

DEVELOPMENT AND EVALUATION OF METERING DEVICES FOR SUGARCANE BILLET PLANTER

Choochart DHALOEMTHOI¹, Khwantri SAENGPRACHATANARUG¹, Saree WONGPICHET¹
Khanittha THAVEESAENG¹ and Nophasin LAOPUKDEE¹

¹*Department of Agricultural Engineering Faculty of Engineering Khonkean University
123 Moo 16 Mittapap Rd., Nai-Muang, Muang District, Khon Kaen 40002, Thailand*

Corresponding author: Khwantri SAENGPRACHATANARUG E-mail: khwantri@kku.ac.th

ABSTRACT

At present, sugarcane billet planter is become more interested by farmers who own the sugarcane harvester, since lack of agricultural labors become more severe. However, the planting consistency of this kind of planter is still low. Thus the metering device of the sugarcane billet planter is needed to be improved. The objective of this study was to develop the shape and arrangement of the metering device of the billet planter and evaluate it. The original billet metering device consists of the rubber conveyor belt attached with the flat steel cleats which have their length equal to the conveyer width. While the developed metering device use the flat steel cleats with the 20 degree inclined-edge. More over the cleats were shorten to 2/3 length of conveyer width and aligned in left-right alternation. Then, the developed metering device was evaluated compared to the original device by considering the precision of billet discharging during the stationary tests. The container inclination was 60 degree from horizontal level. Sugarcane variety of Khon Kaen 3 harvested by the Austoft 7000-2000 harvester was used for the experiments. Linear speed of the conveyor was controlled at 0.189 m/s. The testing results showed that the developed metering devices gave the precision index of 50.67% which is 9.66% higher compare to that of the original one.

Keywords: Sugarcane billet planter; Metering device; Precision index

INTRODUCTION

Sugar cane (*Saccharum officinarum* L.) is an important economic crop of Thailand. Referring to 2013-2014 reports, there are approximately 1.62 million ha in Thailand, with an average yield of 70.25 tons/ha and total sugarcane production of 113.3 million tons (OCSB, 2014). A major problem for sugar cane cultivation is the shortage of labor, especially in the harvesting and planting seasons (Tangwongkit et.al, 2003). Hence, the semi-automatic sugarcane planter was developed, and became widely used by middle to large scale farmers in Thailand (Tangwongkit et.al, 2007). However, the seed cane used by this kind of planter is still needed to be prepared by large numbers of labors, whose preparation processes include: cutting the stalks, removing leaves, gathering, and conveying the seed cane to the semi-automatic planter. Thus, as the labor cost was raised, most of farmers have to bear a very expensive cost in order to finish

plantation in time, otherwise they need to delay the planting (Garrison et al., 2000). The full-automatic billet planter which uses the seed cane harvested by the combined harvester was introduced in order to solve the labor shortage and delay planting problem in United state (Hoy. J.W., 2001). Moreover, the billet planter has the higher field capacity and efficiency. However, the major problem of the billet planter is the low consistency of the planting rate (discharging rate) which in turn resulting in a lower sugarcane yield. In order to improve the precision of the metering device, many researches were carried out. Factors such as linear conveying speed and the inclination of the conveyor belts were studied and modeled (Jalil et al., 2010 and Javad et al., 2012). Refer to the former study (Choochart et al., 2014); the discharge consistency was raised by improving the inclination of the planter container bin. Nevertheless, the conveying behavior of the sugarcane billet planter was

dependent upon the arrangement of the cleats conveyer. Researches results of this dependency factor are rarely. Thus, this study aims to develop the metering device for sugarcane billet planter through the modification of the arrangement of the cleats conveyer. Then the discharge index and consistency of the developed and original metering device were evaluated and compared.

MATERIALS AND METHODS

2.1 Test materials

The Khon Kaen 3 variety was chosen as it is the most suitable variety to be harvested by the combined harvester in Thailand at present (Office of the Cane and Sugar Board, 2014). The 11 months old seed cane planted in the Banhad district, Khon Kaen province, Thailand, was harvested by Austoft model 7000-2000 harvester. The 300 samples of sugarcane billets were taken to measure its physical properties. The billet average length and diameter was 279.3 mm and 27.52 mm respectively. The average weight of the billet was 184.31 g, while the bulk density was 322.2 kg/m³. The trash percentage was controlled at 0%. The prepared billets were kept in the room temperature of about 25°C and 55% air relative humidity approximately. The experiment condition was shown in table 1

Table 1 Experimental condition

Cultivar of sugarcane	Khon Kaen-3
Total weight of sugarcane	600 kg
Linear conveying speed	0.189 m/s
Conveyor inclination angle	60 °
Width of conveyor	0.6 m
Diameter of conveyor drum	0.28 m
Number of metering device arrangements	2 case
Number of replications of each arrangement	3 replications

2.2 Experimental procedure

The modified billet planter Austof 750 BP with the developed container bin from the former study (Choochart et al., 2014) was used for the experiment (Fig.1). The stationary tests were done to compare the discharge precision between the original metering device and the developed metering device. The original metering device consists of the flat cleats attached on the 60 degree inclined conveyer belt. The length of all cleats was the same with the conveyer width which equal to 60 cm (Fig. 2). On the other hands, in the developed

metering device, the original full width flat cleats were replaced by the new cleats, while keeping the same cleat space at 150 mm. The edges of the new cleats were bended to be 20 degree inclined. The cleats were shorten to 2/3 length of conveyer width and aligned in left-right alternation (Fig. 3). The other geometries of the planter except for the shape and the arrangement of the cleats were kept the same for the comparative tests.



Fig. 1 The modified billet planter Austoft 750 BP that used for the experiment

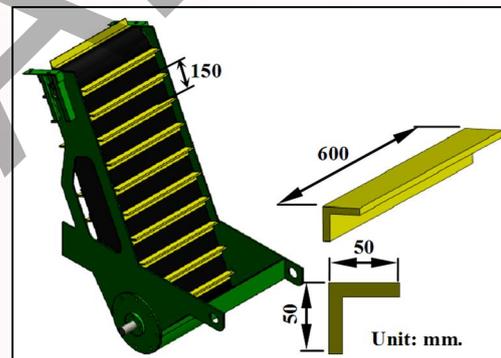


Fig. 2 The geometry of the original metering device

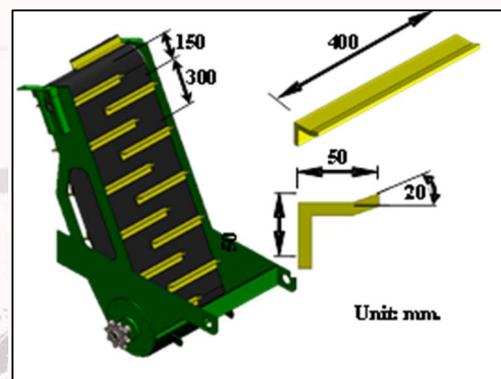


Fig. 3 The geometry of the developed metering device

Fig. 4 shows the schematic of the stationary tests. The billet planter was place on the leveled concrete floor. Then 600 kg of controlled sugarcane billets were loaded into the

container. The billet conveyer was driven by 100 hp tractor PTO through gear box CTA (ASS) single worm with 1:20 ratio. Since the actual forward speed of this type of billet planter was 5.54 km/hr (Thitinai et al., 2013), which resulted in the linear conveying speed of 0.189 m/s. Thus, during the test, the linear conveying speed was controlled at 0.189 m/s by controlling tractor engine speed and randomly checked using digital tachometer (Tachometer Laser AND model AD-5172). The numbers of discharge billets were recorded by the VDO camera contour roam plus 2 (120 Fps) that attached to the tractor roof (Fig.5). The instant discharge rate (billet/sec) was calculated at each 1 sec from the beginning of discharge until the container became empty. The experiments were done in 3 replications for each case. Considering the ratio of the linear conveying speed to the planter's forward speed, R which was 0.17:1 in the actual field operation, the discharge index (billet/m) was calculated from the discharge rate (billet/sec) using equation 1. Consequently, the precision index which represents percentage of discharge accuracy was calculated using equation 2 (Javad et al., 2013).

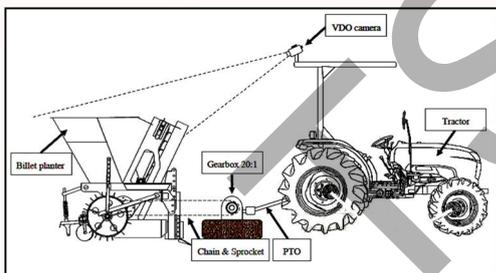


Fig. 4 The schematic of stationary test



Fig. 5 Sample of recorded frame during the stationary test of a) the original metering device and b) the developed metering device

$$\text{Discharge index (billet/m)} = \frac{n}{t} \times \frac{R}{v} \dots(1)$$

Where

n = number of discharged billets during observed time duration (billet)

t = time duration (sec)

v = linear conveyer speed (m/s)

R = ratio of the linear conveyer speed to the forward speed

$$\text{Precision index (\%)} = \frac{N_{n\text{total}}}{N_{\text{total}}} \times 100 \dots(2)$$

Where

$N_{n\text{total}}$ = total distance that billets were discharged within the desired discharge index range (m)

N_{total} = total distance of discharge from beginning until container became empty (m)

RESULTS AND DISCUSSION

Fig. 6 shows the discharge index during the stationary test. The dash line and solid line represents the results of the original and the developed metering device of the container bin, respectively. The discharge index was high at the beginning of the test which the container bin was fully loaded. Then the discharge index decreased. Considering declination trend of the discharge index for each metering device, the discharge index of the original metering device tended to decrease with the higher rate than that of the developed metering device. To compare the discharge consistency, the frequency polygons of the discharge index were plotted as shown in Fig. 7.

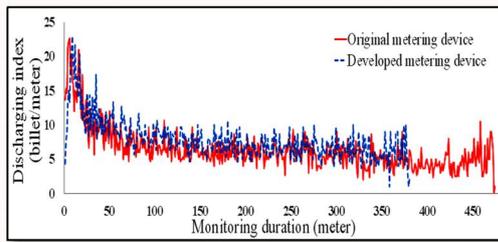


Fig. 6 The comparative discharge index during the stationary test

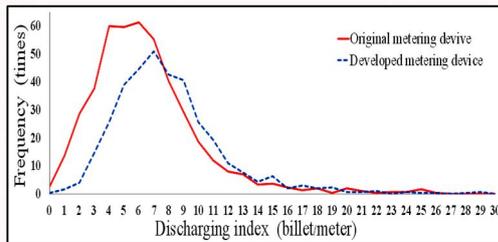


Fig.7. Frequency polygon of discharge index from the stationary test comparing between the original and the developed metering device

Refer to the former research (Jalil et al., 2010), the overlap length of the billet in the planting row should be 15 cm. As the average length of billets was 279.3 mm, the desire discharge index was 7.5 billets/m. Considering $\pm 20\%$ acceptable error, the desire range of discharge index was 6-9 billets/m (Thitinai et al., 2014). Considering the frequency polygon of the discharge index, the original metering device of the container bin had a peak during 4-7 billets/m which was less than the desire range. More over, zero discharges were observed for 3 times, while the total number of discharge was 454 times per replication. That is, there was about 0.66% of the planting distance that the sugarcane billet was not applied. On the other hands, the developed metering device had a peak during 6-9 billets/m which was within the desire range, and totally had no zero discharges. That is; the developed metering device caused more turbulence inside the container bin and allowed wider alignment angle of the sugarcane billet to be conveyed than the original one. Thus, the sugarcane billets that align in horizontal and vertical direction were both conveyed by the developed metering device.

Precision index of the discharge index in desire range was calculated for each metering device as shown in table 2 and table 3. Considering the average results from 3 replications for each case, first metering device had the total precision index of 41.01%, while

the developed metering device had the total precision index of 50.67%. The developed metering device had 9.66% total precision index in the desire ranged higher than the original one. To interpret these results, we can describe in term of planting distance. For the original metering device, there was about 41 m length of the total 100 m length that the sugarcane billets were discharged within the desired numbers. While, there was about 50 m length of the total 100 m in case of the developed metering device which was longer than those of the first pattern.

Table 2 Precision index under the stationary tests of the original metering device

Discharging Index (billet/meter)	Original metering device Precision index (%)			
	Test 1	Test 2	Test 3	Average
6	12.18	13.20	15.01	13.46
7	13.58	11.90	11.21	12.23
8	6.79	10.39	9.30	8.83
9	7.49	5.41	6.55	6.49
Total	40.05	40.91	42.07	41.01

Table 3 Precision index under the stationary tests of the developed metering device

Discharging Index (billet/meter)	Original metering device Precision index (%)			
	Test 1	Test 2	Test 3	Average
6	10.98	13.43	13.42	12.61
7	13.72	14.00	15.53	14.42
8	13.11	10.00	13.16	12.09
9	11.59	12.57	10.53	11.56
Total	49.39	50.00	52.63	50.67

CONCLUSION

The discharge precision comparative station-ary tests were carried out to find the better shape and arrangement of the cleated conveyer as a metering device of the sugarcane billet planter. The original billet metering device used the flat steel cleats which their lengths were equal to the conveyer width. While the developed metering device use inclined-edge cleat. More over the cleats were shorten to 2/3 length of conveyer width and aligned in left-right alternation. The results showed that the developed metering device had no zero-discharge index. Considering the desire range of discharge index between 6-9 billet/m, the average precision index of the developed metering device was 50.67% which was 9.66% higher than those of the original metering device. Thus, the sugarcane billet

planter equipped with the developed metering device can plant with higher precision.

ACKNOWLEDGEMENT

This study was financially supported by The Thailand research fund and Khon kaen University. The discussions shown in this article belong to the authors, which The Thailand research fund and Khonkaen University do not need to agree with. This study was also supported by Applied Engineering for Important Crops of the North East research group, Khon Kaen University. The conference attendance of this paper was financially supported by Agricultural Machinery and postharvest technology research center, Khon Kean University, Khon Kean 40002, Thailand. The authors are graceful to Mr.Kittiphit Eungsathitthaworn, the sugarcane farmer in Khon Kaen province who support the facility and gave the guidance for the experiment practices.

REFERENCE

- [1] Choochart Chaloeomthoi, Saengprachatanarug K.and Wongpicher S. Comparison of discharge index of sugarcane billet planter in khon kaen province. The 15th TSAE national conference, Thailand, pp.364-371 (2014)
- [2] Garrison, D.D., E.O. Dufrene, and B.L. Legendre. Effect of planting date on yields of sugarcane varieties grown in Louisiana. Abstr. J. Amer. Soc. Sugar Cane Technol. 20:115, 2000.
- [3] Hoy. J.W. 2001. Planting Sugarcane: Whole Stalks versusbillets. Available at: <http://www.-lsuagcenter.com/en/communications/publications/agmag/Archive/2001/Fall/Planting+Sugarcane+Whole+Stalks+Versus+Billets. htm>. Acce-ssed on 6 August 2013.
- [4] Jalil Razavi ,Moslem Namjoo. Determination of forward speed effect on planning uniformity in a sugarcane billet planter. Canadian Society for Bioengineering (CSBE/SCGAB) Québec City, Canada. June 13-17, 2010.
- [5] Javad Taghinezhad, Alimardani R. and Jafari A. Optimization cane traction output from hopper in full-automatic sugarcane planters by using response surface modeling and analytical hierarchy process. Journal Agric Eng Int: CIGR July Vol.15, No. 2: 138-147 (2013)
- [6] Office of the cane and Sugar Board [Internet].- 2014 [update 2014 Nov 20]. Available from: <http://www.ocsb.go.th/upload/journal/fileupload/923-9193.pdf>
- [7] Tangwongkit B et. al, Improvement of sugarcane chopper harvester for sugarcane seed cutting,

- Proceedings of 47th Kasetsart Univer-sity Annual Conference: (2007)
- [8] Tangwongkit R et.al, Design and development of a no-tilled sugarcane planter model FM.44 (NRCT-KU). Proceedings of 41th Kasetsart University Annual Conference: Engineering and Architecture (2003)
- [9] Thitinai Tianyam, Khwantri Saengprachata-narug, Nattangrit Veerakulwattana, Suriya Anutara-pongpan. Performance of Sugarcane billet planter and traditional ground wheel planter used in Khon kaen area (in Thai). The 14th TSAE national conference. 2013.
- [10] Titinai Thienyaem, Saengprachatanarug K., Wong-pichet S., Eizo T., Thongrak P. The influence of the metering device arrangement to the discharging consistency of the sugarcane billet planter. The 5th KKU International Conference March 27-29 Khon Kaen, Thailand (2014)