South Asian J. Food Technol. Environ., 6(2): 999-1005 (2020)
ISSN 2394-5168 (Print), 2454- 6445(online)
View on line at www.sweft.in
DOI: https://doi.org/10.46370/sajfte.2020.v06i02.09

Effect of Operational Speed, Cane Seed Length and Diameter on Miss Index of a Sugarcane Billet Planter

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Abstract

The effect of operational speed, cane seed length and cane diameter on miss index of a sugarcane billet planter pulled by tractor was studied. Miss index is an important performance parameter of planters because it is the index which dives an idea of how much the planter skips planting points. This means, it is the degree with which the plant failed to plant at the specified planting distances or points. The miss index is an index of the effectiveness with which the metering mechanism of the planter delivers the planting material accurately**.** A three-variable, four level factorial design ($N = 4^3$) experiment comprising four levels each of the planter's operational speed, cane length and cane diameter was conducted in a 100m x 100m field that was properly ploughed and harrowed. The operational speeds were 6km/hr, 8km/hr, 10km/hr and 12km/hr; cane lengths were 300m, 350mm and 400mm; and 16mm and cane diameters were 20mm, 24mm and 28mm. Result indicates that increase in operational speed tended to increase the miss index of the prototype planter as the highest percent cane seed miss index of 22.1-22.3% were recorded at the highest operational speed of 12 km/h. Miss index was not significantly ($P<0.05$) affected by the cane seed length for various levels of cane diameter while it was significantly ($P<0.05$) affected by cane diameter as bigger cane diameters had higher miss index..

Keyword: Effect, seed, index, sugar.

Paper cited: Gbabo, A., Gana, I.M. and Ndagi, B. (2020). Effect of operational speed, cane seed length and diameter on miss index of a sugarcane billet planter. *South Asian Journal of Food Technology and Environment,* 6(2): 999-1005.

Introduction

Planting of sugarcane is the most expensive on a farm. New planting system has been developed to reduce the cost of planting, primarily by reducing the amount of labour, this lead to the development of mechanical sugarcane planter. The success of the establishment of a sugarcane crops affects the yield of that field for the whole crop cycle According to Berry and Wiseman (2003), large gaps reduce yield and allow weed infestations. A failure to obtain successful establishment can result in the expense of replanting. The size of the sugarcane cutting has a significant effect on both the percentage of buds that will germinate and vigour of the resulting plants. One-eye setts gave 17% better emergence than three-eye setts but plants from one-eye setts had 15% fewer tillers and were 28% shorter than plants from three-eye setts at three months.

Precision planters place fertilizer and cane seed at the required spacing which provide a better growing area per cane seed (Ozmerzi *et al.,* 2002). These parameters can be influenced by the operational speed. The differences between sugarcane yields in relation to the operational speed may be related to other variables that are occurring and are not being considered, such as cane seed distribution mechanism (skips) at different operational speeds and the distance from the seed tank to the soil line (Casao *et al.,* 2000). Liu *et al.,* (2004) observed that once the variation of the planter may affect seed travel and displacement then, the type of seed feeder can affect seed distribution and planting quality. Also, Evandro *et al.,* (2015) reported that factors inherent to the evaluated plant species such as the phenotype size of sugarcane genotypes expressing the component of production, stalk yield and factors linked to population density. Hence the aim of the study is to access the effect of operational speed, cane seed length and diameter on a miss index.

Material and Methods

Equipment

The machine used in this study is Tractor –Drawn Sugarcane Billets Planter (Figure 1 and Plate 1) developed by Gbabo *et al.,* (2019). The machine is made up of the following major parts; the frame which is the skeletal structure of the planter on which all other components are mounted. It has provisions for attaching the 3-point hitching linkages of the tractor connection to the machine. The hopper, this has an inverted frustum of rectangular pyramid truncate with rectangular bottom (420mm x 10mm) and having a height of 350mm and rectangular top of (420mm x 500m x 250m). It has semi - cylindrical base of 320mm diameter and 420mm length with 160mm extension for housing of metering device. It holds cane seed temporarily for planting as the machine is drawn along on the field. The metering device, this is cylindrical in shape and bears grooves at predetermined section on its longitudinal cross-section. It selects the cane seed from seed lot and discharges them at predetermined rate and spacing. The delivery funnel, this is trapezoidal in shape with upper parallel sides of 330mm x 430mm and lower parallel side of 80m x 80m (spout end) with one of its sides bend inward to change the cane seed from horizontally discharge position to vertical one so as to lay the cane seed along the furrow and not across it. The spout of the delivery funnel is 100mm above the seed bed with the hind side open by 100mm from lower end for successive laying of cane seed into the furrow. It is also made from 2mm thick mild steel sheet. The furrow opener, this creates furrow before cane seed is discharge from delivery funnel. It is being fastened to the machine frame using size 22 standard bolts and nuts. The furrow covering/press wheel, this is split packer type it cover and level the soil over the cane seed. The drive wheels, they are circular in shape containing 12mm mild steel rod which serves as spokes. These spokes are used to support the centre bushing or hub. The spokes are arranged in such a way that they braced the circular circumference and also give it necessary radial support. The wheels are connected to the two shafts which are suspended in two sets of bearing. It transmit power obtained from being drawn by tractor to the metering device. The logs are fitted to the drive wheels to improve grip ability of wheels with soil surface. The power transmission system, this performs the work of reducing the ground speed of the tractor to a permissible level that is suitable for the operation of the cane seed metering system. It is comprised of two sprockets of predetermined sizes. A small sprocket (14 teeth) fitted to the shaft of the drive wheel and a bigger one (42 teeth) connected to the shaft of the cane seed metering device. Chain and sprockets are used to transmit power in the drive so as to prevent power loss during transmission.

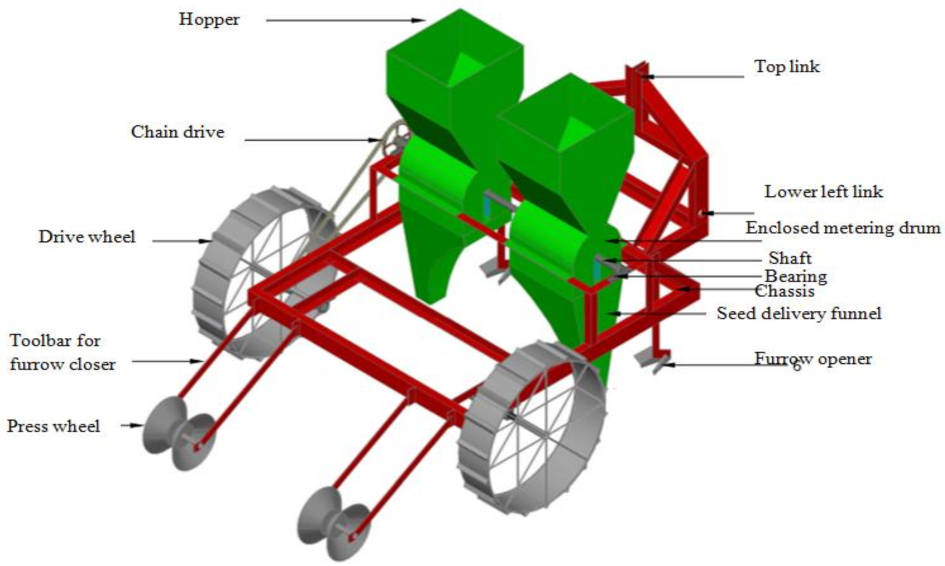

Fig. 1: AutoCAD drawing of the Sugarcane billet planter

Plate 1: Sugarcane billet planter

Experimental Design

A three-variable, four level factorial design ($N = 4^3$) provides the frame work for the experiment. The experimental design was a split-plot design according to the principle of factorial experiment. Four levels of speeds were assigned to main plot, the four levels of cane seed length were confounded with main plot and four levels of the cane diameter were assigned to the split-plot. The data were subjected to Analysis of Variance (ANOVA) using expert design software

Experimental procedure

A 100m x100m field was ploughed and harrowed. The field was then sub divided into sub plots of 20m x50m. Cane stalks were obtained from National Cereal Research Institute Badeggi, Niger State Nigeria sugarcane field. 120kg of sugarcane stalks per batch were cut into 250mm, 300m, 350mm and 400mm cane seed lengths. The stalks were further grouped into diameter sizes of 16mm, 20mm, 24mm and 28mm. The machine was loaded with particular a set of cane seed length and cane diameter at a time and planted on the 20m x 50m sub plots at four different operational tractor/planter's speeds of 12km/h, 10km/h, 8km/h and 6km/h.

Performance evaluation of the machine

Misses or skips are created when seed grooves fail to pick up and deliver seeds to the delivery funnels. Misses are counted along a randomly selected 15m length of each planted row with the covering devices removed.

Miss index

The miss index was determined as reported by Celik *et al.*, (2007), and is given as;

$$MI = \frac{n_s}{N} \times 100 \quad \text{------ (1)}$$

Where,

MI = the missing index,

n_s = the number of skips,

N = the total number of spacing

Results and Discussion

The effects of operational parameters of the developed planter on miss index are presented in figures 2 to 4 and the results of the analysis of variance are presented in tables 1 to 3. In general, increase in operational speed tended to increase the miss index using the prototype planter. The highest percent cane seed miss index of 22.1-22.3% was recorded for various levels of cane seed length at the highest operational speed of 12 km/h as shown in figure 2. Whereas the lowest percent cane seed miss index of 17.1-17.8% was obtained for various levels of cane seed length at the lowest machine operational speed of 6km/h. This is clearly indicated that operational speed greater than 10km/h would result in percent miss index greater than twenty which by far exceeds the ten percent acceptable level of miss index reported by Karayel and Ozmerzi, (2002).

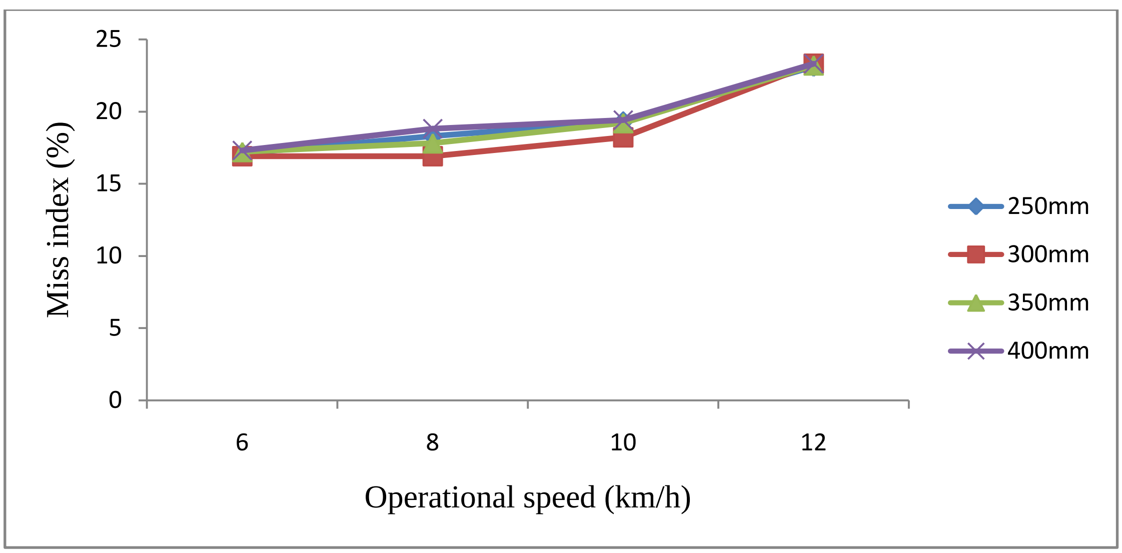

Fig. 2: Effect of operational speed on miss index for various levels of cane seed length at constant cane diameter

The effect of cane seed length on miss index for various levels of cane diameter at constant operational speed of the machine is given in Figure 3. Miss index was not much affected by the cane seed length for various levels of cane diameter.

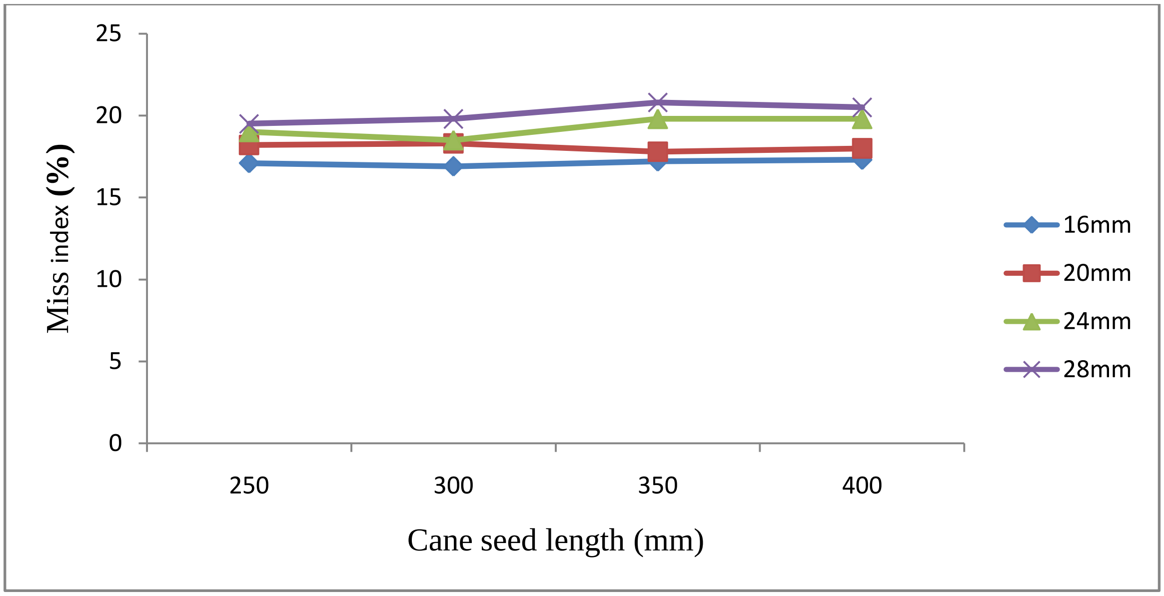

Fig. 3: Effect of cane seed length on miss index for various levels of cane diameter at constant operational speed

The effect of cane diameter on miss index for various levels of operational speed at constant cane seed length is as shown in Figure 4. It was observed that at 6km/h, 8km/h and 10km/h, the percent cane seed miss were almost the same at constant cane seed length, but at higher speed of 12km/h the percent cane seed miss was relatively much higher than those of lower operational speed of the machine at constant cane seed length.

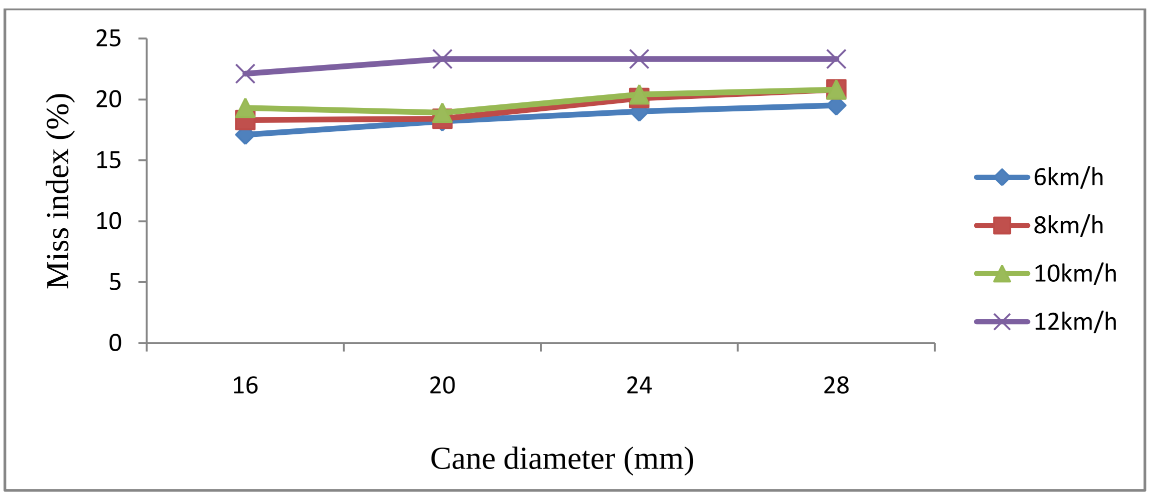

Fig. 4: Effect of cane diameter on miss index for various levels of operational speed at constant cane seed length

Analysis of Variance (ANOVA)

From table 1 to 3, the Analysis of Variance (ANOVA) results show that the operational speed of the sugarcane planter has more significant effect (P<0.0001) on the miss index for various levels of cane seed length and cane diameter. Similarly cane diameter has significant effect (P<0.0001) on miss index, while cane seed length has no significant effect (P>0.0001) on feed index.

Table 1: ANOVA for the effect of operational speed on miss index for various levels of cane diameter and cane seed length

Source	Sum of squares	df	Mean Square	F Value	P-value Prob > F	R-square
Model	220.6	9	24.52	40.27	<0.0001	0.8703 Sig
A	181.36	3	60.45	99.29	<0.0001	
B	5.15	3	1.72	2.82	0.0475	
C	34.15	3	11.38	68.69	<0.001	
Residual	32.88	54	0.61			
Cor Total	253.53	63				

A= operational speed, B= cane seed length, C= cane diameter, df= degree of freedom

Table 2: ANOVA for the effect of cane seed length on miss index for various levels of operational speed and cane diameter

Source	Sum of squares	df	Mean square	F Value	P-value Prob > F	R-square
Model	253.97	9	28.22	93.15	<0.0001	0.9395 Sig
A-A	216.71	3	72.24	238.45	<0.0001	
B-B	3.01	3	1.00	3.31	0.0268	
C-C	34.25	3	11.42	37.69	<0.0001	
Residual	16.36	54	0.30			
Cor Total	270.33	63				

A= operational speed, B= cane seed length, C= cane diameter, df= degree of freedom

Table 3: ANOVA for the effect of cane diameter on miss index for various levels of cane seed length and operational speed

Source	Sum of squares	df	Mean square	F value	P-value Prob > F	R-square
Model	251.83	9	27.98	97.41	<0.0001	0.9420 Sig
A-A	212.11	3	70.70	246.14	<0.0001	
B-B	2.89	3	0.96	3.35	0.0254	
C-C	36.83	3	12.28	42.74	<0.0001	
Residual	15.51	54	0.29			
Cor Total	267.34	63				

A= operational speed, B= cane seed length, C= cane diameter, df= degree of freedom

Conclusion

The study on the effect of operational speed, cane seed length and diameter on miss index of a sugarcane billet planter showed that that increase in operational speed tended to increase the miss index of the prototype planter as the highest percent cane seed miss index of 22.1-22.3% were recorded at the highest operational speed of 12 km/h. Miss index was not significantly (P<0.05) affected by the cane seed length for various levels of cane diameter while it was significantly (P<0.05) affected by cane diameter as bigger cane diameters had higher miss index.

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Received : September, 2020
Revised : October, 2020
Published : December, 2020