Performance Evaluation of NRCRI Cassava Stem Cutting Machine

M. C. Ikejiofor, O. N. Eke-Okoro

ABSTRACT :- The NRCRI developed cassava stem cutting machine was evaluated. It has the overall dimension of 101.5 x 51 x 120cm. A performance test was carried out on the machine using three different cassava varieties of varying sizes. Also, two different cutting velocities of 1.23 and 1.32m/s were used for the evaluation. The cassava stems were fed manually into hopper while the cam mechanism controls the dropping rates of the cassava stems to the cutting unit. Test results showed that the highest cutting efficiency of 99.15% was obtained for the TME 419 cassava variety with stem size of 2.0cm and machine cutting velocity of 1.23m/s, while the lowest cutting efficiency of 94.11% was obtained for TMS 30572 with stem size of 2.6cm and machine cutting velocity of 1.32m/s. The output capacities of the machine were 944 and 984stakes/min for the cutting velocities of 1.23 and 1.32 respectively. The quality of the produced stakes was very good and showed satisfactory germination performance. The machine should be recommended for maximum production of cassava stakes to encourage mechanization of cassava production.

KEYWORDS: Performance Evaluation, Cassava, Stem, Cutting, Machine, Stake, Efficiency

1. INTRODUCTION

Cassava (Manihot esculenta crantz) is high energy starchy root crop. It is popular in parts of Africa, South America, where it thought to have originated, and in the Caribean. Nigeria has been the world leading producer of cassava with an estimated annual production of 36.8 million tons from an estimated area of 3.78 million hectares (FAO, 2009). The major problem of cassava is that it is extremely perishable and the harvested root must be processed to reduce post harvest losses (Davies, 1991). Cassava can grow in poor marginal soil where most crops cannot grow (Ali, 2005). Cassava matures in 12 to 18 months after planting. Cassava can be processed into variety of products such as *gari*, *fufu*, *tapioca*, cassava chips and flour. Recently cassava has occupied a prominent place in National non – oil export commodity, especially exports in Sub – Saharan Africa that international demand is far above the supply (Fresco, 1993; Nweke et al., 2002). This increase in cassava export has also negatively affected local supply. It is also important to note that cassava production is mostly done by rural small holder farmers using low – level production techniques (Omonona, 2009; Onyegbami et al., 2010; Nweke et al., 2002). In Nigeria, with the demand for cassava both for food and industrial uses, mechanization of cassava field operations has become imperative if the huge demand is to be met locally. Mechanization reduces drudgery, thus making farming an attractive enterprise. It therefore, has the potential for national economic growth, food self- sufficiency, industrial growth and employment leading to poverty reduction.

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The presidential initiative on cassava in Nigeria aimed to create awareness among farmers on the opportunities in the cassava market worldwide. The objective of this paper is report on the performance evaluation of the NRCRI cassava stem cutting machine developed to reduce drudgery in stake production operation involved in cassava production.

2. MATERIALS AND METHODS

2.1. Description of the Cassava Stem Cutting Machine

The cassava stem cutting machine was developed at the National Root Crops Research Institute (NRCRI) Umudike. The machine as shown in fig. 1 is made of three main sections: hopper, cutting and outlet section. The overall dimension of the machine is 101.5 x 51 x 120cm. The machine is powered by a 5.5 h.p electric geared motor with an operating speed of 118rpm. The following materials: mild sheet, 40 and 25mm diameter rods, angle iron, steel pipe, cam, blade, rubber material, bearing / casing, bolts / nuts, pulley, belt and electric motor were used in the development of the machine. The hopper unit was made of mild sheet with the dimension 101.5 x 50 x 42cm. It is trapezoidal in shape. At the base of the hopper lies a layer of rubber shield on top of metal frame / cam. The cam helps to control the dropping rate of the cassava cuttings. The cutting unit is the most important part consisting of six rotational blades fixed on steel pipe and also three stationary blades. The outlet unit helps the produced stakes to drop out easily.

Fig. 1: The Developed Cassava Stem Cutting Machine and the produced stakes

2.2 Performance Evaluation of the Machine

The evaluation of the cassava stem cutting machine was carried out at the National Root Crops Research Institute, NRCRI Umudike. Three different cassava varieties of varying sizes, obtained from the NRCRI experimental field were used. The cuttings used were those not beyond 2 years of maturity. The factors considered for the evaluation include: capacity, cutting efficiency, cutting velocity, stem damage and percentage of germination.

a) The Machine Output Capacity (M_C)

This is the rate at which the machine cut the cassava cuttings loaded into it and is calculated as:

$$M_C = Q/t \quad \text{..... 1}$$

Where M_C = Machine capacity (stakes produced/min)

Q = Quantity of cassava stakes produced

t = Time for cutting to be completed (min)

b) The Cutting Efficiency (C_E)

This is defined as the percentage by output of viable quantity of stakes over the total quantity of stakes produced.

$$C_E = \frac{T - X}{T} \quad \text{..... 2}$$

Where C_E = Cutting efficiency (%)

T = Total quantity of stakes produced

X = Non viable stakes produced

c) The Cutting Velocity (C_V)

This is the speed at which the cutting blades rotate and cut the cassava cutting and it is expressed as:

$$C_V = \frac{\pi DN}{60} \quad \text{..... 3}$$

Where C_V = Cutting velocity (m/s)

D = Diameter of the machine pulley

N = Speed of rotation of the machine pulley

d) Percentage of Damaged Stakes (P)

$$P = \frac{D}{S} \times 100 \quad \text{..... 4}$$

Where P = Percentage of damaged stakes (%)

D = Number of damaged stakes after cutting

S = Total number of stakes produced

e) Percentage of Germination (G)

$$G = \frac{A}{B} \times 100 \quad \text{..... 5}$$

Where G = Percentage of germination of stakes planted (%)

A = Number of survived plants one month after planting

B = Total number of planted stakes

3. RESULTS AND DISCUSSIONS

The results of the performance test indicated in table 1 and fig. 2 showed that the highest cutting efficiency of 99.15% was obtained for TME 419 cassava variety with stem diameter size of 2.0cm and machine cutting velocity of 1.23m/s. Also the table and the figure showed that the least cutting efficiency of 94.11% was obtained for the TMS 30572 cassava variety with stem size of 2.6cm and machine cutting velocity of 1.32m/s. The table indicated that the output capacity of 944 and 984stakes/min were obtained with the machine cutting velocities of 1.23 and 1.32m/s respectively. However, the highest cutting efficiencies were obtained for the machine cutting velocity of 1.23m/s. It was also observed that the cutting efficiencies decreases with increase in stem diameter size and the cutting velocity. The table also showed that increase in the cutting velocity increases the output capacity, but reduces the cutting efficiency. In fig.2, S1, S2 and S3 represent the stem size of 2.0, 2.3 and 2.6cm respectively. Also, a and b represent cutting velocities of 1.23 and 1.32m/s respectively. Table 2 showed that high percentage germination was obtained one month after planting from the cassava stakes produced by the machine.

Table 1: Performance Test of the NRCRI Cassava Stem Cutting Machine

RPM	Cutting Velocity (m/s)	Varieties	Diameter of Stem (cm)	Cutting Time (min)	Output Capacity (stakes/ min)	Percentage of Damaged Stakes (%)	Cutting Efficiency (%)
118	1.23	TME 419	2.0	1.0	944	0.847	99.15
	1.23	TME 419	2.3	1.0	944	1.059	98.94
	1.23	TME 419	2.6	1.0	944	1.165	98.83
	1.23	TMS 30572	2.0	1.0	944	0.953	99.05
	1.23	TMS 30572	2.3	1.0	944	1.165	98.83
	1.23	TMS 30572	2.6	1.0	944	1.271	98.73
118	1.23	NR 8082	2.0	1.0	944	0.953	99.05
	1.23	NR 8082	2.3	1.0	944	1.271	98.73
	1.23	NR8082	2.6	1.0	944	1.483	98.52
123	1.32	TME 419	2.0	1.0	984	4.065	95.93
	1.32	TME419	2.3	1.0	984	4.675	95.33
	1.32	TME 419	2.6	1.0	984	5.285	94.71
123	1.32	TMS 30572	2.0	1.0	984	4.675	95.33
	1.32	TMS 30572	2.3	1.0	984	5.183	94.82
	1.32	TMS 30572	2.6	1.0	984	5.894	94.11
	1.32	NR 8082	2.0	1.0	984	4.268	95.73
	1.32	NR 8082	2.3	1.0	984	4.878	95.12
	1.32	NR 8082	2.6	1.0	984	5.488	94.51

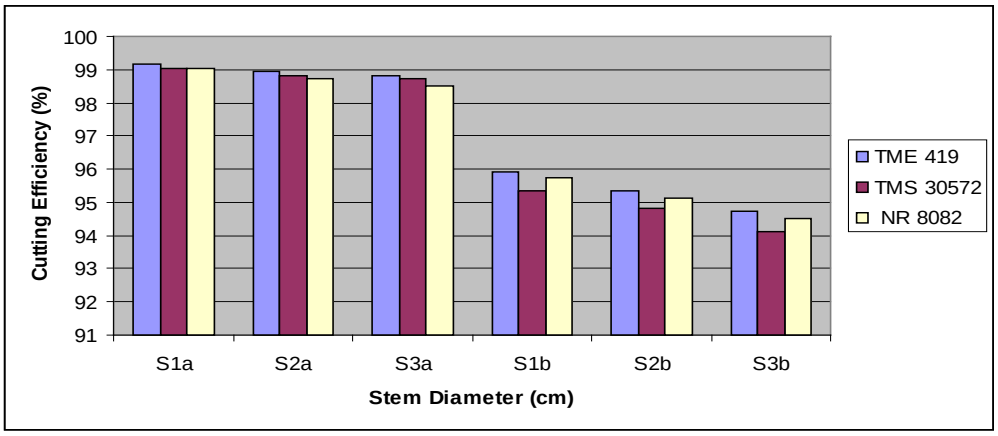

Fig. 2: Bar Chart Representation of Cutting Efficiency (%) versus Stem Diameter (cm) of three different Cassava Varieties with two varying Velocity rates.

Table 2: Percentage Germination of Stakes

Condition	Varieties	No. of Stakes Planted	Plant Survival (1 month after)	Percentage Germination (%)
Traditional Cutting Method	TME 419	40	38	95.0
	NR 8082	40	35	87.5
Machine Cut	TME 419	40	37	92.5
	NR 8082	40	39	97.5

4. CONCLUSIONS AND RECOMMENDATIONS

The cutting efficiency of the machine was affected by the cutting velocity and the cassava stem diameter. The cutting velocity of 1.23m/s and cassava stem diameter of about 2.0cm should be recommended for efficient performance of the stem cutting machine. The machine performed very satisfactorily and should be recommended for medium / large scale production of cassava stakes to encourage commercial production of cassava.

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