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Influence of Intra-row Row Setts Spacing on Yield and Yield Components of Some Sugarcane Varieties at Finchaa Sugar Estate

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ABSTRACT

An experiment was conducted at Finchaa Sugar Estate plantation from 2005-2010 cropping seasons to determine the effect of five intra-row sett spacings [10 cm between setts, 5 cm between setts, setts placed end to end, setts placed ear-to ear (5 cm overlapping) and setts placed ear-to-ear (10 cm overlapping)] on the performance of three sugarcane varieties (B52/298, NCo334 and B41227). The experiment was carried out on Luvisols and Vertisols in split plot design. Combined analysis of the data over soils indicated that sucrose percent cane, cane yield and estimated sugar yield did not show significant ($P<0.01$) differences in response to spacing as well as due to the interaction effects of spacing and variety. The study indicated the possibility of reducing seed cane for planting by 43% using 10 cm intra-row spacing as compared to 5 cm overlapping currently used for commercial planting. Generally from the study it is concluded thatspacing and its interaction with variety did not affect cane yield, cane sucrose content and estimated sugar yield.

Keywords: *ear-to-ear, spacing, ratoon crop, plant crop, intra-row*

1. INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is a vegetatively propagated crop. The yield of sugarcane is greatly affected by different factors. Among these, lack of study based planting population is the important one (Azhar et al., 2007).Establishing an optimum plant population in any crop is vital for achieving maximum production and sugarcane is not an exception. The yield of sugarcane partly depends on the initial stand density of primary shoots and their tillers onwards. These, in turn, are influenced by the number and quality of setts planted (Kakde, 1985). According to Collins (2002), plant density is a function of inter and intra-row spacings.

In many sugarcane-growing countries, it is common to use high density planting through planting canes setts by partially overlapping them (Faucconier, 1984; Verma, 2004).Similarly, Finchaa Sugar Estate uses ear-to-ear (5 cm overlapping) alignment of two budded setts within furrow at the time of planting and even more denser planting in fear of sprouting due to fears of failure of the sett buds to sprout. The amount of setts required for planting a unit area depends on the way the cane setts are arranged in the furrow during planting. The importance of optimal planting density is to obtain optimum sprouts for an adequate initial stand establishment. High density planting results in higher cane population with weak and thinner stalks (Rao, 1990).Furthermore, high density planting reduces the number of tillers produced per each planting material due to mutual shading and competition for light, nutrients, and water (Verma, 2004). On the other hand, sub-optimal density planting results in a loss of yield due to inefficient use of the land space(Azhar et al., 2007).

The use of large numbers of planting materials incurs high costs to the sugar estates resulting in shortage of planting materials to cover commercial fields planned-annually for planting. The use of large numbers of planting material also leads the estates to allocate large areas of land to seed cane production, which competes for fertile land that could be used for production of crop for milling. This is because partial overlapping (ear-to-ear) method of propagation requires large quantities of planting materials to cover a unit area (Verma, 2004). Therefore, optimization of planting density is vital for sugarcane production due to its effect on stalk population, which is an important component of yield.

Studies in other countries indicated that with low density planting, it was possible to minimize the planting material required per unit area. An experiment conducted on plant cane and ratoon cane with pre-seasonal planting indicated that cane girth, number of millable canes per clump and average cane weight were significantly higher at the intra-row spacing of 90 cm rather than at the intra-row spacing off 30 cm and 60 cm (Raskar and Bhoi,2003). This indicated that naturally sugarcane has the capacity to compensate for population densities and maintain potential yield under different plant spacings.

Previous studies conducted in Ethiopian Sugar Estates indicated the possibilities of reducing planting material through manipulation of sett alignments and spacing. Results of an experiment conducted on plant cane crop on two soil types at Wonji-Shoa Sugar Estate on three varieties(B52/298,B41227 and NCo334) with five different sett spacings (10 cm overlapping, 5 cm overlapping, end-to-end, 5 and 10 cm spacing between setts) indicated that there were significant differences among the varieties in most of the characters studied. However, the studies indicated that none of the intra-row spacings of setts resulted in significant differences in cane and sugar yields (Tsehay, 1993). Similarly, a study conducted at Finchaa Sugar Estate in Central Western Ethiopia with the objective of studying the effect of different planting densities (5 cm overlapping, end-to-end, double and double + end-to-end alternatively) for the varieties B41-227, B52-298, Co449 and NCo334 in plant cane indicated that the four planting densities showed non-significant differences on the main sugarcane yield parameters and the ultimate sugar yield. Furthermore, the study indicated the possibility of reducing the amount of seed cane from 21-33%, by shifting from the 5 cm overlapping to end to end (butt-to-butt) alignment (Girma, 1997).

It is vital to explore alternative planting densities for optimal yield and reduced cost of production. However, at Finchaa Sugar Estate though research was conducted it had limitations of not entertaining the succeeding crops (ratoons). Therefore, this paper presents the result of research conducted to determine optimum intra-row setts spacing for three sugarcane varieties at Finchaa sugarcane plantation.

2. MATERIALS AND METHODS

2.1 Site Description

Finchaa Sugar Estate is located in the Finchaa River Valley of Ethiopia at a latitude of 8º31'N and longitude of 39º12'E, respectively with elevation ranging from of 1350-1650 meters above sea level. The area has a mean maximum temperature of 31^0C and a mean minimum temperature of 15^0C. The area has a mean annual total rainfall of 1300 mm. The experiment was conducted from 2005-2010 cropping seasons for plant cane and two successive ratoon crops.

2.2 Treatments and Design

The treatments consisted of five intra-row spacings[10 cm between setts, 5 cm between setts, setts placed end to end, setts placed ear-to-ear (5 cm overlapping) and setts placed ear-to-ear (10 cm overlapping)]. The penultimate spacing mentioned here was used as a check. The sugarcane varieties used were B52/298, NCo334, and N14. The study was carried out on Luvisol (light) and Vertisol (heavy) soils, and three crop types viz-a-viz, plant cane (PC), first ratoon (RI), and second ratoon (RII). The sugarcane varieties were selected based on their yielding potential and area coverage.

The experimental design was split-plot with three replications. The main plots and sub plots were sugarcane varieties and intra-row spacings of setts, respectively. Area of each experimental plot was 29 m^2 (four furrows of 5 m length and 1.45 m width). The distance between adjacent plots and replications were 1.50 and 2.90 meters, respectively. Healthy stalks of 9 months old were used for planting. Diammonium phosphate was applied at planting for plant cane and during moulding (earthing-up) for ratoons as a source of phosphorus. The fertilizer rate was 250 kg/ha for all the crops. Urea was applied for plant cane, first and second ratoons at 150,300 and 350 kg/ha, respectively after $2\frac{1}{2}$ months for plant cane and after 1 month for the ratoons.

2.3 Data Collection

Plant population count data were recorded starting from the 4^{th} month of planting until the plant age of 8 months. The number of millable canes in each plot was counted and average cane weight of 20 stalks was taken per plot at harvest.

Cane yield was taken from the middle two rows and calculated on a hectare basis. For cane quality analysis, juice was extracted from 10 stalk samples using a sample mill. Percent recoverable sucrose (rendiment) was calculated using Winter Carp indirect method of cane juice analysis (James and Chung, 1993). Then, commercial sugar yield per hectare was calculated as follows;

$$ESY\ (t/ha) = CYH\ (t/ha) \times ERS\ (\%)$$

Where;

ESY = estimated sugar yield
CYH = cane yield per hectare
ERS = estimated recoverable sucrose (%)

The cane and sugar yields were described as suggested by Sweet & Patel (1985) according to COTCHM method (Corrected Tones Cane per Hectare per Month).

Finally, the data collected were analysed using Fisher's analysis of variance technique with SAS software (SAS, 2002).Comparisons among treatment means with significant differences for the measured and counted parameters were based on the Duncan Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

3.1 Plant Population Dynamics

The results on plant population dynamics showed a declining trend (Figure 1). In the plant cane, earthing-up drastically affected plant population. There was a linear drop throughout the consecutive months and at the age of 8 months the curve tended to converge (Figure 1)indicating that the difference due to spacing was diminished. The linear drop in population observed could be due to the absence of earthing-up (moulding) operation in plant cane at Finchaa.

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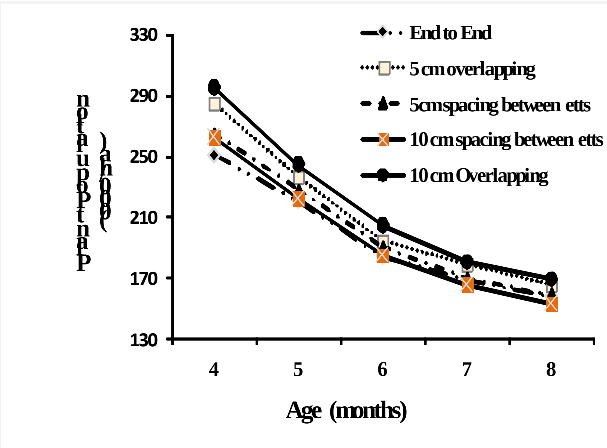

Fig 1: Mean plant population dynamics as influenced by intra-row sett spacings for the study conducted at Finchaa sugar estate.

3.2 Effect of Intra-Row Spacing on Number of Millable Canes

Combined analysis of the data over the two soil types revealed that all the main effects and interactions did not affect significantly the number of millable canes in plant cane and ratoons (Table 1).

The correlation analysis of millable stalk populations at harvest with mean cane weight for plant cane and mean of the crops (plant cane and ratoons) showed a non-significant ($P < 0.01$) negative correlation. The Pearson correlation coefficients for the plant cane and mean of the crops (plant cane and ratoons) were r = - 0.23 and - 0.33, respectively, indicating weak negative correlations between millable stalk population density and stalk weight (Figure 2).

Table 1: Combined analysis over soils averaged for the crops on number of millable canes and cane yield at Finchaa from 2005-2010

	Number of Millable cane (000 ha^{-1})			**Cane yield (t $ha^{-1}m^{-1}$)**		
	PC	RI	RII	PC	RI	RII
Soil (So)	Ns	Ns	Ns	**	**	**
Variety (V)	Ns	Ns	Ns	Ns	Ns	*
Spacing (S)	Ns	Ns	Ns	Ns	Ns	Ns
V x S	Ns	Ns	Ns	Ns	Ns	Ns
So x V x S	Ns	Ns	Ns	Ns	Ns	Ns
CV (%)	17.7	19.7	20.9	12.7	12.4	14.3

** = significant at $P < 0.01$; * = significant at $P< 0.05$; Ns = non-significant. PC = Plant crop; RI= First ratoon; RII = Second ratoon; m = month; V = Variety; So = soil; S = spacing.

Table 2: Combined analysis over soils averaged for the crops on sucrose (%) and estimated sugar yield at Finchaa from 2005-2010

	Sucrose (%)			**ESY (t $ha^{-1}m^{-1}$)**		
	PC	RI	RII	PC	RI	RII
Soil (So)	**	**	**	*	**	**
Variety (V)	Ns	**	**	Ns	**	**
Spacing (S)	Ns	Ns	Ns	Ns	Ns	Ns
V x S	Ns	Ns	Ns	Ns	Ns	Ns
So x V x S	Ns	Ns	Ns	Ns	Ns	Ns
CV (%)	4.3	3.4	6.3	13.5	12.8	15.7

** = significant at $P < 0.01$; * = significant at $P< 0.05$; Ns = non-significant. PC = Plant crop; RI= First ratoon; RII = Second ratoon; m = month; V = Variety; So = soil; S = spacing.

Excess tillering formed in plant cane might have been favored by the absence of earthing-up.This could probably attributed to the high number of tillers formed coupled with the extended competition between tiller formation to the stalk forming stages resulted more uniform population of stalks with low and comparable weighted stalks among the intra-row spacings (Table 3).This also could be justified by the relationship of tiller population taken at the age of 4 ½ months and millable stalks at harvest indicating no correlation at all (Figure 3).

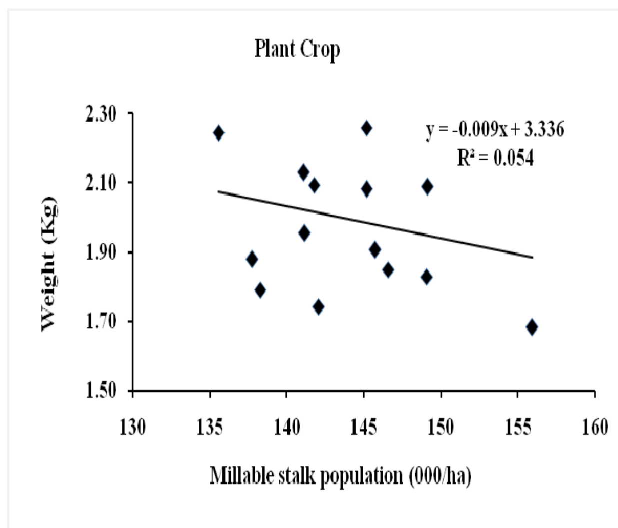

Fig 2: Correlation between millable stalk population and stalk weight at harvest atFinchaa for the plant cane.

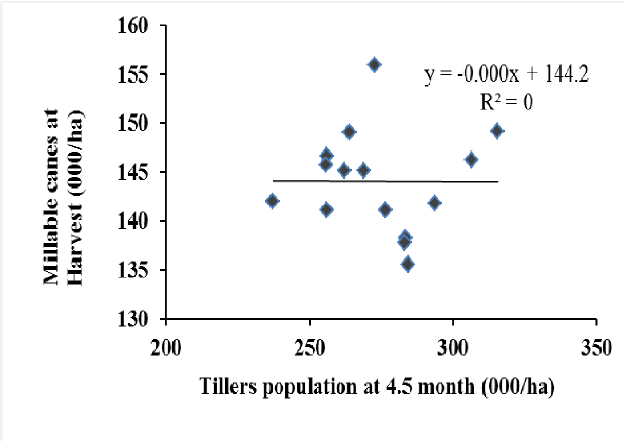

Fig 3: Relationship between mean early tillering at 4.5 months and millable stalk population at harvest at Finchaa for the plant cane.

Table 3: Main effects of soil, variety and spacing on number of millable canes and cane yield at Finchaa from 2005-2010

	Number of Millable cane (000 ha^{-1})			**Cane yield (t ha^{-1}m^{-1})**		
	PC	RI	RII	PC	RI	RII
Soil						
Luvisol	145	161	157	13.7b	13.8a	14.2a
Vertisol	143	158	163	15.1a	8.5b	9.1b
LSD (5%)	Ns	Ns	Ns	**	**	**
Variety						
B52/298	145	159	164	14.4	11.0	12.2a
NCo334	143	159	155	14.2	11.3	11.7ab
N14	144	161	162	14.6	11.1	11.1b
LSD (5%)	Ns	Ns	Ns	Ns	Ns	*
Spacing						
S_1	144	156	162	13.9	11.1	11.4
S_2	145	157	157	15.0	11.1	11.4
S_3	145	165	161	14.3	11.2	11.9
S_4	145	162	161	14.3	11.3	11.8
S_5	141	157	160	14.5	11.0	11.9
LSD (5%)	Ns	Ns	Ns	Ns	Ns	Ns
CV (%)	17.7	19.7	20.9	12.7	12.4	14.3

Means followed by the same letter in a column are not significantly different from each other; PC=Plant cane; RI= First Ratoon; RII = Second Ratoon; m = month; S_1= 10 cm between setts, S_2= 5 cm between setts, S_3= End-to-end, S_4 cm overlapping, S_5=10 cm overlapping.

3.3 Effect of Intra-Row Spacing on Cane Yield

Cane yield was significantly (p<0.01) affected by the main effects of soil in the plant cane and all ratoon crops, and by the main effect of variety in the second ratoon (Tables 1 and 3).However, it was not affected by the main effect spacing (Table 1 and 3).In relation to this result, some studies earlier revealed that cane yield is influenced by the inherent yielding ability of varieties (Orgeron et al., 2007), soil type (Tsehay, 1993) and the crop type (Syed Mehar et. al., 2008).

In general, the cane yields obtained from the widely and densely spaced plantings were in statistical parity (Table 1 and 3). Previous studies conducted at Wonji-Shoa and Finchaa Sugar Estates in Ethiopia revealed a similar results (Tsehay, 1993; Worku, 2001). The presence of significant incident sunlight might have resulted in high photoassimilate production and partitioning of dry matter during heavy tillering and root proliferation in the wider spaced plantings, thereby avoiding diversion of carbohydrate away from the stalks. This may be attributed to the phenomenon that where sunlight quality and intensity is limiting, yield reduction arises due to the diversion of photosynthate away from the primary stalks. It is for this reason that high density planting is practised in some countries (Amolo and Abayo, ND; Nayamuth and Koonjah, 2003).

3.4 Effect of Intra-Row Spacing on Sucrose Percent Cane

Cane sucrose percent was significantly (P<0.01) affected by the main effect of soil in all the crop types. Sucrose percent was also affected by the main effect of variety in all the crops except the plant cane (Table 2 and 4). However, the main effect of spacing and its interactions did not have significant influence on cane sucrose percent (Tables 2 and 4).

The current result indicated differences in response across crops (plant cane and ratoons) for main effects soil and variety. This could be because cane sucrose percent is influenced by many factors, which include variety (Yousaf et al., 2002), soil type, weather and management practices employed during ripening (Sundara, 2000). Furthermore, the main effect of spacing and its interactions with the other factors did not affect cane sucrose percent (Tables 2 and 4).This result corroborates that of Sundara (2003) who reported that spacing did not affect sucrose content. Previous studies conducted at Wonji-Shoa Sugar Estate also indicated that sucrose percent cane was not affected by spacing (Tsehay, 1993 and Girma, 1997).

3.5 Effect of Spacing on Estimated Sugar Yield (ESY)

Estimated sugar yield (ESY) was significantly ($p<0.01$) affected by the main effect of soil in all the crop types, and by the main effect of variety in the first and second ratoons (Tables 2 and 4).However, it was affected neither by the main effect of spacing nor by its interaction (Tables 2 and 4).

Absence of differences in cane yield and cane sucrose percentages in response to the different intra-row spacings meant that comparable sugar yields were obtained in response to the different plating densities. Consistent with the results of this study, previous works done at Wonji-Shoa and Finchaa Sugar Estates in the country also indicated that there were no significant differences in estimated sugar yields among different intra-row spacings in plant cane crop (Woku, 2001; Tsehay, 1993). The result of this study confirms that of Sundara (2000) who reported that sugar yield is a function of cane yield and percent cane sucrose content.

Table 4: Main effects of soil, variety and spacing on percent sucrose cane and estimated sugar yield for Finchaa from 2005-2010

	Sucrose (%)			ESY (t $ha^{-1}m^{-1}$)		
	PC	RI	RII	PC	RI	RII
Soil						
Luvisol	13.0a	12.3b	11.2b	1.78b	1.69a	1.60a
Vertisol	12.5b	13.2a	12.2a	1.88a	1.12b	1.11b
LSD(5%)	**	**	**	**	**	**
Variety						
B52/298	12.6	12.3c	11.5b	1.81	1.33b	1.39a
NCo334	12.8	13.3a	12.3a	1.81	1.49a	1.42a
N14	12.8	12.6b	11.3b	1.87	1.39b	1.26b
LSD (5%)	Ns	**	**	Ns	**	**
Spacings						
S_1	12.9	12.7	11.7	1.79	1.39	1.32
S_2	12.7	12.7	11.5	1.89	1.40	1.31
S_3	12.9	12.7	11.6	1.85	1.41	1.37
S_4	12.5	12.8	11.9	1.79	1.44	1.39
S_5	12.7	12.8	11.7	1.83	1.40	1.39
LSD (5%)	Ns	Ns	Ns	Ns	Ns	Ns
CV (%)	4.3	3.4	6.3	13.5	12.8	15.7

Means followed by the same letter in a column are not significantly different from each other; PC=Plant cane; RI= First Ratoon; RII = Second Ratoon; m = month; ESY= estimated sugar yield;S_1= 10 cm between setts, S_2= 5 cm between setts, S_3= End-to-end, S_4 cm overlapping, S_5=10 cm overlapping.

4. CONCLUSION

The following conclusions could be drawn from the results of this study:

- Absence of earthing-up (moulding operation) in the plant cane retained tiller population. Consequently, the final millable stalk population was a direct manifestation of the high number of tiller population formed which resulted in more uniform stalk population of comparable weight and number at harvest.
- Sucrose content, cane yield, and estimated commercial cane sugar were not statistically different from the control retreatment, which indicates that closer sett spacing results in the same final yield as in wider sett spacing.
- The absence of interaction effect of sett spacing with varieties showed that none of the varieties needs different sett spacing for attaining its maximum cane and sugar yields.

Therefore, it is recommended that the intra-row spacing of 10 cm between setts for all three varieties should be used instead of the conventional ear-to-ear (5 cm overlapping) setts intra-row spacing because the former requires less planting materials without compromising cane and sugar yields.

REFERENCES

[1]. Amolo RA and Abayo GO. ND, Effect of Plant Population and Planting Patterns on Sugarcane Productivity in Western Kenya. Kenya Sugar Research Foundation, Kisumu, Kenya. http://www.kari.org/fileadmin/publications/ 10thproceedings/Volone/Effect on PlantPopulation.pdf. (Accessed 27-6-2013).

[2]. Azhar ,M, Ishfaq, M , IQBAL, J and Shafi NM.. 2007. Agronomic Performance and Juice Quality of Autumn Planted Sugarcane (*Saccharum officinarum* L.) as affected by flat, ditch and pit planting under different spatial arrangements. *Int. J. Agri. Biol.*, **9(1)**: 167-169.

[3]. Collins, JL. 2002. "Final report- SRDC Project BSS212. Investigations of the limits to high density planting" Publication SD02016 (BSES: Brisbane). www.srdc.gov.au/icms_docs/129061_BSS263_Final_Report.pdf (Accessed 20-10-13)

[4]. Fauconnier, R. 1984. *Sugarcane*. The tropical Agriculturalist, Macmillan press Ltd. London.

[5]. Girma, W. 1997. Effect of Planting Density on Yield of Four Sugarcane Cultivars at Finchaa. Finchaa Sugar Industry Project. Agricultural Research and Services. (Unpublished).

[6]. James CPC and Chou, CC. 1993. *Cane Sugar Handbook*, 12th ed. A manual for cane sugar manufacturers and their chemists. John Wiley and Sons, Inc. New York.

[7]. Kakde, JR, 1985. *Sugarcane Production*. Renu printers. New Delhi. India.

[8]. Nayamuth, ARH and Koonjah, S. (2003). Harvesting more solar radiation for higher cane productivity. *In*: Agronomy workshop: Opportunities in sugar cane agronomy to confront the new realities emerging in the 21st century, 21-25 July 2003, MSIRI, Mauritius: Program and Abstracts. Réduit: ISSCT and Mauritius Sugar Industry Research Institute. p. 18

[9]. Orgeron, AJ, Kenneth AG and Keith PB. 2007. Planting Rate Effects on Sugarcane Yield Trials. *American Society of Sugarcane Technologists*. **27**: 23-24.

[10]. Rao, PN. 1990. Recent Advance in Sugarcane. M/S the K.C.P. Limited, Vuyyuru-India.

[11]. Raskar, BS and Bhoi, PG. 2003. Yield attributes of sugarcane as influenced by intra-row spacings, fertilizer levels and planting materials. *Indian Sugar*, **53 (5)**:327-331.

[12]. SAS (Statistical Analysis System). 2002. Institute of Applied Statistics and SAS programming Language. Cary, North Carolina.

[13]. Sundara, B. 2000. *Sugarcane cultivation*. VIKAS Publishing House Pvt. Ltd. New Delhi. India.

[14]. Sundara, B. 2003. Response of new sugarcane varieties to wide row spacing. *In* Proc.65th Ann. Convention Sugar Technol. Assoc, Orissa, India, 22-24 Aug. 2003: A 168-A 177. Record 768 of 772 – CAB Absts 2003/11-2004/04.

[15]. Sweet, CPM and Patel, R. 1985. Changes in cane yield of irrigated variety NCo376 due to season and their implications when evaluating field performance. *Proceedings of the South African Sugar Technologists Association*, **59**, 210–214.

[16]. Shah, SMA, Hidayat-ur-Rehman, Z. Iqbal, F.M. Abbassi, Durrishahwar, A. Ali, M.Y. Khan and D. Jan. 2008. Genotypic evaluation of sugarcane genotypes for rationing ability. 2008. *Sarhad J. Agric.* **24(4)**: 613-617.

[17]. Tsehay, G. 1993. Yield and Yield Attributes of Sugarcane as Affected by Different Cane Varieties and Planting Rates Grown on Two Soil Types at Wonji-Shoa Sugar Estate. MSc. Thesis, submitted to Alemaya University of Agriculture, Ethiopia.

[18]. Verma, RS. 2004. *Sugarcane Projection Technology in India*. International Book Distributing Co. Lucknow. India.

[19]. Worku, B. 2001. Influence of Sett Arrangement in intra-row Furrow on Sugarcane Millable canes and yield pp.144-145. *In* Review of Research on Sugarcane in Ethiopia. Agronomy and Crop Physiology. Ethiopian Sugar Industry S.C. Research and Training Service Division Wonji, Ethiopia.

[20]. Yousaf, M, Ahmed A and Akhtar M. 2002. Response of Two Genotypes of Sugarcane to Different Planting Patterns. *Asian Journal of Plant Sciences.* **1(4)**:346-348.