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RESEARCH ARTICLE

Design and Development of a Two Wheel Tractor Driven Coconut Fertilizer Applicator

A.J.Fernando[1,3], T.B. Adhikarinayake[2] and G.V.T.V.Weerasooriya[1]

[1]*Department of Agricultural Systems, Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura.*
[2]*Agriculture and Post Harvest Technology Engineering Division, National Engineering Research and Development Centre, Ekala, Ja-Ela.*
[3]*Corresponding author:jayaruwanifernando@yahoo.com*

ABSTRACT

Coconut (*Cocos nucifera* L.) is a perennial tree crop with about 60 years of economic life span. Decreasing soil fertility over several decades due to inadequate replenishment of the exhausted nutrients is a major problem affecting coconut production. The annual yield from a single tree can be increased from 50-70 nuts up to 100-125 nuts by proper application of fertilizer. There is no efficient method to apply fertilizer to coconut estates at present except manual application, which is laborious. The general objective of this research was to investigate an efficient method for applying fertilizer to coconut estates.

After investigating physical properties of raw materials and their influences on the performance of fertilizer application, a two-wheel tractor driven granular fertilizer applicator was developed. Main components of the applicator are hopper, opposite-direction screw, two sets of furrow openers, fertilizer tubes, and a furrow closer. Power transmission from the engine to the applicator was done by chain and sprockets. The applicator was designed to apply 5 kg of fertilizer mixture per palm at an optimum speed of 1.1 km/h.

The fertilizer applicator was evaluated in a coconut estate and received satisfactory results. It performed at a fertilizer feeding capacity of 0.45 ha/hr with 72.7 % efficiency. Compared to the traditional method, this fertilizer applicator could save 96.5 % of time and 94 % of the cost of fertilizer application per hectare.

Key words: Coconut cultivation, Fertilizer applicator, Coconut fertilizer

INTRODUCTION

On average a coconut tree bears 50-70 nuts per year. With fertilizer, productivity can be increased up to 100-125 nuts per year ('Govibima'26/04/2004). In recent years, there has been a drastic reduction in fertilizer application in the coconut sector. Although

the government provides fertilizers at a subsidized price, the landlords are not motivated to apply fertilizer due to lack of labour and efficient methods of applying fertilizer. Currently fertilizer is applied manually, which is time consuming and contributes to the high cost of production. Uniformity of fertilizer distribution around the palm cannot be achieved manually. Furthermore, the amount of fertilizer applied to a palm could vary due to incorrect measurements. Unfortunately a suitable machine is not available for the application of fertilizer to coconut cultivations.

The general objective of this research was to increase the coconut productivity in Sri Lanka by introducing an efficient method of applying fertilizer to coconut estates. The specific objectives were; to design and develop a fertilizer applicator operated by a two wheel tractor, to study the performance of the fertilizer applicator, and to increase the coconut production in Sri-Lanka at a reduced cost by increasing efficiency. Thus it will increase the coconut production in Sri-Lanka at a reduced cost by increasing efficiency.

METHODS AND PROCEDURES

It is necessary to study the behaviour of the fertilizer mixture in order to develop the required components of the fertilizer applicator. A dry mixture of urea, Murate of potash, Eppawala rock phosphate, and dolomite in the proportion of 1:2:1:1 was used to test the applicator. The angle of friction, angle of repose, bulk density, and flowability of the fertilizer mixture were determined.

The flowability was measured by measuring the discharge of fertilizer within a 10 s period at different speeds of the driving shaft. The rotational speed of the screw shaft was measured using a tachometer.

Design and Development of the Fertilizer Applicator

The granular type of fertilizer mixture was selected because it requires simple infrastructure and does not require dilution. The size and topography of coconut estates match the capacity of two wheel tractors. Thus, the model EMI 7 two wheel tractor with 7 hp (5kW) rating was used as the power source.

The design should be facilitated to open furrows, direct the contained fertilizer to the opened furrows by a metering mechanism and finally close the furrows. Thus the unit operations of containing fertilizer, metering mechanism, applying fertilizer, opening of furrows, and closing furrows should be performed by the fertilizer applicator.

Furrow Opener

The furrow opener must be constructed to suit the field conditions of coconut lands. Two furrow openers were constructed using mild steel to cut the soil and the roots to open furrows. The mould board plough, two-way trailing plough, and ridger were used as an inspiration for the construction of the furrow openers.

The shares of furrow openers were designed to dig into the soil and separate the surface soil from the bed soil. Side wings helped to partially turn the soil to make a furrow. Two furrow openers were vertically attached to the front frame of the fertilizer applicator. The distance between two furrow

openers were 30 cm. The depth of the furrow between 8 - 15 cm, can be controlled by shifting the furrow openers.

Hopper

The hopper was constructed to contain fertilizer before it was applied to the soil. The following factors were considered when designing the hopper geometry.

A symmetric shape hopper was constructed to overcome the segregation problems. Forty five degree steep and smooth hopper walls were constructed to obtain the ideal mass flow pattern (Arnold et al., 1981). Mild steel was selected as the construction material due to its low cost.

The lower part of the hopper was constructed in a wedge shape for its capability of handing materials with a wider range of flowability (Marinelli & Carson, 2001). The construction of a screw conveyor at the bottom of the hopper was also aided by this wedge shape. The upper part of the hopper was constructed in a pyramid shape to obtain a larger storage capacity (Chase, 2008).

Maximum load weight of 25 kg can be handled by 95 % of men and 70 % of women (ISO 11228-1). A person can make the coconut fertilizer mixture of 25 kg and load it at once into the hopper. Thus the capacity of the hopper was designed to apply fertilizer to five palms per load.

Screw Conveyor

The mild steel horizontal screw conveyor on the bottom of the hopper was used as the metering mechanism. Fertilizer was equally transferred to both sides and discharged to the two fertilizer tubes at the same rate. This was achieved by attaching two coiled spiral blades in opposite directions from the center of the same shaft in a U-shaped trough. The shaft is driven at one end and free at the other. The discharge points were at the base of the trough.

The rotational rate of the shaft helped control the rate of volume transfer by the screw conveyor. Thus the volume of fertilizer applied for each palm could be controlled. The screw conveyor shaft was powered by the power take-off shaft of the tractor. The PTO driven screw conveyor shaft was supported by bearings that revolved in the trough. The constructed metal pinned shaft helped break the arch of fertilizer that occurred over the screw conveyor.

The metal pinned shaft consisted of 12 pins that were spirally attached to the shaft. It was powered by the transmitted power from the chain and sprocket attached to the screw conveyor shaft. The two sprockets had 13 teeth and rotated at the same speed. The clutch for the metering mechanism was a flap that was placed on the top of the fertilizer tubes.

Fertilizer Tubes

The fertilizer tubes were constructed to carry fertilizer from the fertilizer metering mechanism to the opened furrows in the soil. The construction material was transparent plastic, so the operator could see whether fertilizer was being applied or not.