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PERFORMANCE EVALUATION OF A GINGER HARVESTING MACHINE

Agu, C. V., Oriaku, L. C. and Chukwuemeka, O. S.

National Root Crops Research Institute, Umudike, Abia State
Corresponding Authors email: chiomagu@gmail.com

Abstract
In this study, experimental field trials were conducted at National Root Crops Research Institute (NRCRI), Umudike, on a flat land with sandy clay loam soil, to evaluate the performance of the machine at two different tractor forward speeds of 4km/h and 8km/h. The following field parameters were recorded: operation speeds, number of ginger rhizomes harvested, number of un-harvested ginger, number of ginger rhizomes with cut, effective/theoretical field capacity and efficiency. Harvesting of ginger rhizomes in Nigeria is done manually by the use of fork, spade and other farm implements. A Randomized Complete Block Design (RCBD) was used to design the experiment and analyses carried out with Analysis of Variance (ANOVA). From the results, the tractor forward speed of 4km/h has the highest number of ginger rhizomes harvested at 88.7%, while the speed of 8km/h has the highest number of un-harvested ginger at 31%, and number of ginger with cut at 33.7%. The harvester gave a satisfactory performance as it was able to carry out harvesting operation of ginger, with the effective field capacity, theoretical field capacity and field efficiency of 0.0261ha/h, 0.000505ha/h and 52% respectively.

Keyword: Ginger, mechanization, harvesting, and performance evaluation

Introduction

Ginger (*Zingiber officinalle*) is a rhizomatous spice of culinary and medicinal importance (Amadi, 2012). Ginger is an important commercially grown crop for its aromatic rhizomes which are used as a spice, condiment and as a medicine. It has been used as a spice for over 2000 years (Bartley and Jacobs, 2000). It is known for its hot, pungent aroma due to the presence in its rhizomes of oleoresin and essential oils. Ginger is used widely in the preparation of soft drinks and beverages.Nigeria produces an average of 369 metric tonnes of fresh weight of ginger per annum (FAO, 2018). It is one of the important articles of trade in the world spice market. It is a widely grown spice and consists of over 90 species of perennial rhizomatous herbs. It can be found fresh, dehydrated, dried, powdered and in other forms. According to (Ezeagu, 2006), 20% of dried ginger is consumed locally for various uses and 80% is exported.

The production of ginger in Nigeria started in 1927 from an investigation carried out to find a crop that would generate internal trade for the people of Southern Kaduna, the traditional home of ginger production in Nigeria. (Arene *et al.,* 1987).Ginger is cultivated commercially as an annual crop, by planting small rhizomes or pieces of rhizome either on flat soil or in furrows between ridges. The growing plants require adequate manure to get the best yield possible. Ginger is ready for harvesting 7 to 10 months after planting, when the leaves turn yellow and start drying. Harvesting is done by digging the rhizomes up. Practically all the operations on ginger, including; planting, mulching, fertilizing, weed control, harvesting, and most processing are done by hand.

Hoki *et al.*, (1992) and Yohanna, (2007), pointed out that agricultural mechanization can be achieved simply by the introduction of advanced technologies which can reduce drudgery, increase productivity and enhance financial growth of the nation.Mechanization of ginger production and processing has received little attention in Nigeria. Itsproduction operations need to be mechanized to increase the production and use (Nwandikom and Njoku, 1998).

Methodology

The developed two row ginger harvesting machine was attached to a tractor PTO via the speed reducer. As thetractor moves, the digger turns and uproots the ginger rhizomes from the soil, while the rake carries the uprooted ginger rhizomes with the soil and conveys it to the separator mechanism,which separates the rhizomes

from the soil and then conveys it to the collector.After the fabrication of the machine, performance tests were carried out on the harvester when coupled to a tractorin order to determine the following:

- Effect of tractor forward speeds on the number of ginger harvested
- Effect of tractor forward speeds on the number of unharvested ginger
- Effect of tractor forward speeds on the number of ginger with cut using two tractor forward speeds of 4km/h and 8km/h.

A Randomized Complete Block Design (RCBD) with Analysis of Variance (ANOVA) of the material efficiency was investigated against the two tractor forward speeds to estimate significance at 5% level of probability.

Effective Field Capacity (EFC)

$$EFC = \frac{\text{Total Area}}{\text{Total Time}} \quad \ldots\ldots (1)$$

Where,
Total Area = 0.00914ha
Total Time=0.35hr

$$EFC = \frac{0.9144}{0.35} = 0.0261 \text{ ha/hr}$$

Theoretical Field Capacity (TFC)

$$TFC = \frac{\text{Width} \times \text{Speed}}{8.25} \quad \ldots\ldots (2)$$

Where,
Width = 3 feet (0.9144m)
Speed = 0.000456 m/hr

$$TFC = \frac{0.9144 \times 0.00456}{0.25} = 0.000505 \text{ha/hr}$$

Field Efficiency (FE)

$$FE = \frac{\text{Effective Capacity}}{\text{Theoretical Field Capacity}} \times 100 \quad \ldots\ldots (3)$$

$$FE = \frac{0.0261}{0.000505} = 52\%$$

Results and Discussion

The effect of tractor forwards speeds on the number of ginger harvested shows that the speed of 4km/h gave the highest number of ginger harvested 85.7% while the speed of 8km/h gave the lowest of 68% as shown in Table 1and Figure 1.

Table 1: Effect of Tractor Forwards Speeds on the Machine

Parameters	4km/h	8km/h
Number of ginger harvested	85.7±0.882 [a]	68± 4.04[b]
Number of ginger un harvested	27±1.53[c]	31± 2.08[c]
Number of ginger with cuts	26.67 ±0.88[c]	33.7 ± 0.67[bc]

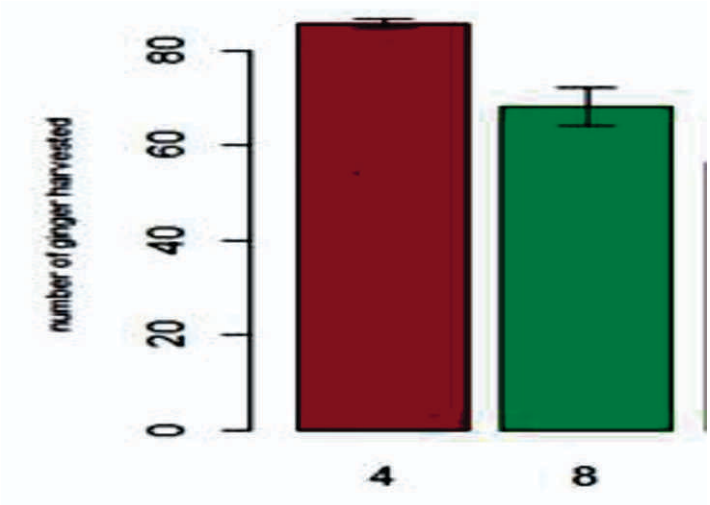

Fig. 1: Effects of Tractor Forwards Speeds on Number of Ginger Harvested

The results were subjected to statistical analysis using Analysis of Variance (ANOVA) as shown in Table 2. The F-value of 49.52 was highly significant at 1% level, implying that tractor forwards speed has a significant effect on number of ginger harvested.

Table 2: Effect of Tractor Forwards Speeds on the Number of Ginger Harvested

Model	Df	Sum Sq	Mean Sq	F-Value
Tractor. Speed	5	4485	896.9	49.52***
Residuals	12	217	18.1	

The effect of tractor forwards speeds on the number of unharvested ginger at two tractor forward speeds. From the Table 1 and Figure 2, the speed of 4km/h gave the lowest number of unharvested ginger of 27 while the highest value of 31 was obtained at the speed of 8km/h.

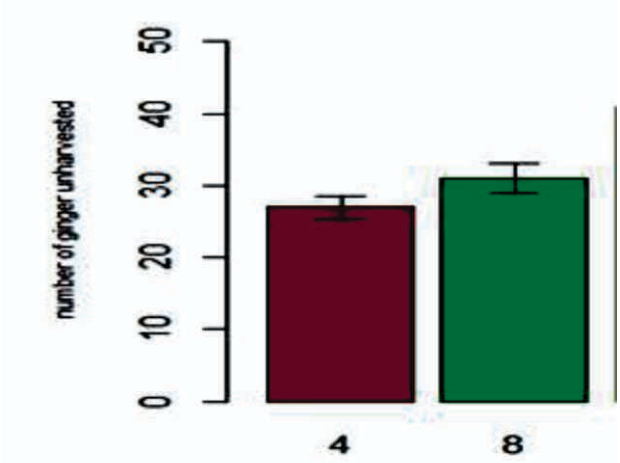

Fig. 2: The Effects of Tractor Forwards Speeds on Number of Unharvested Ginger

As shown in Figure 3, the tractor forward speeds of 4km/h gave the lowest number of ginger with cut of 26.67 while the speed of 8km/h gave the highest of 33.7.

Table 3: Effect of Tractor Forwards Speeds on Number of Unharvested Ginger

Model	Df	Sum Sq	Mean Sq	F Value	P(>F)
Tractor speed	5	1215.8	243.16	31.95***	1.56e-06***
Residuals	12	91.3	7.61		

The results were subjected to statistical analysis using Analysis of Variance (ANOVA). The F-value of 31.95 was highly significant at 1% level, implying that tractor forwards speed has a significant effect on damage index.

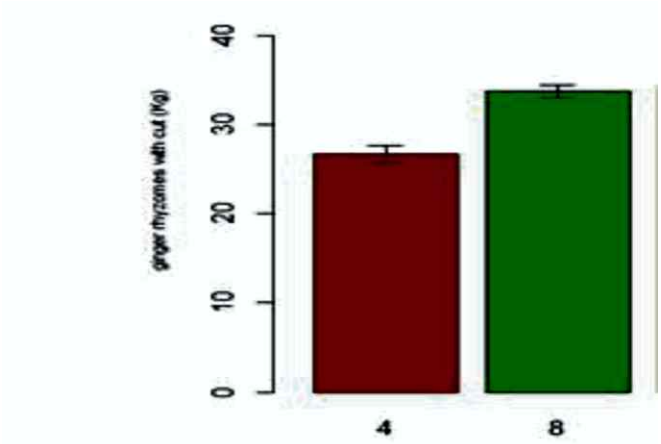

Fig. 3: The Effects of Tractor Forwards Speeds on number of ginger with cuts

Table 4 shows the ANOVA table on the number of ginger rhizomes harvested with cuts. The F-value of 12.19 was highly significant at 1% level, implying that tractor forwards speed has a significant effect on number of ginger with cuts.

Table 4: Number of Ginger Rhizomes Harvested with Cuts

Model	Df	Sum Sq	Mean Sq	F Value	P(>F)
Tractor. Speed	5	548.5	109.7	12.19	0.000231***
Residuals	12	108.0	9.0		

Conclusion

The implement has shown better performance at the speed of 4km/h for ginger harvesting in terms of effects of tractor forwards speeds on number of ginger harvested. From the investigation, as the speed reduces, the number of ginger with cut reduces from 33.7 to 26.67. The lowest was obtained at speed of 4km/h, while the highest was obtained at the speed of 8km/h. It was also observed that the speed of 4km/h gave the lowest number of unharvested ginger of 27 while the highest value of 31 was obtained at the speed of 8km/h.

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