DESIGN AND DEVELOPMENT OF NRCRI CASSAVA STEM CUTTING MACHINE

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ABSTRACT
The need to encourage commercialization of cassava production is the major reason for the design and development of cassava stem cutting machine in the Engineering Research Unit of National Root Crops Research Institute, Umudike. The machine developed is powered by a 5.5 h.p electric geared motor with an operating speed of 118rpm. The overall dimension of the machine is 101.5 x 51 x 120cm. The cassava cuttings used for testing of the machine were those not more than 3.5 cm in diameter and also not beyond 2 years of maturity. Performance evaluation of the machine using different cassava varieties and of varying sizes showed that the machine has cutting efficiency of 98.7%, with actual production capacity of 56,640 stakes per hour, provided the cassava stem used were within the allowable size / maturity. The length of each stake produced is 25cm. The machine has easy operational / maintenance procedures.

KEY WORDS: Design, Development, Cassava, Stem, Cutting, Machine

INTRODUCTION

Cassava (Manihot esculenta) belongs to the family Euphorbiacaea, and originated in Latin America and is now cultivated in all parts of the world. It is the most important root crop in most tropical countries and provides the major source of dietary calories for about 500 million people in many developing countries in Africa, Latin America and Asia. The roots are used as food for humans and livestock, and leaves of many cultivars are used as vegetables. In Africa, cassava is important not just as a subsistence or food security crop but also as a major source of income for producing households (Nweke, 1996).

Planting of cassava involves stake production operation and manual stake production using secateur or sharp matchet is tedious and time consuming. The production rate for one person is only about 5000 stakes per day. The normal plant density for cassava is 10,000 stakes per hectare for spacing of 1m x 1m (Eke-Okoro, *et al* 2005). However, about 100,000 cassava stakes is required per day for mechanized commercial planting. Also, cassava cutting needs special machine for proper handling because of the variations in the physical and mechanical properties (Lungkapin, et al 2007; Sukra, *et al* 1992). Also, the presence of prominent nodes all over the surface makes cassava stakes very unique planting materials which are extremely difficult to handle (Odigboh, 1985).

The objective of this paper is to report on the development of a simple designed / affordable machine that can produce the required quantity of stakes for commercial cassava planting.

MATERIALS AND METHODS

The design of the cassava stem cutting machine was carried out followed by the development of the machine in the Engineering Research Workshop of National Root Crops Research Institute, Umudike. The following materials were used: mild sheet, 40 and 25mm diameter

rods, angle iron, steel pipe, cam, blade, rubber material, bearing / casing, bolts / nuts, pulley, belt and electric motor. The machine / tools used include: welding, lathe, grinding / cutting, drilling, vice, hand file, spanner, hand saw, hand drill, plier, and other hand tools. Performance evaluation of the machine using cassava stems of different varieties was carried out considering the capacity, cutting rate / efficiency and quality of the produced stakes.

Design Considerations

A number of factors were considered in the design of the cassava stem cutting machine.

- The hopper section of the machine was designed such that it will allow horizontal feeding of the cassava cuttings of 100cm length.
- The maximum allowable size of cassava cuttings was considered in the design of the metering unit.
- The number of rotational and stationary blades used was to achieve the expected production capacity.
- Cam mechanism was also used to control the dropping rate of cassava cuttings into the cutting unit.
- Simplicity of operation and maintenance of the machine were also considered.

Design Calculations

A 4kw, 105 rpm electric geared motor provides all the power requirement of the machine.
The power required for cutting was calculated using the equation given by Hannah and Hillier (1988).

$$P = F \times V_c \quad \ldots\ldots\ldots\ldots \quad 1$$

Where P = Power (Watts)
F = Cutting Force, N
V_c = Cutting Velocity, m/s

The cutting velocity, $V_c = \frac{\pi DN}{60}$ ………… 2

Where $\pi = 3.142$
D = Diameter of rotor, m
N = Speed of rotor, rpm

Also, the cutting force $F = \frac{mV^2}{r}$ ………… 3

Where m = Weight of rotor, kg
V = Velocity, m/s
r = Rotor radius, m

The pulleys relationships were as thus:

For the cutting unit, $S_1 \text{ X } D_1 = S_2 \text{ X } D_2$ ………… 4

Where S_1 = Speed of driver (gear motor), rpm
D_1 = Diameter of driver pulley, cm
S_2 = Speed of driven (rotor), rpm
D_2 = Diameter of rotor pulley, cm

For the metering unit, $S_2 \times D_2 = S_3 \times D_3$ ………… 5

Where S_3 = Speed of cam pulley, rpm

D_3 = Diameter of cam pulley, cm

Design Features

The pictorial view of the developed cassava stem cutting machine is as shown in fig.1, while the sectional view as shown in fig.2.

Fig. 1: The Developed NRCRI Cassava Stem Cutting Machine

- The overall dimension of the machine is 112cm x 50cm x 120cm.
- The machine has three main units: hopper, cutting and outlet unit.

The Hopper

This was made of mild sheet with the following dimensions 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 controls the dropping rate of the cassava cuttings.

The Cutting Unit

The cutting unit has six rotational and three stationary blades. The rotational blades were fixed on top of the steel pipe.

(i) The machine output capacity is the rate at which the machine cut the cassava cuttings loaded into it and is calculated as:

$$M_C = Q/t \quad \text{..... 6}$$

Where M_C = Machine capacity (Kg/hr)
Q = Quantity of cassava stakes produced
t = Time for cutting to be completed (hr)

(ii) The cutting efficiency (C_E) is defined as the percentage by output of viable quantity of stakes over the total quantity of stakes produced.

$$C_E = \frac{T - X}{T} \quad \text{..... 7}$$

Where T = Total quantity of stakes produced
X = Non viable stakes produced

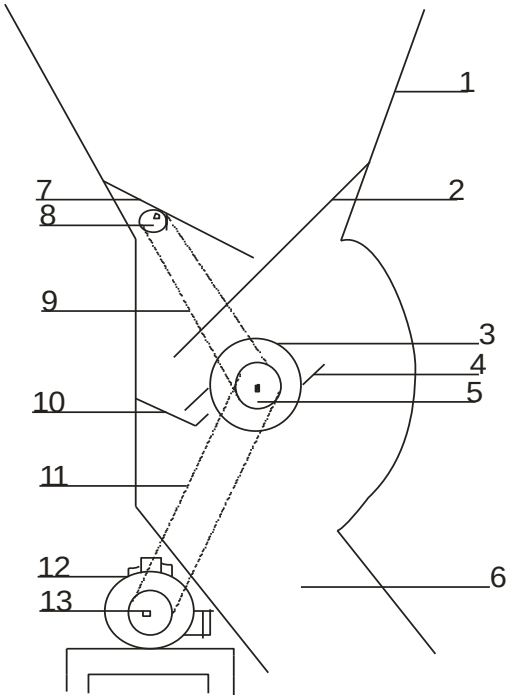

Fig. 2: Sectional View of the Stem Cutting Machine

1. Hopper 2. Directing tray 3. Steel pipe 4. Rotating blade 5. Rotor pulley 6. Outlet 7. Metering tray 8. Cam 9. Belt drive 10. Stationary blade 11. Belt drive 12. Electric motor 13. Pulley

The cassava cuttings used for testing were those not beyond 2 years of age and diameter of not more than 35mm. The machine was able to produce about 8 viable cassava stakes of 25cm length each per revolution of the rotor. The number of revolutions of the rotor per minute is 118. The machine therefore has actual production capacity of 944 stakes per minute and 56,640 stakes per hour.

CONCLUSION

The performance evaluation of the machine showed that the machine performed very satisfactorily in production of maximum quantity / viable cassava stakes. The machine should be recommended for production of stakes for commercial planting of cassava, and also for use by small scale farmers in co-operative for maximum productivity of both cassava stems and roots.

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