Investigating the Effectiveness of Manual Drum Pulper on Genotypes of Robusta Coffee (*Coffea canephora* L.) for Seed Production

Baba Nitsa, M.[1]*; Adeleke, S. A.[2] and Idrisu, M.[3]

[1]Department of Crop Improvement Cocoa Research Institute of Nigeria, Ibadan
[2]Department of Value addition Research, Fabrication and Design CRIN, Ibadan
[3]Agronomy Section Cocoa Research Institute of Nigeria, Ibadan.
Corresponding author`s Email: bmohammed241@yahoo.com

***Abstract*— *Mortar and pestle has long being in used to de-pulp coffee cherries for planting either in small or in large scale farm. This method is very laborious, time consuming and is not devoid of seed damage. Therefore it becomes imperative to use mechanical pulper for both small and large scale seed production. Ripe coffee cherries were harvested during 2019 season from three different genotypes of Robusta coffee planted on the field. Two genotypes were selected from coffee germplasm and the third genotype was from agronomy plot all from cocoa research institute of Nigeria. The cherries were processed using both traditional method of de-pulping and manual drum pulper. Three operators were used to create different speed rate of 40, 75 and 90 rev/min. Equal quantity of cherries were fed into the pulper. The de-pulped coffee seeds were air dried, undamaged seed were selected for planting at pre-nursery. Data on seed emergence were collected periodically, twenty five days after sawing, forty days after sawing and sixty days after sawing. Data were subjected to analysis of variance (ANOVA) using statistical analysis system (SAS) version 9.1. The result shows best percentage de-pulping efficiency (99.91), separation efficiency (98.87) and percentage beans damage (0.2) were achieved with the machine speed range between 40-75 rev/min. The percentage seed emergence of genotype T797 (66.67), FM (66.67) and T45 (64.44) were statistical similar irrespective of de-pulping method used. Better machine performance was observed on genotype T797. Genotype FM de-pulped with manual drum pulper gave least germination percentage; lowest machine performance was observed on genotype FM. Coffee seed production with minimal affection on seed emergence, could be achieved through use of manual drum pulper to reduce time and labour required using traditional de-pulping method.*

Keywords*— *Coffee seeds production, genotypes, manual drum pulper, effectiveness, seed emergence.

I. INTRODUCTION

Coffee is one of the agricultural products that is of economic importance and serve as a means of income to farmers (Muleta, 2007). In Nigeria, many farmers established their coffee plantation using seedlings derived from seeds. Establishment of coffee farm through vegetative propagation (clone/grafting) is being practice only by research stations for improvement in productions (Wilson 1999). Cherries are harvest when most of them are fully ripped. It is appropriate for coffee cherries to be harvested once the pulp is soft and become easy to remove. Harvesting of coffee cherry is either done by strip picking method or selective picking method. Strip picking method which is the commonest among coffee farmers involving removal of all cherries from the branches. As it is being practice, both ripe and unripe cherries are harvested together and subject the harvested fruits to further post- harvest processing. The Selective picking method of harvest allowed picking of only ripe cherries, while unripe cherries remain on the tree branches until when fully ripe.

Knowledge about coffee fruit is very important, as it consist of exocarp (pulp), mesocarp (mucilage), endocarp (parchment or hull), spermoderm (silver coat), endosperm (albumen) and embryos with tow cotyledons. Coffee cherry is a drupe containing two flat seeds which is use for propagation. Germination of the coffee seeds under field condition is defined as emergence of seedling from soil, with radical extending down ward. Cotyledons are the first seed part to emerge from the soil, showing epigeal seedling germination characteristics (Huxley, 1964). Coffee seeds are ready to germinate as soon as possible since they have no dormancy, but also lose viability easily when stored for a longer time (Coste, 1992). According to Rena *et al.*, (1986), germination of Coffee seeds is very slow; this make establishment of coffee plantation through seeds not encouraging early enough to increasing production. However, some species that have smaller seeds such as C. *racemosa* germinate within 10 days or less after sawing. Sowing period also affect germination of coffee seeds, as *C. arabica* seeds sown during warm period, begin to germinate from 50 to 60 days of sowing (Maestri and Vieira, 1961). Also germination could be delayed up to 90 days if coffee seeds are sown under low temperature as reported by (Went, 1957).

Report of Rosa *et al*., (2005) revealed that endocarp prevent early emergence of coffee seeds its removal will improve emergence of coffee seed. Studies carried out by Da-Silva *et al*., (2004), on mechanism and regulations concerning coffee seed germination, show that parchment cause the cell wall not to expand on time and prevent surrounding endosperm from being active.

A coffee cherry is processed after harvest followed by the removal of both the pulp either by dry, wet or semi-dry method (Mussatto *et al*., 2011). Mucilage is removed by fermentation, followed by washing or machines processes (Brando and Brando, 2015).Viscous nature of mucilage is of greater advantage during processing of coffee as it easy de-pulp even with little apply of pressure, expel the beans from the fruit. Selmar *et al*., (2006), reported that germination of coffee seeds start during post-harvest processing which involved removal of fruit flesh (pulp) either manually or mechanically. He further corroborated is findings through the using of germination-specific isocitrate lyase (ICL) test with b-tubulin, a maker for cell division or elongation (Selmar *et al*., 2006).

Traditionally, the exocarp (pulp) is manually removed during seed processing by farmers as it is widely practice and believed to be devoid of low seed damage. Traditional coffee processing method of de-pulping requires soaking of cherries, use of mortar and pestle or even matching or tramping on cherries to remove pulp. This is followed by separation of pulps from the beans (scooping) and drying of beans. Unfortunately, the process is very tedious with attendant, drudgery and low work rate. Personal experience and that of other processors showed that separation of pulp form the beans are specifically difficult and discouraging.

Damage is a very vital index to be considered in seed production approach. De-pulping of coffee cherries using mechanical methods to reducing labour, time and cost should be paramount for the purpose of increasing coffee production **(**Weinberg *et al.*, 2001). According to Murthy and Naidu, (2011), pulp removal of fresh berries using machine is one of the process leading to increase in coffee seed production. The use of machine to increase efficiency and large scale production with little or no drudgery has been evolved since the time immemorial. Mechanical de-pulp result in higher quality beans (Wintgens, 2012). However, the use of machine with low levels of damages to seed will depend on its design should be regarded as a necessity for effective coffee seed production.

Proper understanding of coffee seed germination will help in improvement of agricultural activities and increase production of coffee needed for international market. Work done on coffee seed germination with regards to seed processing/ production using manual drum pulper is scarce considering the economic important of coffee crop in the world market. Hence effort should be intensified toward processing of coffee seeds (*C. canephora* L.) for planting using manual drum pulper. The purpose of this study was to determine the effectiveness and efficiency of coffee seed production using hand de-pulp (pestle and mortar) and manual drum pulper. It is therefore necessary to compare different methods to ascertain whether manual drum pulper can be injurious to seed production. Findings from this study will provide basic information needed for large scale coffee seed processing and production.

II. DESCRIPTION OF THE MACHINE

The drum pulper consists of 220 mm diameter and 280 mm long perforated cylinders with a hopper of 450 mm × 300 mm and 280mm × 150mm at the top and bottom respectively. The cylinder rotated through 300mm flywheels which operate two mashing spur gears of 210 mm and 100 mm diameter respectively. De-pulping occurs through abrasion force between the cylinder and adjustable plate. Separating of beans from the pulp is achieved through a fixed 290 mm × 70 mm× 5 mm plate. The drum roughened surface revolves over coffee cherry, force between it and fixed plates make the berries to be squashed and eventually separate the beans from the pulp. The viscous nature of the beans facilitates the slippery of the seeds out of the machine through the grooves.

III. MATERIALS AND METHODS

The trial was conducted at cocoa research institute of Nigeria, Ibadan, during peak harvest of 2019 season. Ripe matured Robusta coffee cherries were harvested using selective picking method. Three C. *canephora* genotypes were used for this trial from where coffee cherries were harvested from trees growing on the field. Two of the genotypes were selected from coffee germplasm, while the third genotype was selected from agronomy plot. Harvested cherries were immediately soaked in water for 24-48 hours as suggested by Palmino (2016), to allow separation of damage cherries, removal of lighter cherries and to easy de-pulp. Two de-pulped methods were applied, hand manual de-pulp and manual drum pulper. Hand manual de-pulp was done using pestle and mortar as a local method of de-pulping that has not been modified for many years, until beans and pulp is separated. Mechanical de-pulp was done with manual drum pulper, with the help of three operators to create different speed rate as suggested by (Ademosum *et al*., 1993). The same quantity of the soaked cherries were fed into the manual drum pulper. The adjustable plate was adjusted for optimal de-pulping. Operators were allowed to reach stable machine speeds of 40 rev/min, 75 rev/min and 90 rev/min respectively before feeding the cherries into the pulper. Each speed rate was replicated three times for each genotype making twenty seven observations. The de-pulp and unde-pulp beans were separated manually after which the de-pulped coffee seeds were washed in water, to remove mucilage and air dried. The good (undamaged) seeds from manual drum pulper and manual hand de-pulp after air dried were planted on pre-nursery until there emergence.

Ten seeds were selected from each genotype, planted per plot and replicated three times on pre-nursery bed prepared with sawdust, laid in complete randomized design (CRD). All pre-nursery practices were well carried out during the experiment period without bias. Data on seed emergence were taken periodically based on sowing days; twenty five days, forty days and sixty days after sowing respectively. Data on seed count emergence were subjected to analysis of variance (ANOVA) using statistical analysis system (SAS) software (version 9.1).

The means of three speed rates represent the replicates and were used to calculate the machine efficiency, separation efficiency and percentage bean damage following the procedures of (Adeleke *at al*., 2016, and Adekanye *et al*., 2016).

$$\text{De-pulping efficiency} = \frac{\text{Depulped beans}}{\text{Total beans inputs}} \times 100$$

$$\text{Separation efficiency} = \frac{\text{Chafts removedby machine}}{\text{Total chafts}} \times 100$$

$$\text{Beans damage} = \frac{\text{Damage beans}}{\text{Total beans inputs}} \times 100$$

IV. RESULT AND DISCUSSION

There are appreciable de-pulping efficiency separation efficiency and reasonable percentage beans damage (Table 1). These are comparable to what had been reported by some other scientists. De-pulping efficiency, separation efficiency and percentage beans damage ranges from (79.73 to 99.91 %), (73.57 to 98.87 %) and (0.2 to 7.26 %) respectively. Very high de-pulping and separation efficiencies and very low beans damage indicate that this kind of machine is suitable for seed production at a very low power input. The close range in the performance remarks is also an indication of its versatile at different speeds. The close values of these parameters considering the varieties are also an indication that the machine is suitable for reasonable types of genotypes. The little differences in the value may be due to genotype or edaphic factors (Adeigbe *et al*., 2016).

The result revealed operation of the machine for this particular activity should be at 40-75 rev/min for optimum performance as these two speed range gave relatively reasonable (%) de-pulping efficiency (99.91), separation efficiency (98.87) and relatively low damage to the beans (0.2), these are key factors needed to determine the use of the manual drum pulper for coffee seed production.

Table 1: Performance of manual drum pulper at different speed rate

Genotype	40 rev/min			75 rev/min			90 rev/min		
	DEF %	SEF %	BDE %	DEF %	SEF %	BDE %	DEF %	SEF %	BDE %
FM	95.55	94.99	0.74	81.96	79.88	0.2	79.73	73.57	0.67
T45	99.91	98.87	7.26	99.33	98.72	1.90	98.42	96.79	4.79
T797	98.11	96.03	2.60	98.05	95.06	1.30	94.55	89.54	1.36

Where DEF is De-pulping Efficiency, SEF is Separation Efficiency, BDE is Beans Damage.

Performance of manual drum pulper, on genotypes as presented on Table 2. Genotype T45 and T797 were statistically similar (99.22) and (96.90) with regards to de-pulp efficiency, they both differ significantly with genotype FM (85.75). Genotype T45 was observed to be differ significantly (98.13), with other genotypes in terms of separation efficiency of seeds. Damage done to the seeds of genotype T45 (4.65) was significantly higher than on other genotypes. T797 revealed better de-pulp efficiency, moderate separation efficiency and moderate damage to the seeds when compared to other genotypes. FM shows least significant different with regards to performance of manual drum pulper. This suggests that effective performance of manual drum pulper could be genotype based. Indicating that some genotype could be viscous than the others, which is the natural means that facilitates the slippery of the seeds out of the machine through the grooves.

Table 2: Performance of manual drum pulper on genotype (%)

genotype	DEF (%)	SEF (%)	BDE (%)
T45	99.22a	98.13a	4.65a
T797	96.90a	93.54ab	1.75ab
FM	85.75b	82.81b	0.54b

Means with the same letter are not significantly different

Where DEF is De-pulping Efficiency, SEF is Separation Efficiency, BDE is Beans Damage.

The result of analysis (Table 3) shows genotype FMH, T797 and T45 were statistically similar with regard to percentage emergence of coffee seeds sixty days after sowing, but they differ significantly with others. The percentage emergence with regards to twenty-five days and forty days after sowing irrespective of genotypes were similar. This could be due to few seeds emergence within this period occasion by slow rate of seed germination. Since most of the seeds during this period were still on their dormancy period. Implying that germination of coffee seeds does not start until many days after sowing, as reported by (Maestri and Vieira, 1961). This result show that irrespective of genotype, speed rates of manual drum pulper has no significant effect on seed emergence percentage as observed among the genotypes.

Table 3: Means of Percentage germination, Sixty days after sowing, Forty days after sowing and Twenty five days after sowing.

Genotype	Speed	Twent-five days after sowing	Forty days after sowing	Sixty days after sowing	Germination percentage (%)
FM H	0.00b	0.00a	3.00a	6.67a	66.67a
T797	68.33a	0.22a	3.67a	6.67a	66.67a
T45	68.33a	0.44a	3.33a	6.44a	64.44a
T45 H	0.00b	0.00a	3.00a	5.67b	56.67b

T797H	0.00b	0.33a	2.67a	5.67b	56.67b
FM	68.33a	0.11a	3.22a	6.00b	60.00ab

Means with the same letter are not significantly different

Pearson correlation (Table 4) revealed negative correlation between speed rates of manual drum pulper and twenty-five days after sowing. There was significant correlation between germination percentage and sixty days after sowing corroborating the initial result on Table 3 that higher percentage germination were observed at sixty days after sowing.

Table 4: Pearson Correlation: Speed, twenty five days, forty days, sixty days, and germination percentage

Speed	Speed	Twenty-five days after Sowing	Forty days after Sowing	Sixty days after Sowing
Speed				
Twenty-five days after sowing	-0.050			
Forty days after sowing	0.278	0.059		
Sixty days after sowing	0.254	0.075	0.073	
Germination Percentage (%)	0.254	0.075	0.073	1.000**

Significant ** ($P \leq 0.01$)

V. CONCLUSION

De-pulping of coffee cherries is among steps taken in processing of coffee seeds for planting. Efforts have been made to see how effective and efficient de-pulping of cherries can be done with less stress. Percentage emergence of seeds processed with manual drum pulper and traditional method of de-pulp (pestle and mortar) did not differ significantly. This implies the effectiveness of the machine. This finding had proving that using of manual drum pulper could be effective in reducing effort and money spends on processing of coffee seed for planting. Therefore mechanical manual pulper can be useful for coffee seed production which will assist local farmers and seed producers. In cognizant of this, efforts should be intensified toward incorporating of manual drum pulper for coffee seed production.

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