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Study on Dry-off period before harvest at Finchaa Sugarcane Plantation: Cool Season Study

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ABSTRACT

This study was conducted at Fincha'a Sugar Estate during 2003/4 to 2007/8 cropping seasons on two dominant soil types (Vertisol and Luvisol) of the estate. When the cane reached maturity stage it was subjected to six (4-9 weeks) length of drying off period. Sugarcane varieties used for investigation were B52298, B41227, NCo334 and CO 449.The experimental design used was split- plot with four replications, as the main plot being varieties while sub plots were length of dry-off period. The experimental fields were planted and managed following the standard cultural practice of the Estate. During the course of the experiment soil wetness, leaf sheath moisture content, Sucrose % cane, stalk weight, cane yield and sugar yield were measured. Soil samples were collected from 30–60cm depth for moisture content (Wt basis); Gravimetric moisture content was determined by auger whole methods. From the result of the study it was observed that extending dry off periods resulted in a sharp drop in soil moisture in both soil types. The drying off treatment did not affect stalk weight on both soils which shows that cane tonnage is not significantly affected. On Luvisol, better sucrose % cane and ESY were obtained for soil moisture around 13% which fell almost within 7 to 9 weeks drying off treatment for the tested varieties. On the other hand, on Vertisol, dry off period did not affect sucrose content and sugar yield. Generally, it is recommended to harvest the test sugarcane varieties within 7 to 9 weeks drying off treatment in Luvisol while in Vertisol it can be harvested when the field is dry enough for machine movements.

Keywords: Drying-off, juice quality, Luvisol, soil moisture, sugarcane, Vertisol.

INTRODUCTION

The processing of sugarcane for the extraction of sugar begins in the field. The variety of cane, the soil on which is grown, the different cultural practices used, including the fertilizer and irrigation, degree of maturity, and inherent character produce raw materials of varying millability. The harvesting method and its condition on reaching the first stage of the factory process affect the milling quality of the cane, the extractability and yields of commercial sugar and by products, as well as the details of the various operations conducted to recover the sugar (Barnes, 1974). Sugar recovery is dependent on the quality or composition of juice. Juice quality is essentially a relative character which is influenced by many factors that give a strong variety environment interaction (Kakde, 1985).

Sucrose will not accumulate to maximum levels until the plant encounters conditions highly restrictive against growth. The rapid growth processes tend to slacken as water and nitrogen resources are depleted. Sugar cane can easily be ripened within a few months after germination by withholding water, nutrients or other factors needed for growth (Alex, 1973). Sugar cane requires sunlight and moisture and warmth to grow properly. In contrast, it requires a dry, cool period to ripen (Fauconnir, 1993). At harvest time the grower is concerned with the moisture content of the millable cane since quality is associated with low moisture content (Humbert, 1983). Soil moisture is important factor affecting the growth of plants and other mechanical properities of the soil such as consistency, plasticity, strength, compactibility, stickiness and trafficability (Daniel, 1982).

Sugar cane is one of those crops that are seriously affected in quality by lesser moisture although it doesn’t show much in growth (Kakde, 1985). Water stress causes primarily stomatal closure, decrease assimilation and therefore growth. Although water stress induces negative growth, it is not always injurious. In certain cases it improves the quality of the plant products especially when the yield is a chemical constituent (sugar, fiber etc). Since water stress favours the decomposition of starch and protein for the formation of certain chemical constituents (Ramulu, 1998).

To achieve good crop ripening, gradual drying out of the crop is of primary importance, whether it is rain fed or irrigated. Soil type and moisture retention capacity will affect the ease with which this is achieved (Fauconier, 1993). High soil moisture conditions during ripening also reduce sucrose content and purity of juice. The sever moisture deficit increases fiber, bagasse and content of various intermediate products of metabolism through protein and carbohydrate hydrolysis (kakde, 1985).

Drying-off is easily accomplished on deep soils of good moisture holding capacity simply by with holding irrigation water for some weeks prior to harvest. On shallow soils adequate dry-off to induce ripening induces serious problems as the leaf canopy may be excessively damaged or on in extreme cases, the whole plant may be killed (Blackburn, 1984). Drying-off is also necessary for the practical purpose of allowing the mobility of in-field harvesting machineries. Soil wetness during harvest time has a pronounced effect on the mechanical properties of the soil (Daniel, 1982) and this has determining factor on the ease with which the crop will be harvested (efficiency, workability) and hence, has effect on successive ratoon management. Generally, ripening period is more important for its effect on juice quality and hence, optimum harvest time (Kakde, 1985).

Therefore, ripening and harvest are closely connected and the ability to control the one and to carry out the other has strongly influenced the development of different patterns of agriculture and concepts of reaping that exist in the industry.

Drying off the soil prior to harvest practiced by with holding irrigation in Wonji/Shoa sugar estates ranges from 63 in C_1 soil type to 89 days in A1 soil and there exist 4-5 days difference for the other soil cycles which may not be significant (Mukherji, 2000) even though it is not experimentally determined: while Finchaa sugar estate has no specific length of dry off period.

Objective:

- To determine optimum length of pre-harvest dry-off period at Finchaa Sugar Estate

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at Fincha’a Sugar Estate during 2003/4 to 2007/8 cropping season. The area is found 330 km west of Addis Ababa, and is located at $9^{\circ}31'$ to 10° N latitudes and 37°15' to 37° 30' E longitude with an elevation between 1350–1650 m a.s.l. The area characterized by average annual rain fall of 1280 mm with a mean minimum temperature of 14.5°C and 30.6°C, respectively. Moisture demand of the crop is supplemented by sprinkler irrigation.

Experimental Design and Treatments

The study was carried out on two dominant soil type (Vertisol and Luvisol) of Finchaa sugar estate using four dominant sugar cane varieties i.e. B52298, B41227, NCo334 and CO 449. The experimental fields were planted and managed following the standard cultural practice of the Estate. When the cane attains the harvesting age, it was subjected to six (4-9 weeks) length of drying off period. The experimental design used was split- plot with four replications, as the main plot being varieties while sub plots were length of dry-off period. Each experimental plot had a size of 52.2 m^2 (6 furrow of 6m length and 1.45 m width). The distance between replication and variety was 2.9 m and 3 m (two furrow) respectively.

Parameters Collected and Data Analysis

During the course of the experiment soil wetness, leaf sheath moisture content, Sucrose % cane, stalk weight, cane yield and sugar yield were measured at harvest by taking 21 random samples stalks from the middle four furrows of each plot. The soil physical parameter gravimetric moisture content was determined by auger hole methods, mentioned by Baruha and Barthakur (1997). The soil samples were taken at 30 – 60cm depth for moisture content (Wt basis).

Finally, data were subjected to General Linear Models Procedure (GLM) using SAS software statistical package (SAS, 1989) following a procedure appropriate to the design of the experiment (Gomez and Gomez, 1984). The treatment means that were significantly different at 5% levels of significance were separated using the Duncan Multiple Rang Test (DMRT). The degrees of relation between variables were measured by calculation of the two tailed Pearson Correlation Significance Test. Levels of significance (P) for these correlations were obtained by F-testes based on analysis of variance.

RESULTS

Effect of drying-off on soil and sheath moisture content

Analysis of variance of soil moisture content from 30 and 60 cm depths indicated that except 30 cm depth in luvisol, there was no significant difference among varieties and the interaction of variety by drying off periods; however the main effect drying off periods significantly ($p<0.01$) affected soil moisture (Appendix table 2). Significantly lower soil moisture content was recorded in the 7, 8 and 9 weeks dry-off periods in 0-30cm depth for both soils (Appendix table 2), which is in consistent with Verma (2004) that increase in drying off periods depletes moisture of the soil; however, on 30-60cm depth even if the trend similar it has a slight decline in soil moisture along dry off period.

Sheath moisture content was significantly ($p<0.01$) affected by the main effects variety and drying off periods; however, the interaction of variety by drying off periods was not significant (Table 1). The variety NCo 334 gave significantly higher sheath moisture content on both soils, except on Vertisol where it was at par with B52 298. Significantly higher sheath moisture was obtained in the 4^{th}, 5^{th} and 6^{th} weeks off dry-off periods while the significantly lower sheath moisture was recorded on the 7^{th}, 8^{th} and 9^{th} weeks after withholding irrigation.

Figure 1 shows the trend of soil moisture content as drying-off periods extended in two soil types. In luvisol, at both 30 and 60cm soil depths, soil moisture content at the fourth week after withholding irrigation was higher and then a sharp decline was observed till the seventh week. Thereafter, a slight decline in soil moisture percent was observed between seventh and ninth week after withholding irrigation. In vertisol, while the trend was the same at both depths higher moisture content was observed after each week of withholding irrigation, this could be due to better water holding capacity of the soil. In both soil types soil moisture at 30cm depth is lower as compared to that at 60cm indicating that soil moisture at 30cm is depleted more than that of 60cm.

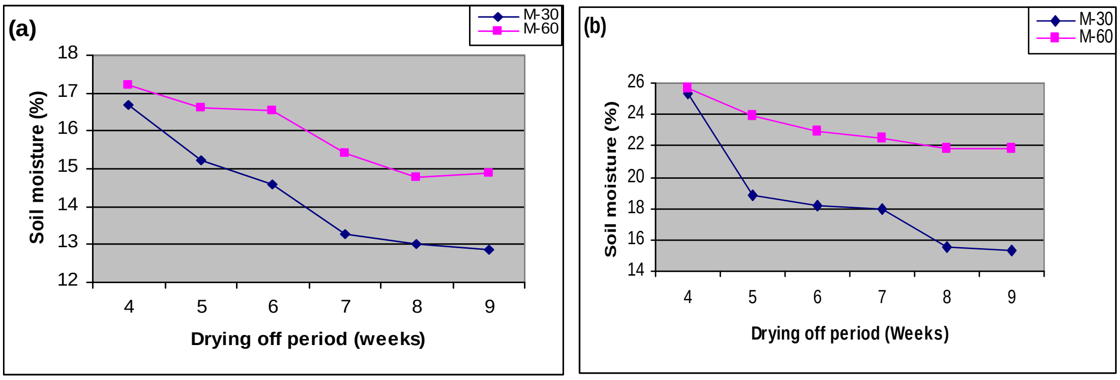

Figure 1: Relationship of dry off period before harvest and soil moisture content at 30 and 60cm depth on (a) luvisol and (b) vertisol

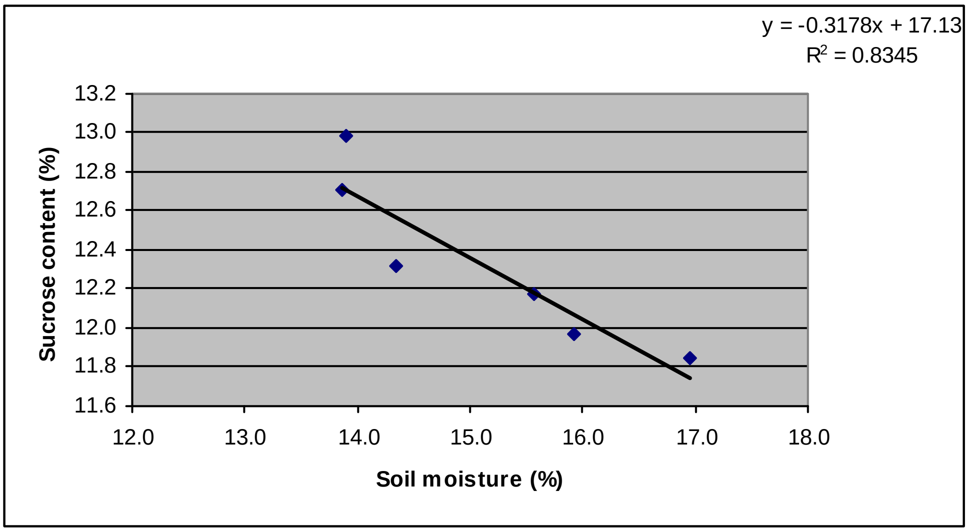

Figure 2: Relationship between soil moisture content and sucrose percent cane in Luvisol

Effect of drying-off on stalk weight and cane yield

Cane weight and Yield were significantly ($p<0.01$) affected only by the main effect of variety while drying off periods and the interaction of variety and dry-off periods were not significant on both soils (Table 1).

The higher stalk weight were attained in variety B41 227; in relation to this some studies indicated that cane weight and yield is influenced by inherent yielding ability of varieties, and their response also differs across soils (Worku and Chinawong, 2006). In both stalk weight and cane yield the non significant difference between drying off periods might be due to the subjected moisture stress the cane cannot grow further, and on the other hand higher moisture stress (nine week) might not be the upper limit which can seriously affect the vegetative growth of cane. Generally, there is less probability that drying off could result in cane yield loss due to low stalk weight in this study.

Effect of drying-off on sucrose % cane and estimated sugar yield

Statistical analysis of sucrose % cane and estimated sugar yield showed significant ($p<0.05$) differences in the main effect of varieties and drying off periods in luvisol. Whereas, in vertisol no significant difference observed in the main effect of varieties and drying off periods except varieties in sucrose % cane (Table 1). There was also no interaction effect existed between varieties and drying off periods. The highest sucrose % cane was recorded for variety Co 449 (12.90 for luvisol and 13.00 for vertisol). Variety Co 449 (34.80) and B41 227 (31.88) had got significantly higher sugar yield (t/ha) than the rest varieties in luvisol. The feature of this parameter is analogous to sucrose % cane with respect to dry off period treatments.

In luvisol an increase in sucrose % cane and estimated sugar yield was observed as dry off period proceeds, whereas in vertisol no difference were observed between dry off periods (Table 1).

Sucrose content had a strong and negative relation (r=-0.91) with soil moisture content, when moisture depleted corresponding improvement in sucrose percent were observed (Figure 2). In line with this according to Yang *et al.*, (2009) and Oliver *et al.*, (2006) the percentage of recoverable sugar was inversely proportional to soil moisture.

Table 1: Effect of drying off period on sheath moisture content, stalk weight, cane yield, Sucrose % cane and Estimated Sugar Yield of some sugarcane varieties in luvisol and vertisol during cool season of Finchaa Sugar Estate: Plant cane

	Sheath moisture,%		***Stalk wt (kg)***		***Cane Y.(t/ha)***		***S% cane***		***Est.sugar Y. (t/ha)***	
	Luvisol	Vertisol	Luvisol	Vertisol	Luvisol	Vertisol	Luvisol	Vertisol	Luvisol	Vertisol
Variety (V)										
B52-298	71.50^{b}	71.59^{a}	1.80^{a}	1.25^{b}	185.20^{b}	170.97	12.45^{b}	12.29^{b}	22.95^{b}	21.00
B41-227	70.41^{b}	70.12^{b}	1.78^{a}	1.35^{a}	276.44^{a}	184.06	11.49^{c}	12.41^{b}	31.88^{a}	22.87
NCO-334	74.51^{a}	72.07^{a}	1.34^{b}	0.98^{d}	261.34^{a}	174.63	12.49^{b}	12.34^{b}	32.55^{b}	21.50
CO-449	66.92^{c}	70.55^{b}	1.70^{a}	1.10^{c}	269.31^{a}	165.31	12.90^{a}	13.00^{a}	34.80^{a}	21.50
LSD (5%)	**	**	**	**	**	ns	**	*	**	ns
Dry off period (D)										
4 weeks	72.71^{a}	72.8^{a}	1.63	1.22	244.33	180.26	11.85^{c}	12.73	28.93^{b}	22.94
5 weeks	72.66^{a}	72.81^{a}	1.68	1.14	248.99	176.26	11.97^{c}	12.59	29.69^{b}	22.15
6 weeks	71.94a	72.03^{a}	1.68	1.16	234.84	169.45	12.17^{c}	12.66	28.47^{b}	21.44
7 weeks	69.61^{b}	70.76^{b}	1.64	1.22	246.19	183.98	12.32^{bc}	12.53	30.18^{ab}	22.94
8 weeks	68.61^{b}	68.61^{c}	1.59	1.16	247.13	167.20	12.98^{a}	12.18	31.94^{ab}	20.38
9 weeks	69.48^{b}	69.49^{c}	1.73	1.14	266.96	164.75	12.71^{ab}	12.36	34.05^{a}	20.45
LSD (5%)	**	**	ns	ns	ns	ns	**	ns	*	ns
V * D	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)	4	2	19	13	17	15	6	7	18	16

*** = significant at p<0.01; * = significant at p<0.05; ns = non significant*

Appendix table 1: Rainfall (mm) data of Finchaa

Years	**Months**											
	Jan.	**Feb.**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
2000	0.0	0.0	0.9	115.2	73.0	355.1	262.1	271.7	293.4	212.0	6.4	9.0
2001	0.0	0.4	66.3	46.1	115.7	263.2	295.6	283.6	111.0	60.4	1.6	4.1
2002	6.4	2.7	33.8	42.0	46.6	239.3	320.1	221.0	156.7	12.3	0.0	18.6
2003	1.5	24.9	52.7	11.5	5.0	292.7	294.3	271.6	217.7	11.6	5.5	4.0
2004	0.4	0.4	2.3	56.6	36.6	251.9	295.4	272.2	194.7	42.1	4.9	0.0
2005	9.6	0.0	112.1	30.5	53.8	418.7	351.8	232.1	244.3	77.0	15.7	0.0
2006	0.0	1.0	27.7	13.7	115.9	185.8	465.4	290.8	253.0	73.9	3.3	22.6
2007	3.5	38.2	36.6	36.4	126.1	259.4	273.9	237.5	192.8	61.9	0.0	0.0
2008	0.0	0.0	0.0	55.1	174.8	161.9	477.6	280.8	170.5	58.3	76.2	5.7
2009	0.1	11.7	14.7	43.1	16.6	200.8	304.2	431.6	98.1	137.7	0.0	4.1
Mean	**2.2**	**7.9**	**34.7**	**45.0**	**76.4**	**262.9**	**334.0**	**279.3**	**193.2**	**74.7**	**11.4**	**6.8**

** Correlation is significant at the 0.01 level (1-tailed);* Correlation is significant at the 0.05 level (2-tailed).

Appendix table 2: Effect of drying off period on soil moisture content of some sugarcane varieties in luvisol and vertisol during cool season of Finchaa Sugar Estate

	Soil moisture content, %			
	0-30cm		30-60 cm	
	Luvisol	**Vertisol**	**Luvisol**	**Vertisol**
Variety (V)				
B52-298	14.2^{b}	19.4	15.9	23.4
B41-227	13.5^{b}	19.2	15.1	23.8
NCO-334	15.2^{a}	17.6	16.2	22.9
CO-449	14.2^{b}	17.9	16.5	22.3
LSD (5%)	**	ns	ns	ns
Dry off period (D)				
4 weeks	16.7^{a}	25.4^{a}	17.2^{a}	25.7^{a}
5 weeks	15.2b	18.8^{b}	16.6^{ab}	24.0^{ab}
6 weeks	14.6^{b}	18.2^{b}	16.5^{ab}	23.0^{b}
7 weeks	13.3^{c}	18.0^{bc}	16.5^{ab}	22.5^{b}
8 weeks	13.0^{c}	15.6^{cd}	14.8^{c}	21.8^{b}
9 weeks	12.9^{c}	15.3^{d}	14.9^{c}	21.8^{b}
LSD (5%)	**	**	**	**
V * D	ns	ns	ns	ns
CV (%)	10	18	13	14

CONCLUSION

From the result of the study it was found that extending dry off periods resulted in a sharp drop in soil moisture in both soil types. Significantly lower Sheath moisture content was registered after 7 weeks withholding irrigation in both soils. Stalk weight was not affected significantly due to drying of period indicating and thus the treatment did not affect cane yield on both soil types. Better sucrose % cane and ESY were obtained for soil moisture around 13% which is almost within 7 to 9 weeks drying off treatment for the tested varieties in Luvisol. On the other hand, in Vertisol dry off period did not affect sucrose content and sugar yield. Sucrose content had a strong and negative relation (r=-0.91) with soil moisture content.

Generally, in cool season, it is recommended to harvest the test sugarcane varieties within 7 to 9 weeks drying off treatment in Luvisol while in Vertisol it can be harvested when the field is dry enough for machine movements. If rainfall occurs drying off period should be judiciously extended to the desired soil moisture status, thus soil moisture testing should be performed while subjecting fields to drying off treatment. Furthermore, the result should be verified in large commercial fields, and separate experiment should be done for ratoon crops.

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