical Agriculture* **11**: 249–254.

Bell, M.J and Garside, A.L.(2005). Shoot and stalk dynamics and the yield of sugarcane crops in tropical and subtropical Queensland, Australia. *Field Crop Research* **92**: 231-248

Bhullar, M.S., Saini, L.K., Kapur, M.L. and Singh, S. (2002). Effect of Method and Density of Planting on Growth and Yield of Late Planted Sugarcane. *Sugar Tech* **4**(3&4): 181 - 184.

Bhullar, M.S., Thind, K.S., Uppal, S.K. and Singh, K. (2008). Productivity,profitability and quality of sugarcane(Saccharum sp.) plant-ratoon system in relation to planting methods and seeding rate. *Indian Journal of Agronomy* 53(**3**): 195-199

Bull, T. (2000).The Sugarcane Plant. In: Mannual of cane growing . M. Hogarth; P. Alsopp eds. Bureau of Sugarcane Exp. Station. Indoorapilly, Asustria pp. 77-83

Chattha, U.M., Ali, Asgar and Bilal, M (2007). Influnce of planting techniques on growth and yield of spring planted sugarcane (*Saccharum officinarum*) *Pakistan Journal of Agricultural Sciences* **44**(3): 452-56.

Cheeroo-Naymuth, F.C., Robertson, M.J., Wegener, M.K and Nayamuth, A.R.H.(2000).Using a simulation model to assess potential and attainable cane yield in Mauritius. *Field crop Research* **66**: 225-243

Dhawan, A.K., Sahtiya, H.L. and Dendsay, J.ES.(1997). Low germination of sugarcane setts in Indian sub-tropics: Constraints and their Management. *Indian J. Sugarcane Tech* **12**: 17-21.

Islam,M.S.,Miah,M.A.S., Begum,M.K.Alam, M.R and Arefin,M.S (2011). Growth, yoeld and juice quality of some selected sugarcane clones under water-logging stress condition. *World Journal of Agricultural Sciences* **7**(4) : 504-11.

Kumar, Navneet., Singh, Harendra., Kumar, Rakesh and Singh, V.P. (2012). Productivity and profitability of different genotypes of sugarcane(*Saccharum* Spp) as influenced by fertility levels and planting seasons. *Indian Journal of Agronomy* 57 **(2):** 180-185.

Manimaran, S., Kalyanasundaram, D., Ramesh, S. and Sivakumar, K. (2009). Maximizing sugarcane yield through efficient planting methods and nutrient management practices. *Sugar Tech* 11**(4):** 395-397.

Mohammad, Sarwar, M.A. Gill, K.B. Malik, and M. Sarwar. (1996). Comparison of pit and trench planting of sugarcane at different fertilizer levels. *Pakistan Sugar Journal* **10**: 11–13.

Singh, G.B. 2002 Management of plant population in sugarcane for higher productivity and quality: Proceedings of International Symposium on Food, Nutrition and Economic Security through Diversification in Sugarcane Production and Processing Systems, 9–18. IISR Lucknow, India, February 16–18: 9–18.

Singh, A.K., Lal, Mehni., Singh, Iswar., Yadav, R.L and Yadv, D.V. 2008. Effect of planting method and drought management technique on growth,yield and quality of sugarcane (*Saccharum* hybrid complex) under limited irrigation. *Indian Journal of Agronomy* 53 **(3):** 200-204.

Singh, K., Singh, A., Choudhary, O. P., Gill, M. S., Uppal, S. K. and Singh, D. 2013. Productivity, profitability and soil properties as influenced by planting methods and band application of FYM in autumn Sugarcane. *Sugar Tech* **15(2):**145–151.

Sundara, B. (1998).Sugarcane Cultivation. Vikas Publishing House Pvt. Ltd., New Delhi.

Yadav, R.L. (1991).High population density management in Sugarcane. *Proceedings Indian National Science Academy*, B **57**(**3&4):** 175-182.

Yadav, R.L. Kumar, R. and Verma, R.S. (1990). Effect of planting technique and planting density on yield of late planted sugarcane in North Central India. *Experimental Agriculture*, **27**: 281-286.

Yadav, R.L and Kumar,R. (2005).On Farm comparison of ring pit and convetional flat planting methods for yield and quality of sugarcane in northwest *India.Indian Journal sciences* **75**:605-10

Yadav, R.L., Singh, R.V., Singh, R. and Srivastava, V.K.(1997).Effect of planting geometry and fertilizer nitrogen on nitrate leaching, nitrogen use efficiency and sugarcane yield. *Tropical Agriculture* **74**: 115–120.