คุณสมบัติทางกายภาพบางประการของอ้อย
Some Physical Properties of Sugarcane

สุพรรณ ยั่งยืน[1] **และ เสรี วงส์พิเชษฐ**[2]
Suphan Yangyuen [1] and Seree Wongpichet[2]

Abstract

Some physical properties of sugarcane *(Saccharum officinarm L.)* were determined at the raw sugarcane previously into processing condition in Northeast Thailand. In order to design equipment for study and develop sugarcane cleaning. The dimension of sugarcane viz., length of whole stalk, length of stalk internode, and diameter, apparent density, true density, number of stems a bundle were measured. The static coefficient of friction on various surfaces also measured. Commonly used four commercial caltivars of sugarcane such as K84-200, K88-92, K-lueng and U-thong1 were used.

Key words: Sugarcane, physical properties, static coefficient

บทคัดย่อ

คุณสมบัติทางกายภาพบางประการของอ้อยก่อนเข้าสู่กระบวนการผลิตน้ำตาลในเขตภาคตะวันออกเฉียงเหนือ เพื่อเป็นข้อมูลสำหรับการออกแบบและพัฒนาเครื่องทำความสะอาดอ้อย โดยทำการศึกษาเกี่ยวกับมิติของอ้อย กล่าวคือ ความยาวลำอ้อย ความยาวปล้อง เส้นผ่าศูนย์กลาง ความหนาแน่นปรากฏ ความหนาแน่นจริง จำนวนลำอ้อยต่อมัด สัมประสิทธิ์ความเสียดทานสถิตย์บนพื้นผิววัสดุต่างกัน โดยทำการศึกษาอ้อยที่นิยมปลูกเชิงการค้าทั้งหมด 4 พันธุ์ ได้แก่ พันธุ์เค 84-200 พันธุ์เค 88-92 พันธุ์เคเหลือง และพันธุ์อู่ทอง 1

คำสำคัญ อ้อย คุณสมบัติทางกายภาย สัมประสิทธิ์ความเสียดทานสถิตย์

Introduction

Sugarcane *(Saccharum officinarm L.)* is an important raw material for the sugar industry (Frank, 1984). Thailand is one of the world's leading producers of sugar. The sugar industry combines the agricultural task of sugar cane cultivation with the factory activity of producing raw and refined sugar, syrups, specialized sugars and other by-products. Sugar is produced at 2003/04-season average of about 6.7 million tons, that increasing about 12 per cent during of 10 years ago (Office of the cane and sugar board, Thailand, 2004).

Presently, Thailand sugar industry has identified a major problem: the soil that is delivered with the sugar cane consignments is having a negative impact on the industry. The soil and sand impurities increase the wear of processing machinery, reduce extraction efficiency and result in the unnecessary transport of material to and from the mills (Khotavivattana, 2003; Kitjarernpunya *et al*., 2000). Unfortunately, no research reported on the sugarcane cleaning in Thailand. Occasionally, knowledge of the some physical properties of sugarcane is essential to facilitate the design equipment of handing, spreading of thin layer and cleaning the sugarcane. Various types of cleaning, grading and separation equipment are designed on the basis of the physical properties of the material. However, not much published work seems to have been carried out on the physical properties of Thai sugarcane and their relationship. The objective of this study was to determine some of the physical properties of the whole stalk, 300 mm of length sugarcane chopped: such as dimension, apparent density, true density and static coefficient of friction.

Materials and Methods

[1] นักศึกษาปริญญาเอก ภาควิชาวิศวกรรมเกษตร คณะวิศวกรรมศาสตร์ มหาวิทยาลัยขอนแก่น ขอนแก่น 40002
Graduate School, Department of Agricultural Engineering, Faculty of Engineering, Khon Kaen University, Khon Kaen 40002
[2] ผู้ช่วยศาสตราจารย์ ภาควิชาวิศวกรรมเกษตร คณะวิศวกรรมศาสตร์ มหาวิทยาลัยขอนแก่น ขอนแก่น 40002
Assistant Professor, Department of Agricultural Engineering, Faculty of Engineering, Khon Kaen University, Khon Kaen 40002

The sugarcane use in this study was obtained from the 2004/05 crop previously into process at the sugarcane factory in Northeast Thailand. The sugarcanes were randomized on the three types of truck and commercial four cultivars, which the trucks were waiting unloading into the process.

The sample for testing at randomized on the three types of truck: such as tenth-wheeled type, sixth-wheeled type and fourth-wheeled type while randomly selected sugarcane commercial in four cultivars: such as K84-200, K88-92 K-lueng and U-thong. Twelve bundles of each sugarcane cultivars were randomize, the number of stem per a bundle, the diameter was measured using a caliper with a reading accuracy within 0.01 mm, the length of whole cane and the length of internodes were using a tapemeasure with a reading accuracy within 0.5 mm.

The apparent density (ρ_b) of whole stalk of sugarcane was measured the three dimensions of the pile of cane on the truck, then calculated the bulk volume, and weighed the net cane $\rho_b = m/ V_b$.
Where m is total mass of sugarcane, kg and V_b is the bulk volume in m^{-3} including volume of void spaces (Abalone *et al.,* 2004).

The methods described by Sinclair *et al.* (2005) of the volume of stalk internodes, that measured diameter and length with this relationships were calculated by assuming was a cylindrical. For, the true density (ρ_t) was measured the diameter and weighted of 300 mm chopped along of whole stalk. The both densities calculated from the mass and volume. The porosity (P_t) was using the following relation (Visvanathan *et al*., 1996) $P_t = 1- (\rho_b/\rho_t)$.

The static coefficient of friction was measured using a friction device against different surfaces (plywood, mild steel and sugarcane) (Sudajan *et al.,* 2001; Sitkei, 1986). The sugarcanes were randomly selected 10 stalk from the each cultivars with the sugarcane chopped in 300 mm along of the whole stalk.

Results and Discussions

The value of all the properties measured is summarized the details of all properties are show in these follows (Table 1):

3.1 Sugarcane dimension

(a) K84-200 cultivar

The length of whole cane (stem-end) of K84-200 caltivar ranged from 1130-3350 mm, the length of stalk internode ranged of the bole of cane stalk, the middle of stalk and the tip of stalk were 20-214, 62-201 and 22-215 mm respectively. The diameter of stalk ranged of the bole of cane stalk, the middle of stalk and the tip of stalk were 15.2-42.0, 7.0-33.0 and 10.6-30.2 mm respectively. The number of sugarcane stems per a bundle was found 10.5 stems.

(b) K88-92 cultivar

The length of whole cane (stem-end) of K88-92 caltivar ranged from 1480-2640 mm, the length of stalk internode ranged of the bole of cane stalk, the middle of stalk and the tip of stalk were 50-165, 53-170 and 53-158 mm respectively. The diameter of stalk ranged of the bole of cane stalk, the middle of stalk and the tip of stalk were 18.4-15.7, 14.2-35.2 and 16.2-30.3 mm respectively. The number of sugarcane stems per a bundle was found 11.0 stems.

(c) K-lueng cultivar

The length of whole cane (stem-end) of K-lueng caltivar ranged from 770-3240 mm, the length of stalk internode ranged of the bole of cane stalk, the middle of stalk and the tip of stalk were 67-160, 64-174 and 44-143 mm respectively. The diameter of stalk ranged of the bole of cane stalk, the middle of stalk and the tip of stalk were 22.9-41.1, 18.3-37.9 and 16.4-30.8 mm respectively. The number of sugarcane stems per a bundle was found 12.7 stems.

(d) U-thong cultivar

The length of whole cane (stem-end) of U-thong caltivar ranged from 1440-2710 mm, the length of stalk internode ranged of the bole of cane stalk, the middle of stalk and the tip of stalk were 41-130, 60-160 and 37-110 mm respectively. The diameter of stalk ranged of the bole of cane stalk, the middle of stalk and the tip of stalk were 16.9-35.0, 18.1-31.8 and 14.0-31.8 mm respectively. The number of sugarcane stems per a bundle was found 13.0 stems.

Table 1 Some physical properties of sugarcane

Physical properties	Number of observations				Mean value				Standard deviation			
	CV1	CV2	CV3	CV4	CV1	CV2	CV3	CV4	CV1	CV2	CV3	CV4
Length of whole stalk, mm	109	93	72	65	2,086	2,174	2,021	1,992	548	291	758	314
Length of stalk internods, mm	109	93	72	65								
The bole of cane stalk					93.7	93.2	99.8	80.0	31.2	25.8	20.7	16.3
The middle of cane stalk					118.0	117.0	108.5	91.1	28.8	24.1	19.2	17.7
The tip of cane stalk					87.4	92.1	79.4	70.7	30.3	19.4	21.1	15.4
Diameter, mm	109	93	72	65								
The bole of cane stalk					25.4	27.8	30.8	25.8	5.8	4.4	3.8	3.4
The middle of cane stalk					23.3	23.9	27.8	24.3	5.0	4.2	4.2	3.2
The tip of cane stalk					20.9	22.8	24.3	21.4	4.2	3.2	2.9	3.2
Number of stems a bundle	12	12	12	12	10.5	11.0	12.7	13.0	1.8	2.3	1.6	2.9
True density, kg m^{-3}	242	169	109	118	1,011.9	1,065.8	1,071.7	1,023.6	100.3	88.3	55.2	91.1
Apparent density , kg m^{-3}	5	4	3	2	423.5	397.0	490.6	453.4	19.0	51.3	38.0	40.7
Porosity of sugarcane					0.58	0.62	0.54	0.55	0.05	0.04	0.03	0.04
Static coefficient of friction on	242	169	109	118								
Plywood					0.36	0.38	0.31	0.31	0.05	0.05	0.04	0.06
Mild steel					0.38	0.40	0.37	0.35	0.05	0.05	0.05	0.05
sugarcane					0.48	0.48	0.44	0.44	0.06	0.07	0.06	0.07

Remark: CV1, CV2, CV3 and CV4 are symbol of name sugarcane cultivars such as K84-200, K88-92, K-lueng and U-thong1 respectively

The dimension results cane be use for the design such as width of conveyer, thickness of sugarcane for suitable to cleaning, relation with the sugarcane pour rate and pattern of sugarcane movement.

3.2 Apparent density and true density

The apparent density for all cultivars of sugarcane was found to be highest on the K-lueng followed by U-thong, K84-200 and K88-92, which were ranged 471.6-527.0, 424.6-482.2, 398.1-443.4 and 334.7-448.6 kg m^{-3} respectively. The true density for all cultivars of sugarcane was found to be highest on the K-lueng followed by K88-92, U-thong and K84-200, which were ranged 869.9-1305.0, 566.4-1309.6, 685.6-1303.5 and 603.9-1233.0 kg m^{-3} respectively.

The porosity of K-lueng cultivar was range from 0.44-0.70, K84-200 was range from 0.30-0.66, and K88-92 was range from 0.30-0.70 while U-thong was range from 0.34-0.65. However, the porosity was depended on the pattern of sugarcane pile in a truck, this property is important in the development of unloader and cleaner designs for sugarcane, relation with the sugarcane pour rate and pattern of sugarcane movement.

3.3. Static coefficient of friction

The static coefficient of friction was found to be highest on the sugarcane friction against followed by mild steel and plywood for all cultivars. The sugarcane friction against of K84-200, K88-92, K-lueng and U-thong found

range from 0.37-0.70, 0.37-0.62, 0.32-0.65 and 0.32-0.69 while plywood found range from 0.27-0.51, 0.30-0.58, 0.21-0.45 and 0.21-0.54, for mild steel found range from 0.27-0.60, 0.31-0.58, 0.24-0.49 and 0.26-0.53.

These results can be use for design such as incline of the truck unloading, angle of sugarcane conveyer and so on.

Summary

(1) The average length of whole stalk of K84-200, K88-92, K-leung and U-thong cultivar was 2086, 2174, 2021 and 1992 mm.

The length of stalk internode, 93.7, 118.0 and 87.4 mm for the bole, middle and tip of cane stalk of K84-200, while K88-92 was 93.2, 117.0 and 92.1 mm, K-lueng was 99.8, 108.5 and 97.4, U-thong was 80.0, 91.1 and 70.7 mm. The middle of stalk internode was highest, follow by the bole and tip respectively.

The diameters of the bole, middle and tip of cane stalk were 30.8, 27.8 and 24.3 mm for K-lueng cultivar was highest, and whiles the all diameters were nearly of K84-200, K88-92 and U-thong.

The number of sugarcane stems per a bundle was found 10.5, 11.0, 12.7 and 13.0 stems for of K84-200, K88-92, K-leung and U-thong cultivar.

(2) The average apparent density of K84-200, K88-92, K- leung and U-thong cultivar were 423.5, 397.0, 490.6 and 453.4 kg m^{-3}, for the true density were 1011.9, 1065.8, 1071.7 and 1023.6 kg m^{-3} respectively.

The average porosity of K84-200, K88-92, K- leung and U-thong cultivar were 0.58, 0.62, 0.54 and 0.55 respectively.

(3) The average static coefficient of friction against sugarcane, 0.44-0.48 of all calitvars, was highest while 0.31-0.38 for plywood of all cultivars was the lowest.

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