

**DEVELOPMENT OF A COCOYAM PLANTER**

**BY**

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## APPROVAL PAGE

We certify that this project work was carried out by FALEYE, Tope in the Department of Agricultural Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Akure.

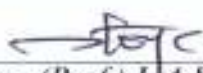


  
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## DEDICATION

This project is dedicated to the glory of Almighty God for giving me the opportunity to complete it.



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My special thanks go to my supervisor, Engr. (Prof.) L.A.S. Agbetoye for his professional advice, guidance, encouragement and good suggestions which cannot be divorced from the success of this project. The effort and contributions of the following people cannot but be acknowledged, Engr. O. A. Atere , Engr. C. O. Olowojola, Mr Adekunle Toyese, Mr Oladimeji Ife and my dear wife Bunmilola. Am very grateful to you all May God bless you.

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Tope Faleye.



## ABSTRACT

A cocoyam planter was designed, fabricated and evaluated for performance. The major components of the planter are hopper, metering system, ridging disc, furrow opening disc, furrow covering disc and chain and sprocket mechanism for power transmission. The materials for fabricating the planter were sourced locally.

Performance tests were conducted to evaluate the effect of forward speed of operation on the following parameters; planting depth, number of corms planted, average spacing along rows and quality of work done. Results of the test were statistically analysed using regression analysis to investigate the effect of forward speed of operation on the parameters of evaluation.

From the regression statistics and the ANOVA of each parameter, it was shown from the values of  $R^2$  obtained for each parameter that all the machine parameters are dependent variable on speed of operation. Comparing the values of  $F$  (calculated) and  $F$  (critical) there is strong significant effect of forward speed on all the evaluation parameters.

The operations within the speeds 2.32 and 2.90 km/h shows optimal performance considering the result obtained at this interval. While the recommended spacing for cocoyam planting is 60 cm (Purewal, 1980), planting spacing obtained with the machine were 60 cm, 53 cm and 57 cm while the corresponding field efficiencies were 70 %, 67 % and 69 % respectively. The estimated cost of production is ₦ 35,341 which is affordable by farmers. This will no doubt ease the problem of cocoyam planting mechanization if commercialized.

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## NOMENCLATURE / LIST OF SYMBOLS

- $\lambda$  = Kinematics index factor  
 $u$  = Linear velocity  
 $r$  = Radius, m  
 $P$  = Power, kW  
 $F_c$  = Centrifugal force, N  
 $v$  = Velocity, m/s  
 $m$  = Mass, kg  
 $d$  = diameter, m  
 $\pi$  = constant pi  
 $A$  = Cross sectional area, m<sup>2</sup>  
 $L$  = Length, m  
 $V.R$  = Velocity ratio  
 $n$  = number of revolutions, rpm  
 $N_t$  = Number of teeth  
 $V_f$  = Forward speed, m/s  
 $D$  = Planting distance, m  
 $T$  = Time of planting, s  
 $\rho_s$  = Density of steel, kg/m<sup>3</sup>  
 $K_s$  = service factor  
 $W_s$  = Weight of shaft, N  
 $M_m$  = Mass of metering device, kg

The protein content of the corm (about 7% on a dry – weight basis) is slightly higher than that of yam, cassava, or sweet potato. The protein is rich in most of the essential amino – acids, but is rather low in histidine, lysine, isoleucine and methionine.

All parts of the corm do not have exactly the same composition. The dry matter as well as the starch content of the corm are lower at the apex of the corm than at the base. In addition, most of the non – starchy nutrients of the corm are concentrated in the outer peel. The peels can therefore be utilized as feed for ruminants rather than being discarded.

Two edible aroids are grown commercially in the U.S. The major crop is cocoyam (*Xanthosoma sagittifolium*) which originated in northern South America. It is known by several common names and in the U.S. is marketed as malanga, its Cuban name. Yautia and tannia are common names for the crop in the Caribbean. Taro (*Colocasia esculenta*, Schott) is grown primarily in Hawaii being most well-known in its cooked form as *poi*, the traditional staple food of native Hawaiians. Both aroids are known for their love of a humid environment and their ability to flourish in shaded conditions. They are among the most shade-tolerant of terrestrial food crops (O’Hair, 1990).

Both edible aroids are short-statured perennial plants, grown as annuals. They store starches in large corms at or below the soil surface. Vegetative propagules are taken from the top portion of the corms. Planting is labour intensive with plant populations ranging from 10,000 to 30,000 plants/ha.

Harvest begins 8 to 12 months after planting, yielding from 7 to 30 t/ha of edible corms. Lifting devices similar to potato diggers are used as harvesting aids (Hunt, 2001). Considerable amounts of hand labour are involved in this process. Many of the steps in both planting and harvesting could be mechanized further. In the Caribbean and South East Asia, young tender leaves are consumed as pot herbs. Limited amounts of leaves are harvested and sold in U.S. markets. The potential for expansion of these markets is considered to be very limited.

Asokan (1986) noted that corms which contain 25 to 35% starch are plagued by the presence of an acrid factor (unpleasant smell), which causes itchiness and considerable inflammation of tissues. Cooking removes most, if not all, of this factor from domesticated clones. Shelf life of harvested corms varies considerably between taro and cocoyam and depends on the care taken during the harvesting and packaging process. Cocoyam has a considerably longer shelf life of several weeks. This can be extended further with curing and refrigerated storage.

Corms are usually peeled and boiled. Processing is limited to the production of deep-fried chips and poi from taro in Hawaii. Expansion of production for processing in the southern states of the U.S. mainland is possible. However, like cassava, the bulkiness of the propagules and lack of tolerance to freezing temperatures, presents problems. One area that deserves additional investigation concerns is the digestibility of the starch. In Cuba, it is a good medicinal use for babies, and people with mild ulcers are placed on diets of cocoyam (Rickard, 1985).

### 1.3 Production Level of Cocoyam

Data on world production and trade of edible aroids is difficult to estimate because of their very limited significance in terms of total production of root and tuber crops. Estimated world production in 1998 was around 5.5 million metric tonnes, and constituting about 3.3% of all root crops (FAO, 1999). Total world production area of taro alone was estimated to be about  $993 \times 10^3$  ha in 1993, with 80% in Africa. During this period, global production of taro was 5.607 million metric tonnes, with about 61.33% in Africa and 38.67% in Asia. Estimates made recently indicated that total world production of the major edible aroids (taro and tannia) was about 5.23 million metric tonnes in an area of 983 million ha, with average yield of  $5314 \text{ kg}\cdot\text{ha}^{-1}$  (FAO, 2000). Production declined by 5.3% from 5.64 million metric tonnes in the 1989-91 period to 5.34 million metric tonnes in 1999. Current statistics indicates that it increased slowly during the past 5 years from 5.6 million to 8.8 million metric tonnes (Table 1). Although exports increased by over 23% in volume, the value of exports remained fairly uniform over this period. Farmers and exporters interested in future business must ascertain the factors contributing to this trend and the potential impacts on business.

**Table 1.1: World production and trade in edible aroids (cocoyams)**

	2005	2004	2003	2002	2001	2000
Production (Mt)	8,834,796	8,823,625	8,697,133	6,621,519	5,977,828	5,586,372
Exports, Quantity (Mt)	-	108,845	108,067	90,881	101,670	88,099
Exports, Value (1000US\$)	-	70,840	88,245	73,710	80,971	70,420

Source: FAOSTAT (2005)

#### 1.4 The Need for Mechanization of Cocoyam Planting

The production of cocoyam is laborious. Planting and harvesting require the most labour. Unfortunately, most of the cocoyam production in the world is on small holdings where manual labour with hand tools is the method of production. The solution to the laboriousness of cocoyam production lies in greater mechanization (Ezumah, 1988). NRCRI (2006) made a breakthrough in selective cocoyam breeding protocols by giving rise to seven new cocoyam breeds and it was observed that there was a huge export potential of cocoyam which had not been exploited with rising population and food demand.

Efforts should be increased to device machines that will plant and harvest the crop. The design and operation of a model cocoyam harvester has been reported by Agbetoye (2000). The harvester, which is drawn by a mini track – laying tractor consists of a blade whose digging and lifting unit operations are controlled by a land wheel – driven cam and two extension springs. The harvester also incorporates a hydraulic dynamometer for measurement of draught acting on

the implement, Therefore, it is imperative to design a simple machine that will be used for mechanization of cocoyam planting.

### **1.5 Objectives of the Project**

The major objective of the project is to enhance the mechanization of cocoyam production. The specific objectives are to:

- i. Design a tractor-mounted cocoyam planter
- ii. Fabricate the planter using locally available materials
- iii. Carry out the performance evaluation of the planter.

## CHAPTER TWO



### 2.0 LITERATURE REVIEW

#### 2.1 Existing Methods of Cocoyam Planting

For upland cultivation of cocoyam, the setts are planted 5-7 cm deep in the soil. Where stem cuttings are used, the top of the corm – portion of the cutting should lie 5-7 cm beneath the soil. It is important that the sett – piece or the stem cutting should not be planted too shallow because shallow planting causes the new corm to develop above the soil surface, or to be partially exposed. Such exposed corms are prone to damage by pests before they are harvested. Also shallow planting results in extremely shallow rooting (Mapes, 1980). Application of mulch soon after planting is sometimes beneficial in upland cocoyam culture.

In flooded culture, planting is done in 2-5 cm of standing water. The sett or stem – cutting is inserted by hand into the loose puddle soil. Strings placed across the field serve as guides in aligning the plantings. The traditional method of planting flooded cocoyam is an extremely unpleasant task, involving hours of stooping and standing in mud. The use of a tomato transplanter to plant the crop into fairly dry soil has proved reasonably successful in Asia (Plucknett *et al.*, 1983).

#### 2.2 Land Preparation for Cocoyam

Taro is grown under flooded (lowland) or unflooded (upland) conditions. Yields are generally higher under flooded conditions, but the time required for the crop to mature is longer, and the amount of effort expended in land preparation is greater. Tannia is grown almost exclusively under upland cultivations.

For flooded culture of taro, land preparation involves essentially clearing, ploughing, disking, harrowing and puddling. In Hawaii, where land preparation for taro culture has attained a high degree of mechanization, ploughing and disking are done with rubber – tyred farm tractors equipped with special devices (Silva, 1982). Puddling is then done with a disk or spike – tooth harrow. Puddling does not necessarily result in higher yields (Barrau, 1989), and may be completely omitted. In most of the fields, land preparation is done while the field is wet. Studies were conducted into the advisablility of preparing the soil and planting the crop while the soil is dry and it was found that water for flooding can be introduced after land preparation (Plucknett *et al.*, 1978). In other localities, other kinds of equipment or even hand tools are employed in land preparation for flooded taro culture. Whatever means of preparation has been employed, the goal is to have a field that is relatively level and has dikes or embankment on sides so that water can be impounded within the field. The soil should be sufficiently puddled so that percolation of impounded water is reduced to a minimum.

For upland culture of taro or tannia, land preparation also involves clearing, ploughing and harrowing. There is no necessity to build dikes around the field since no standing water will be needed, there is also no need to ensure that the field is level, but if furrow irrigation is to be utilized, the field must be gently sloped and furrows must be constructed. Planting is most commonly done on the flat, although planting on ridges or beds may sometimes be practiced. It has been shown that planting on ridges does not necessarily give higher yields, although it may be of some advantage if mechanized harvesting is to be done (Barrau, 1989)

In traditional method of cocoyam production, less mechanization is done, planting is done, on low mounds or in holes dug in unploughed land. In many parts of West Africa, for example cocoyams are commonly grown on low mounds which are identical to the mounds prepared for production of yam or cassava (Sivan, 1983).

### **2.3 Agronomic Parameters of Cocoyam Relevant to Planting**

The agronomic parameters that may affect mechanized planting of cocoyam are: (i) Type of planting material (ii) Size of planting material (iii) Spacing (iv) Soil type and (v) Soil moisture. The commercial planting material used for cocoyam production may be: (a) small corms or setts cut from larger corms, (b) cormels or setts cut from larger cormels, (c) stem cuttings consisting of the apical portion of the corm and the lower 15 – 25 cm of the petioles, this type of stem cutting is referred to as "huli" in taro culture in Hawaii. Purewal (1980) noted that setts from corms normally give a higher yield than those from comels, while the stems cutting give a higher yield than even setts from corms. The high yield of cocoyam from the stem cuttings may be due to the fact that they produce a greater number of roots and a greater total leaf weight than the other two kinds of planting material (Moursi, 1980). The optimal size of setts used for cocoyam planting is about 150 g.

As with many of the other tropical tuber crops, the rapid multiplication of cocoyam is made difficult by the low incidence of seed set and seed germination in the crop. However, where rapid multiplication of clonal material is desired, two general methods are currently available, the first apical bud of the corm, thereby

enabling the lateral buds of the corm to grow. In practice, the apical dominance is removed by destroying the apical bud, slicing the corm into horizontal slabs, or excising the lateral buds and growing them separately, where the apical bud is destroyed or the corm is sliced, the lateral buds must later be excised after they have begun to grow. After excision, they are planted individually and allowed to continue growth, the second method of multiplying cocoyams rapidly involves mericloneing (Mapes, 1980). Meristems from the lateral buds of the corm are grown in special tissue culture. The meristem then proliferates to produce a mass of cells which can differentiate into small cocoyam plants.

The general relationship between field spacing and cocoyam performance is as follows: close spacing increases the corm yield per plant, the contribution of sucker corms to the yield, and the leaf area per plant. This has been found true from trials in Brazil (Silva, 1982). High yields per hectare continue to be realized even if spacing is decreased to 30 cm, but at such high planting densities (109000 plants per hectare), the net return per unit of planting material is low. As a compromise, a spacing of 60 cm is recommended. (Purewal, 1980). This is the spacing recommended for Fiji (Silva, 1982), where the wide spacing of 90 cm previously used by the farmers results in low yields. Indeed, most cocoyam growers around the world employ spacing that are too wide, and increases in yields should result from closer spacing. Weed incidence in the field should also decrease when closer spacing is employed. In many traditional settings, cocoyam is grown as an inter-crop, spacing under such conditions is not fixed, but is determined by the density of the other crops that share the field.

## **2.4 Other Root Crop Planting Devices**

### **2.4.1 Principal components of machines**

Sowing and planting operations are performed by the following working parts: Feed arrangement (seed bins or cans, feed hoppers, bunkers), Feed roll for sowing or planting, Feed tube (seed tubes, trays or troughs, funnels), shares and a trailing arrangement to cover the seeds.

Sowing and planting generally consists of the following processes: The seeds stored in the feed hopper travel to the feed roll either by gravity or by an external force. The delivery of the seeds is activated by agitators, screw conveyors and shakers. Sowing or planting devices take up some of the seeds and eject them into a feed tube which delivers them to the shares. The shares plow furrows of the requisite depth into which the seeds fall and later they partially cover the seeds with soil by a plunger.

In square – row sowing or planting, the seed drill has, in addition, a clustering device to facilitate sowing or planting the required number of seeds or plants in a group. The operation described above may vary depending upon the function of the machine and its constructional features.

## 2.4.2 Kinematics of Planting Units

Planters transport and deposit the seedlings into the furrows. The quality of planting seedlings largely depends upon the kinematics of the planting unit.

The kinematics index (factor)  $\lambda$  for the operation of planter is the ratio of the linear velocity  $u$  of the extreme point of clamping of the seedlings and the speed  $v$  of the machine, that is (Klenin, *et al.*, 1985);

$$\lambda = \frac{u}{v} \quad 2.1$$

In planters presently in use, the seedlings are manually loaded into the seed holder, the speed of the buckets is therefore governed by the average number of seedlings that can be deposited by the planter (Klenin, *et al.*, 1985)

It has been established that the average number of seedling that can be planted manually is  $K = 35 - 40 / \text{min}$ . If the spacing between the plant in the rows is assumed to be  $a$ , then

$$V = K \frac{a_s}{60} \text{ m/sec} \quad 2.2$$

For a radius  $R$ , measured up to the end of the bucket arm and  $Z$  number of such folders, the time interval  $t$  between successive depositions of tuber is:

$$t = \frac{2\pi R}{Zu} \text{, sec} \quad 2.3$$

Based on the permissible number of deposition of tubers, the interval  $t$  may be expressed as:

$$t = \frac{60}{K} = \frac{a_s}{V} \text{, sec} \quad 2.4$$

Solving equation (2.3) and (2.4) simultaneously we have

$$\lambda = \frac{2\pi R}{Za_s} \quad 2.5$$

Equation (2.5) interrelates the kinematics of the planting unit with its design parameter  $R$  and  $Z$  and the spacing  $a_s$ .

In planters presently in use, the spacing between adjacent plants can be varied over a wide range, from 15 to 210 cm, the spacing is altered by changing the number of tuber buckets

For a giving spacing  $a_s$ , the number of buckets  $Z$  is selected on the basis of the kinematic index  $\lambda$ . The value of  $\lambda$  may be unity, in which case the linear velocity of the extreme clamping point of the bucket would equal the linear velocity of the machine at the instant of deposition of the seedling and would be in a direction opposite to that of the machine that is:  $u = v$

Under such condition the absolute velocity of the pedial of the seedling in its lower position equals zero. However, due to slip of the driving wheels from which the planter receives its drive, it is difficult to realize this condition in practice. Simultaneously, it has been found that the seedling, at the instant of its release into the furrow, leans somewhat forward due to the action of the compacting roll. Hence, for seedling to stand upright the factor may be made greater than unity. The optional value of  $\lambda$  is selected on the basis of active field condition (Klenin *et al.*, 1985).

### 2.4.3 Picker Unit of Potato Planter.

The picker grabs the tuber from the feed hopper and delivers them to the furrow openers. Picker wheels with spoon which scoop the tuber from the hopper are extensively used. Such a unit consists of a wheel, (1) with spoon (2) mounted on the periphery of the former. Each spoon has the clamp (3) to help hold the tuber in the spoon, the clamp consist of a rod which can rotate around its axis in guide sleeves. The lower end of this rod is attached to a lever A, the spring (4) tends to turn the rod and hold its projecting arm B pressed into the spoon.

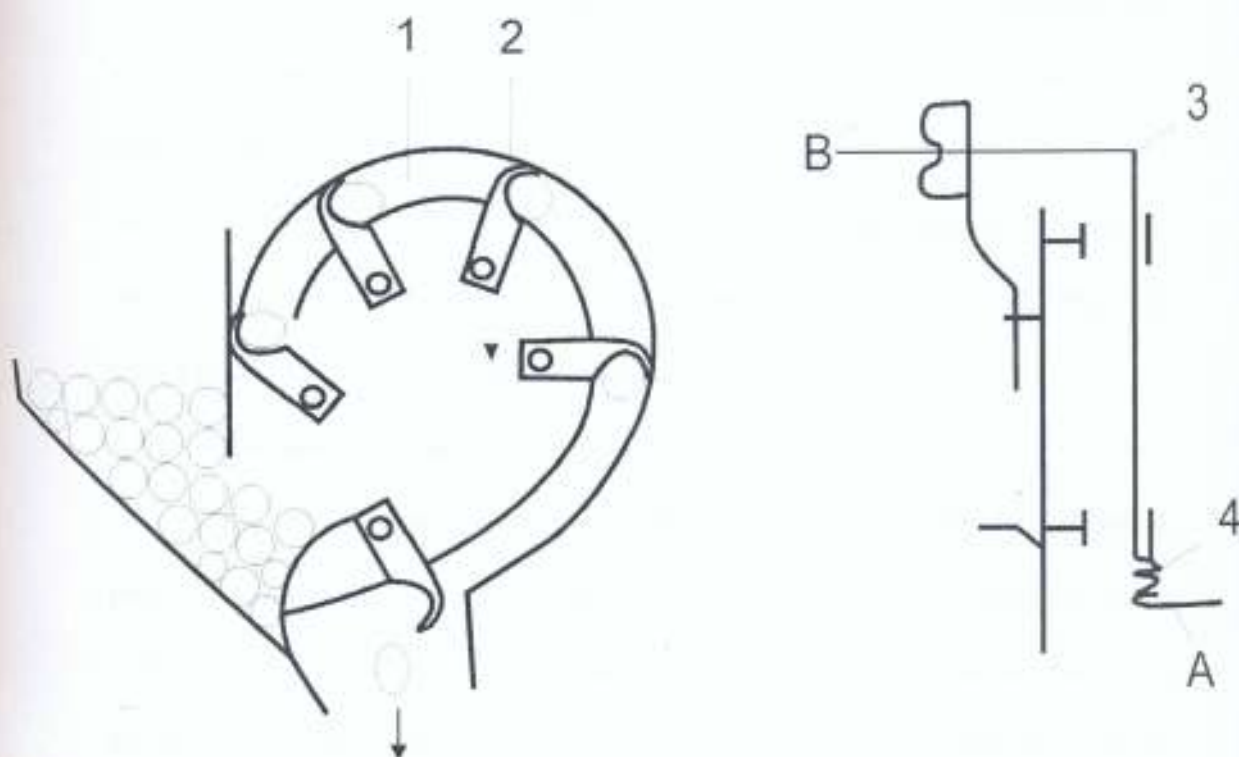


Fig. 2.1: Picker wheel with spoon for planting potatoes (Culpin, 1987).

When the disk rotates, the lever A slides in its guide, overcomes the spring resistance and releases the projecting arm B from the spoon, the spoon then enters the layer of the seed potato in the hopper and scoops them up. When the spoon emerges from the potatoes, the lever slides out. The rod 3 turns around its axis due to the spring force and holds the potato tuber against the spoon with its axis due to the spring force and holds the potato tuber against the spoon with its projecting arm B, in the release zone, the lever once again runs and rotate the rod around its axis releasing the tuber from the spoon, the tuber then falls into the furrow opener.

The picker wheel with spoon is used together with a bucket transport unit which also operates on the same principles. With appropriate controls, picker wheels with spoons provide fairly uniform planting, releasing the tubers within the permissible void limits up to 3% (Hideo, 1985). During planting of vernalised potatoes, the unit tends to damage the sprouts and sliced, oval and large size tubers (80 g) are poorly held by the spoons.

#### **2.4.4 Precision Planting**

Precision planters provide accurate placement of single seeds at equal intervals within row, the rows are usually spaced widely enough to allow cultivation. Precision planters are available in many variations, but four functions are always included. These are opening a furrow of controlled depth, metering seeds into the furrow at uniform intervals, covering the furrow, and firming the soil against the seeds. On some planters a pair of inclined wheels accomplish both the covering and the soil firming.

Precision planters are designed to meter one seed at a time and to place the seeds in a furrow at a desired spacing. It is common practice to check metering accuracy in the laboratory using stationary tests. The drive wheels of the planter are placed on a treadmill and turned at the speed which simulates the device is pulled under the drop tube at the desired travel speed. The collection device must be able to capture the seeds as they exit from the drop tube. In the greased – board techniques, sticky grease is placed on a board which is pulled under the drop tube.

The grease prevents seed bounce in capturing each seed as it exits the planter. Spacing of the seeds on the greased board can then be assessed, either manually or by an automatic counter. The number of skips or multiples can be determined by observation. A skip is created when a cell fails to deliver a seed to the drop tube. Multiples are created when more than one seed is delivered by a cell, skips and multiples can be reported as a percentage of the total number of cells that passed the drop point during the run. After skips and multiples are removed from the data, the average spacing can be calculated using the remaining data and the average can be compared to the desired average seed spacing.

Uniformity of planting depth and firming of soil around the seeds are important considerations for precision planters and are assessed during field tests. Kepner *et al.*, (1978) suggested that, ideally, seeds should be placed in a narrow trench of uniform width which has a firm bottom. For many crops, the seed should be covered with approximately 12 mm of compacted soil and the remainder of the furrow should be filled with loose soil.

#### 2.4.5 Equipment for planting seedlings and tubers

The seeds (tubers), which are partially covered by the soil after the furrow opener moves ahead, are finally covered by special covering devices such as the leveler, smoothing harrow, coverers, rollers with or without attached coverers, disks and so on.

a. **Levellers** – are in the form of a chain of rings connected by links, they level the surface of the soil and fill up the furrows. Leveler are installed on grain drills, grain and grass seed drills and composite seed drills working on light soils.

b. **Harrows** – are in the form of a circular ring with teeth, the teeth of the harrows help to pulverize the clods and cover the seeds. Their action is superior to that of levelers, and they are widely used in narrow row sowing.

c. **Rollers** – are used in square – row hill – drop drilling, grain drilling corn and cotton drilling and on tuber and seedling planters. The rollers used have either a cylindrical or a conical surface at the rim. Two such rollers are placed on either side of the row with a certain distance between them. The rollers fill the soil into the furrows and pack the soil around the seeds or seedlings.

Rolling and compacting the soil after drilling gives greater yield, especially on soils subject to wind erosion, in certain cases (especially during sowing of vegetable crops), a coverer is placed ahead of the roller, seed drills used for accurate sowing of sugarbeet have only a coverer without the rollers.

d. **Disks** – are installed on machines designed for drilling (planting) the seeds (tubers) at great depth, these disks often spherical and are mounted at an inclined axis. A harrow is installed after the disks when such a machine is used to plant

potatoes in smooth, even rows, the covering devices act not only on the soil but shift the seeds and seedlings in the furrows, in heavy moist soils it was found that the seed clusters are shifted by the disks and hence care must be taken to properly adjust the distance between the disks in their convergence zone (Hunt, 2001).

## CHAPTER THREE

### 3.0 METHODOLOGY

#### 3.1 Description of the Cocoyam Planter

The cocoyam planter has 3-point linkage system attached to the mainframe. On the frame are ridging discs and two other discs, one serves as a furrow opener while the other serves as furrow coverer. A hopper with the metering drum is mounted on the frame. The metering device takes its power from one of the ridging discs. The connection is through a chain and sprocket mechanism. As the tractor pulls the machine forward, the ridging discs make a row ridge and the furrow opener opens the ridge for the corms to drop and thereafter the furrow coverer covers the ridge (Figure. 3.1).



Fig. 3.1: Developed Cocoyam Planter.

### 3.2 Design Considerations.

In order to ensure efficiency and reliability, the machine was designed based on the following assumptions:

- i. The machine should be able to make a ridge on ploughed and harrowed land, open the ridge, plant the corms at a depth of 15 cm and cover it properly.
- ii. It should reduce the labour requirement and drudgery involved in manual method of planting.
- iii. It should plant at a rate higher than manual method of planting.
- iv. The cost of the machine should be within the buying capacity of local farmers.
- v. It should be simple to operate and maintain by farmers who do not have formal education.

### 3.3 Design of Components of the Planter

#### 3.3.1 Power required to drive the metering device

The power required to drive the metering device depends on the weight of the metering device, the velocity required of the metering device and friction at the bearings. The friction at the bearings are negligible, since it was made of well lubricated ball bearings, so the power required in this case is assumed to depend on the weight and the required velocity of rotation.

Therefore: Power required to drive the metering device was given by

$$P = F_c V \quad 3.1$$

Where:

$P$  = Power required to drive the metering device

$F_c$  = Centrifugal force, N

$V$  = Velocity of metering device, m/s

The centrifugal force ( $F_c$ ) is given by (Culpin, 1987)

$$F_c = \frac{mv^2}{R} \quad 3.2$$

Where:

$m$  = mass of metering device, kg

$R$  = radius of metering device, m

Substitute for  $F_c$  in equation (3.1) above

$$P = \frac{mv^3}{R} \quad 3.3$$

The values of  $m$ ,  $v$  and  $R$  are 5.739 kg, 0.26 m/s and 0.185 m respectively. This gave a power of 0.545 kW required to drive the metering device.

#### 3.3.4 Chain and sprocket design

Chain drive was selected over belt drive because of the following:

- i. Perfect velocity ratio can be obtained as no slip will take place.
- ii. It gives high transmission efficiency (up to 98%).
- iii. It gives less load on the shafts.
- iv. It transmits more power than belts
- v. It can be operated under adverse temperature and atmospheric conditions (Khurmi and Gupta, 2005).

The design procedure given by (Khurmi and Gupta, 2005) was used to design and select the chain and sprockets (Appendix I).

### 3.3.5 Shaft design

Considering the horizontal and vertical loading on the shaft, its diameter was obtained using the ASAE (1998) equation:

$$d^3 = \frac{16}{\pi S_e} \sqrt{(K_s M_o)^2 + (K_t M_t)^2} \quad 3.4$$

Detailed calculations are as shown in Appendix I.

The diameter of mild steel shaft obtained was 30 mm.

### 3.3.6 Determination of sizes

All the component sizes were determined considering the shape of the hopper as an inverted pyramid (Appendix I).

## 3.4 Material Selection for Component

The materials for the fabrication of the machine components were sourced locally and selected based on the reasons highlighted in the table below.

**Table 3.1: Material Selection**

S/NO	MACHINE COMPONENT	MATERIAL SELECTED	REASONS FOR SELECTION
1	Hopper	Galvanized Iron	1. Tensile strength 2. Low cost
2	Shaft	Mild Steel	1. Machine-ability 2. Low cost 3. Ductility
3	Hitch Point	Mild Steel	1. Tensile Strength 2. Availability
4	Frame	Angle Iron	1. Rigidity 2. Low cost 3. Shock load and stress absorbent capacity.
5	Planting Disc	Mild Steel	1. Tensile strength 2. Low cost
6	Chain and Sprocket	Roller chain	1. High transmission efficiency 2. Less load on shaft

### 3.5 Production of the Machine

The cocoyam planter was fabricated at the equipment development workshop of the Agricultural Engineering Department, FUTA. The planter was fabricated and sized based on the designed dimensions shown in the prototype drawing using AUTOCAD. The workshop has the following machines amongst others which were used during the fabrication of the experimental prototype of the harvester.

- Lathe machine
- Milling machine
- Pillar and hand drilling machine
- Welding machine (Electric arc)
- Table and hand grinding machine

All the materials used for the fabrication of the machine were locally sourced.

### 3.6 Estimation of Production Cost of planter

The cost of materials for production of the machine was estimated by adding the cost of materials, cost of machining jobs and cost of non – machining jobs together. They are shown in Tables below.

**Table 3.2: Cost of fabrication of materials**

S/N	MATERIALS/ SPECIFICATION	NAME OF COMPONENT	QUANTITY REQUIRED	UNIT COST (₦)	AMOUNT (₦)
1	Hollow pipe (2 mm thick)	Frame	8230 mm	70k /mm	5,761: 00
2	Flat bar (4 mm thick)	3 Point Hitch	2200 mm	1: 50/mm	3,300: 00
3	Galvanized sheet (2 mm thick)	Hopper / Metering Device	2.9 m <sup>2</sup>	1,000: 00/m	2,900: 00
4	Shaft (30mm Ø)	Driving shaft	1500mm	2: 50/mm	3,750: 00
<b>TOTAL</b>					<b>15,711: 00</b>

**Table 3.3: Cost of bought-out items**

S/N	MATERIALS/ SPECIFICATION	NAME OF COMPONENT	QUANTITY REQUIRED	UNIT COST (₦)	AMOUNT (₦)
1	Smaller sprocket (14 teeth)		1	400: 00	400: 00
2	Larger sprocket (28 teeth)		1	600: 00	600: 00
3	Ridging Disc (250mm Ø)	Disc	2	1,400: 00	2,800: 00
4	Planting furrow opener (250mm Ø)	Disc	1	1,400: 00	1,400: 00
5	Planting furrow cover (250mm Ø)	Disc	1	1,400: 00	1,400: 00
6	Chain (08B)	Roller chain	1	600: 00	600: 00
7	Ball bearing (25mm)		3	600: 00	1,800: 00
8	Electrodes (Gauge10)		1.5 packets	2000: 00	3,000: 00
9	Paint	Gloss paint	1 liter	500: 00	500: 00
10	Bolts and Nuts	M14	6	20: 00	120: 00
		M17	3	20: 00	60: 00
		M18	2	20: 00	40: 00
		M20	2	30: 00	60: 00
<b>TOTAL</b>					<b>12,780</b>

**Table 3.4: Cost of machining job**

S/N	MATERIALS/ SPECIFICATION	TYPE OF JOB	MACHINE USED	LABOUR COST/HR	AMOUNT (₦)
1	Shaft (30mm Ø)	Cutting	Power hack saw	1000: 00	2000: 00
2	25 mm Ø MS rod	Size reduction	Lathe	1000: 00	1000: 00
3	25 x 6 mm angle iron	Cutting	Hacksaw	400: 00	800: 00
<b>TOTAL</b>					<b>3,800: 00</b>

**Table 3.5: Cost of non-machining job**

S/N	JOB	TIME SPENT (HR)	LABOUR COST/HR( ₦)	EQUIPMENT COST/HR (₦)	AMOUNT (₦)
1	Marking out	5	100: 00	50: 00	750: 00
2	Welding	10	100: 00	50: 00	1,500: 00
3	Machine assembly	2	200: 00	100: 00	600: 00
4	Painting	1	300: 00	100: 00	400: 00
<b>TOTAL</b>					<b>3,250: 00</b>

**GRAND TOTAL = ₦ 15,711 + ₦ 12,780 + ₦3, 800 + ₦ 3,250 = ₦ 35,541**

### 4.0 EXPERIMENTATION

#### 4.1 Preparation of Experimental Plot.

The experimental plot was located at the flood plain of Ogbese near Akure town. The topography of the plot is flat and this area is chosen for its suitable soil structure, texture, water retention capacity and loam fertile soil. The plot area of 900 m<sup>2</sup> was ploughed and harrowed before the planter was tested.

#### 4.2 Experimental Design

Experiments have established that for speeds ranging from 5 to 10 km/h, specific resistance is practically invariant. For speeds above 10 km/h, specific resistance increases and is quite severe for mounted units, this is due to their increasing swing in a direction perpendicular to that of the motion of the unit (Klenin *et al.*, 1985). Since productivity of seeders and planters is entirely dependent upon the working speed of the machine, the evaluation of the planter was based on effect of the working speed on the following: uniform distribution of seeds (spacing) over the field, constant rate of sowing, minimum seed damage and uniform depth of planting. Cocoyam corms of average size of 150 g were obtained from local market in Akure for the experiment, according to planting setts size recommended by (Moursi, 1980).

### 4.3 Experimental Procedure

**i. Forward Speeds of Planter:** The forward speed of the planter was determined from  $V_f = \frac{3.6D}{T}$  (Celik, 2006), where  $V$  = forward speed (km/h),

$D$  = Planting distance (m), and  $T$  = Time of operation (s).

Different forward nominal speeds were considered and were designated  $S_1, S_2, S_3, \dots, S_n$  for each forward low gear selections. The corresponding time  $T$  of planting at a given distance was recorded for each speed and three replicates were taken.

**ii. Theoretical field capacity:** is the maximum possible area capacity at a given operating speed and fully utilizing the operational width of the machine.

$$\text{Theoretical field capacity } C_{th} = \frac{\text{area covered}}{\text{Total Time Taken}}$$

Given, operational speed = 6.5 km/h,

Distance traveled = 100m,

Width of operation = 1m

$$C_{th} = \frac{6.5 \times 1}{10} = 0.65 \text{ ha/h}$$

**iii. Actual Field capacity of the planter:** This is the measurement of the area of corns planted per unit time in ha/h. The performance of an agricultural machine is assessed by the rate at which an operation is accomplished and by the quality of the output.

$$F_c = \frac{swc}{10} \text{ (ha/h)}$$

iv. **Field efficiency:** This is the ratio of the overall rate of work to the theoretical rate of work measured in percentage (%)

$$= \frac{\text{Actual Field Capacity}}{\text{Theoretical Field Capacity}} (\%)$$

v. **Planting spacing:** Average spacing of cocoyam corms/setts along rows for machine operation for a given distance was determined. This was compared statistically with the theoretical and recommended spacing of cocoyam corms/setts. The recommended spacing along rows for cocoyam is 60 cm (Purewal, 1980)

vi. **Performance Test:** The machine was coupled to a 2WD 55 hp (41 kW) New Holland TT55 tractor. A rated engine speed of 1800 rpm was selected for the different forward speeds of the tractor. The corms were loaded into the hopper and the tractor was made to traverse a distance of 20 m while the planter plants the corms. The time taken to cover the given distance at different forward speeds were taken with stop watch in three replicates and other parameters such as planting depth was measured with steel rule, number of seeds dropped was counted after the removal of soil cover.



**Fig: 4.1: Developed cocoyam planter mounted on a tractor**

vii. **Method of Analyzing data:** Regression analysis was used to evaluate the performance of the machine at various operational speeds. All the parameters of evaluation such as the field efficiency, effective field capacity, planting depth, average spacing along the rows and the number of corms dropped were compared statistically with the operational speed.



## CHAPTER FIVE

### 5.0 RESULTS AND DISCUSSION

#### 5.1 RESULTS

The results obtained from the field test of the developed cocoyam planter are presented in the Table 5.1., while Table 5.2 shows the parameters for performance evaluation of the planter. Regression analysis was used to evaluate the performance of the machine at various operational speeds.

Table 5.1: Performance test results of the cocoyam planter based on time of operation

Row	Forward speed (km/h)	Time Record (mins)				
		Loading Time	Clogging Time	Turning Time	Actual Time	Total Time Taken
1	1.90	3	3	4	22	32
2	2.32	4	2	3	21	30
3	2.83	6	0	3	19	28
4	2.90	5	0	3	18	26
5	3.21	5	0	2	15	22
6	3.50	4	3	2	9	18
7	3.89	3	0	2	11	16

Table 5.2: Parameters of evaluation of the planter

Row	Forward Speed (km/h)	Total Time of Operation (hr/ha)	Field Efficiency (%)	Theoretical Field Capacity (ha/h)	Eff. Field Capacity (ha/h)	Average Spacing (cm)	Planting Depth (cm)	No of Corn Dropped
1	1.90	8.89	68.77	0.1636	0.1125	58	14	28
2	2.32	8.33	70.01	0.1714	0.1200	60	16	26
3	2.83	7.78	67.86	0.1895	0.1286	58	15	29
4	2.90	7.22	69.25	0.2000	0.1385	57	15.5	27
5	3.21	6.11	68.17	0.2400	0.1636	60	13	25
6	3.50	5.00	50.00	0.4000	0.2000	62	14.5	27
7	3.89	4.44	68.74	0.3273	0.2250	61	14	26

## 5.2 DISCUSSION

### 5.1.1 Effect of forward speed on field capacity

From the analysis of the result, it was shown that forward speed has significant effect on the field capacity as one of the parameters of evaluation of the machine. From the regression statistic, the value of  $R^2 = 0.928$ . This tends to 1 for an overall fit of hypothesis testing. The field capacity increased with an increase in operational speed and other parameters of evaluation varies from one speed to another.

**Table 5.3: ANOVA result of forward speed compared with field capacity**

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0.008208537	0.008208537	51.58131421	0.001990771
Residual	4	0.000636551	0.000159138		
Total	5	0.008845088			

### 5.2.2 Effect of forward speed on number corms dropped

The number of corm dropped varies from one speed to another, the minimum is 25 corms at a speed of 3.21 km/h and maximum is 29 corms at 2.83 km/h and the depth obtained at this speed is 15 cm, which is the expected depth the planter supposed to plant. From the statistical analysis the effect of forward speed is also significant on the rate of dropping, it was observed that at higher speed the rate of dropping reduces which implies that at relatively high speed the planter may not drop.

Table 5.4: ANOVA result of forward speed compared with number of corm dropped

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0.374080381	0.374080381	1.167014095	0.703712009
Residual	4	8.959252952	2.239813238		
Total	5	9.333333333			

### 5.2.3 Effect of forward speed on average spacing along rows

Purewal, (1980) recommended spacing 60 cm for cocoyam planting was obtained at forward speed 2.32 km/h and 3.21 km/h which is also the speed that the minimum number of corm dropped was obtained. Considering other parameters of evaluation at this interval, the required depth of planting 15 cm was obtained and the maximum number of corms dropped was obtained. From the statistical analysis, forward speed also has significant effect on this parameter.

**Table 5.5: ANOVA result of forward speed compared with average spacing along rows**

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	4.972816992	4.972816992	1.60925866	0.273397188
Residual	4	12.36051634	3.090129085		
Total	5	17.33333333			

#### 5.2.4 Effect of forward speed on field efficiency

Optimum field efficiency was obtained at 2.32 km/h and the required spacing was also obtained while the depth is 16 cm but this is not too far from the expected 15 cm. Nevertheless from the statistical analysis it was shown that forward speed also has significant effect on the machine efficiency. The value of  $R^2$  attest to this and this shows that speed of operation is the predictor of all the parameters of evaluation of the planter.

**Table 5.6: ANOVA result of forward speed compared with field efficiency**

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	44.97596094	44.97596094	0.711938056	0.446306169
Residual	4	252.6959224	63.1739806		
Total	5	297.6718833			



### 5.2.5 Effect of forward speed on planting depth

The expected planting depth 15 cm was obtained when the machine was operated at 2.83 km/h and at 2.90 km/h, 15.5 cm was recorded while at greater speeds the depth reduces. From the statistical analysis it was observed that forward speed also has significant effect on the planting depth, the value of  $R^2$  from the regression statistic also attest to this as it tends to fit  $R^2 = 0.485$ .

Table 5.7: ANOVA result of forward speed compared with planting depth

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	2.833536574	2.833536574	3.778304734	0.123837567
Residual	4	2.999796759	0.74994919		
Total	5	5.833333333			

## CHAPTER SIX

### 6.0 CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 CONCLUSIONS

In this study, a mechanical cocoyam planter was designed, fabricated and tested. Its was utilized in making a row ridge and plant along the row. Results of the performance evaluation showed that:

- i. The planter planted at a rate higher than manual method of planting, i.e. at a forward speed of 2.90 km/h the time of operation is 7.22 hr/ha.
- ii. It is simple to operate and maintain by farmers who do not have formal education.
- iii. The planter's optimum performance was achieved at the forward speed between 2.32 and 2.90 km/h
- iv. All the parameters of evaluation of the machine, (i.e. Field Efficiency, Field Capacity, Average Spacing, Planting Depth and Number of Corms Dropped) were significantly affected by the speed of operation.

#### 6.2 RECOMMENDATIONS

The machine can be used to plant cocoyam on a large scale, and this will reduce the drudgery associated with manual method of planting cocoyam. The following improvements are suggested for further investigation.

- i. The metering device should be modified in order to improve the metering rate of the machine.
- ii. Research interest should also be focused on the possibility of planting in two rows so as to save time of operation.

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## APPENDICES

## APPENDIX I

### 3.3.2 Determination of mass of metering device

The metering device is made of a hollow cylindrical roller with four holes to size of the tuber cuttings and the shaft. The mass of the shaft, weight of the metering device and the power required to drive it was calculated.

### 3.3.3 Mass of the shaft (steel rod)

$$M_s = \rho_s A L = \frac{\pi d^2 \rho_s L}{4} \quad 3.4$$

Where:

$$\rho_s = \text{density of steel rod (mild steel)} = 7.992 \times 10^3 \text{ kg/m}^3$$

$$A = \text{cross sectional area of shaft} = \frac{\pi d^2}{4}$$

$$d = \text{diameter of rod} = 0.025 \text{ m}$$

$$L = \text{length of shaft} = 0.96 \text{ m}$$

$$\therefore M_s = \frac{\pi \times (0.025)^2 \times 7.992 \times 10^3 \times 0.96}{4}$$

$$= 3.766 \text{ kg}$$

Weight of shaft,  $W_s$  becomes

$$W_s = 3.766 \times 9.81$$

$$W_s = 36.946 \text{ N}$$

### 3.3.4 Mass of metering device

Volume of the roller is given by:

$$V = \pi \frac{d_1^2}{4} L - \pi \frac{d_2^2}{4} L - 4\pi \frac{d_3^2}{4} l$$

$$= \frac{\pi}{4} (d_1^2 - d_2^2) L - \pi d_3^2 l \quad 3.5$$

Where:

$$d_1 = \text{outer diameter of roller} = 0.185\text{m}$$

$$d_2 = \text{inner diameter of roller} = 0.025\text{m}$$

$$d_3 = \text{diameter of a hole on roller} = 0.08\text{m}$$

$$L = \text{length of the roller} = 0.16\text{m}$$

$$l = \text{length of a hole on roller} = 0.08\text{m}$$

$$V = \pi \left( \frac{(0.185)^2 - (0.025)^2}{4} \right) 0.16 - (0.08)^2 (0.08)$$

$$= 3.710 \times 10^{-3} \text{m}^3$$

$$M_s = 3.710 \times 10^{-3} \times \rho$$

$$\text{Where } \rho = 7.992 \times 10^3 \text{ kg/m}^3$$

$$M_s = 1.855 \text{ kg}$$

Weight of the roller becomes

$$W_s = 1.973 \times 9.81$$

$$= 19.355\text{N}$$

$$= 19.4\text{N.}$$

Total mass of the metering device

$$M_d = M_s + M_m \quad 3.6$$

$$= 3.766 + 1.855$$

$$= 5.594 \text{ kg}$$

Total weight of the metering device

$$\begin{aligned}
 W_d &= W_s + W_m && 3.7 \\
 &= 36.946 + 19.355 \\
 &= 56.301 \text{ N.}
 \end{aligned}$$

The machine is to be tested and powered or (driven) by a chain and sprocket drive mechanism. The smaller sprocket or pinion takes its power from the disc which is to be operated at the same speed with the pinion. However the disc rotates as it engages the soil. The whole assembly would be pull by tractor at 3 point linkage system.

Therefore, the number of teeth on the larger sprocket can be calculated from the relation, (Srivastava *et al.*, 1993).

$$N_1 T_1 = N_2 T_2 \quad 3.8$$

Where:

$N_1$  = speed of rotation of pinion

$T_1$  = number of teeth on the pinion

$N_2$  = speed of rotation of larger sprocket

$T_2$  = diameter of larger sprocket

Since the whole assembly is to be pulled by tractor at the speed of operation of about 6.5 km/hr. Therefore, speed of rotation of the rear wheel of the tractor is given by

$$V = \pi dn \quad 3.9$$

Where:

$V$  = speed of operation = 6.5 km/hr

$d$  = diameter of the rear wheel =  $1.4 \times 10^{-3}$

$n$  = speed of rotation of the rear wheel = ?

$$\begin{aligned}\therefore n &= \frac{V}{\pi d} \\ &= \frac{6.5 \text{ km/hr}}{\pi \times 1.4 \times 10^{-3}} \\ &= 1477.86 \text{ rph} \\ &= 24.631 \text{ rpm.}\end{aligned}$$

Number of revolution of the larger sprocket will be:

$$N_d d_d = N_i d_i \quad 3.10$$

Where:

$N_d$  = speed of rotation of driven disc = ?

$N_i$  = speed of rotation of tractors rear wheels = 24.631

$d_d$  = diameter of driven disc = 0.48m

$d_i$  = diameter of tractors rear wheel = 1.4m

$$\begin{aligned}N_d &= \frac{24.631 \times 1.4}{0.48} \\ &= 71.841 \text{ rpm.}\end{aligned}$$

The shaft connects the disc and the pinion, however both has same speed of rotation, i.e. speed of rotation of the pinion is 71.841 rpm.

Then; the speed of rotation required to drive the metering device is half of the speed of rotation of the pinion i.e. 35.920 rpm.

$$T_2 = \frac{T_1 N_1}{N_2} = \frac{14 \times 71.841}{35.920}$$

$$T_2 = 28$$

Power required to drive the metering device:

$$P = \frac{mV^3}{R}$$

$m$  = mass of metering device

$V$  = velocity of metering device

$R$  = radius of metering device

$$\text{Velocity} = \frac{\pi DN}{60} = \frac{T_p N}{60} \quad 3.11$$

Where  $D$  = Pitch circle diameter of the sprocket in meters

$$= \pi \times 0.07 \times \frac{71.841}{60}$$

$$= 0.26 \text{ m/s}$$

$$\text{Power} = \frac{5.739 \times 0.26^3}{0.185}$$

$$= 0.545 \text{ kW.}$$

**3.3.5 Velocity Ratio of Chain Drives is given by:**

$$V.R. = \frac{N_1}{N_2} = \frac{T_2}{T_1} \quad 3.12$$

Where  $N_1$  = Speed of rotation of smaller sprocket in rpm

$N_2$  = Speed of rotation of larger sprocket in rpm

$T_1$  = Number of teeth on the smaller sprocket, and

$T_2$  = Number of teeth on the larger sprocket

$$N_1 = 71.841 \text{ rpm}$$

$$T_1 = 14$$

$$N_2 = 35.920 \text{ rpm}$$

$$T_2 = ?$$

$$VR = \frac{73.841}{32.920} = 2$$

Number of teeth on the larger sprocket is given by:

$$T_2 = \frac{N_1 T_1}{N_2} \quad 3.13$$

$$= \frac{71.841 \times 14}{35.920}$$

$$T_2 = 28$$

Determination of Design Power

$$= \text{Rated power} \times \text{service factor} (K_s)$$

The service factor ( $K_s$ ) is the product of various factors  $K_1$ ,  $K_2$  and  $K_3$ .

The values of these factors are taken as follows:

Load factor ( $K_1$ ) for constant load = 1

Lubricating factor ( $K_2$ ) for drop lubrication = 1

Rating factor ( $K_3$ ) for 8 hours per day.

$$\therefore \text{Service factor, } K_s = K_1 \cdot K_2 \cdot K_3 = 1 \times 1 \times 1 = 1$$

and design power = 0.545 kW

Pitch = 0.016 m = 16 mm

Roller diameter  $d_1 = 11$  mm

Minimum width of roller,  $W = 10.61 \text{ mm}$

Breaking load,  $W_B = 27.136 \text{ KN}$

$$= 27136 \text{ N}$$

Pitch circle diameter of the pinion,

$$d_1 = P \operatorname{cosec} \left( \frac{180}{T_1} \right)$$

$$= 16 \operatorname{cosec} \left( \frac{180}{14} \right)$$

$$= 16 \times 4.4739$$

$$= 71.9 \text{ mm}$$

$$= 0.072 \text{ m}$$

Pitch circle diameter of the larger sprocket

$$d_2 = P \operatorname{cosec} \left( \frac{180}{T_2} \right)$$

$$= 16 \operatorname{cosec} \left( \frac{180}{28} \right) \text{ mm}$$

$$= 16 \times 8.93$$

$$= 142.9 \text{ mm} = 0.1429 \text{ m}$$

Pitch line velocity of the smaller sprocket

$$V_1 = \frac{\pi d_1 N_1}{60} = \frac{\pi \times 0.072 \times 71.841}{60}$$

$$= 0.271 \text{ m/s}$$

Load on the chain

$$W = \frac{\text{Rated power}}{\text{Pitch line velocity}}$$

$$= \frac{0.545}{0.271}$$

$$= 2.011 \text{ kN}$$

$$= 2011 \text{ N}$$

$$\text{Factor of safety} = \frac{W_n}{W}$$

$$= \frac{27136}{2011}$$

$$= 13$$

The minimum center distance between the smaller and larger sprocket should be 13 to 20 times the pitch. Let us take it as 13 times the pitch.

∴ Center distance between the sprockets

$$= 13p = 13 \times 16 = 215.9 = 216 \text{ mm}$$

In order to accommodate initial sag in the chain, the value of center distance is reduced by 2 to 5 mm.

∴ Connect centre distance

$$X = 215 - 3 = 213 \text{ mm}$$

Number of chain in the links

$$\begin{aligned} K &= \frac{T_1 + T_2}{2} + \frac{2x}{p} + \left[ \frac{T_1 - T_2}{2\pi} \right]^2 \frac{p}{x} \\ &= \frac{14 + 28}{2} + \frac{2 \times 213}{16} + \left[ \frac{28 - 14}{2\pi} \right]^2 \frac{16}{213} \\ &= 21 + 26.625 + 0.3729 \end{aligned}$$

= 48

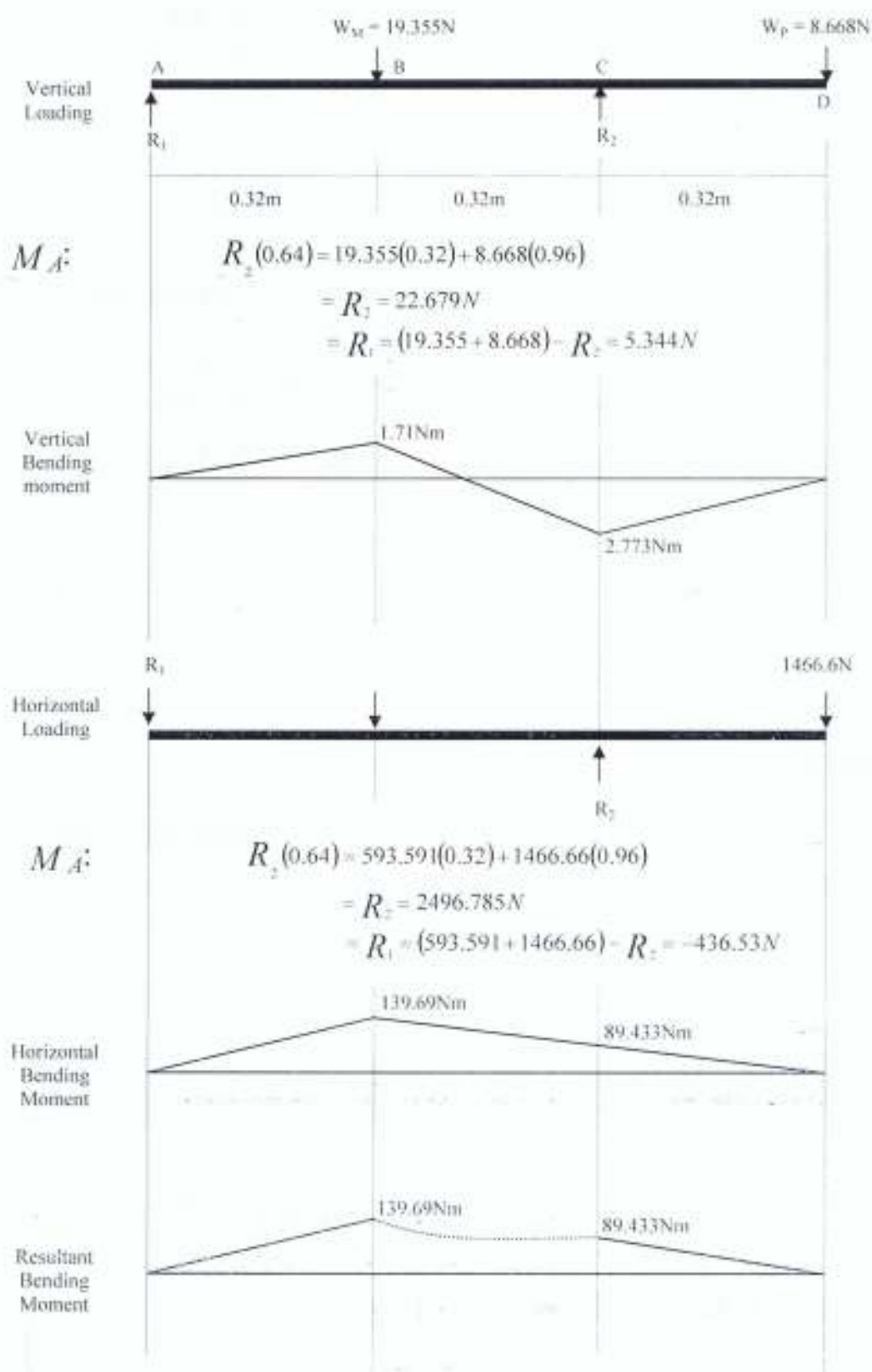
Length of chain,  $L = k.p = 48 \times 16$

= 767.97 mm

= 0.768 m.

### 3.3.5 Shaft Design Calculation

Loading on shaft is both vertical and horizontal:



$$M_t = \frac{P}{2\pi r}$$

$$= \frac{206.389}{2\pi 35.92}$$

$$= 0.915 \text{ Nm}$$

$$d^3 = \frac{16}{\pi S_s} \sqrt{(K_s M_s)^2 + (K_t M_t)^2}$$

for shaft with keyways, allowable shear stress  $K_s = 40 \times 10^6 \text{ N/m}^2$ ,  $K_t = 1.0$

$$d^3 = \frac{16}{\pi 40 \times 10^6} \sqrt{(1.5 \times 139.7)^2 + (1.0 \times 0.915)^2}$$

$$d = 0.02988 \text{ m}$$

$$d \approx 0.030 \text{ m}$$

$$d = 30 \text{ mm (selected).}$$

### 3.3.7 Capacity of the hopper

This is given by the determination of the volume of the shape taken, the shape of the hopper is that of an inverted pyramid with a square base.

$$\text{Volume of pyramid} = \frac{1}{3} \times \text{base area} \times \text{altitude}$$

$$= \frac{1}{3} lbh$$

$$\text{Volume} = \left( \frac{1}{3} \times 0.4 \times 0.4 \times 0.37 \right) - \left( \frac{1}{3} \times 0.1 \times 0.1 \times 0.07 \right)$$

$$= 0.01973 - 2.33 \times 10^{-4}$$

$$= 0.019497$$

$$= 0.0195 \text{ m}^3$$

### 3.3.8 Weight of frame

The frame can be divided into the following parts: A, B, C and D.

∴ Volume of a part is given by:

$$V = \text{length} \times \text{breadth} \times \text{height} = lbh$$

$$V_A = (1.2 \times 0.1 \times 0.05) - (1.2 \times 0.09 \times 0.04)$$

$$= 6 \times 10^{-3} - 4.32 \times 10^{-3}$$

$$= 1.68 \times 10^{-3}$$

$$\text{For } V_{2A} = 2 \times 1.68 \times 10^{-3} = 3.36 \times 10^{-3}$$

$$V_{2A} = (0.3 \times 0.1 \times 0.05) - (0.3 \times 0.09 \times 0.04)$$

$$= 1.5 \times 10^{-3} - 1.08 \times 10^{-3}$$

$$= 4.2 \times 10^{-4}$$

$$\text{For } V_{2B} = 2 \times 4.2 \times 10^{-4} = 8.4 \times 10^{-4}$$

$$V_C = (0.35 \times 0.1 \times 0.05) - (0.35 \times 0.09 \times 0.04)$$

$$= 1.75 \times 10^{-3} - 1.26 \times 10^{-3}$$

$$= 4.9 \times 10^{-4}$$

$$\text{For } V_C = 2 \times 4.9 \times 10^{-4} = 9.8 \times 10^{-4}$$

$$V_D = (0.3 \times 0.1 \times 0.05) - (0.3 \times 0.09 \times 0.04)$$

$$= 1.5 \times 10^{-3} - 1.08 \times 10^{-3}$$

$$= 4.2 \times 10^{-4}$$

$$\text{Total volume} = V_{2A} + V_{2B} + V_C + V_D$$

$$= 3.36 \times 10^{-3} + 8.4 \times 10^{-4} + 9.8 \times 10^{-4} + 4.2 \times 10^{-4}$$

$$= 5.6 \times 10^{-3} \text{ m}^3$$

Mass of the frame is given by:  $m_f = \rho V_f$

Where  $\rho$  = density of steel =  $7.992 \times 10^3 \text{ kg/m}^3$

$V_f$  = determined volume of frame

$$\begin{aligned}\therefore m_f &= 7.992 \times 10^3 \times 5.6 \times 10^{-3} \\ &= 44.755 \text{ kg}\end{aligned}$$

Weight of frame is given by:  $w_f = m_f g$

Where  $g$  = acceleration due to gravity ( $9.81 \text{ m/s}^2$ )

$$\begin{aligned}\therefore w_f &= 44.755 \times 9.81 \\ &= 439 \text{ N}\end{aligned}$$

### 3.3.9 Weight of flat bars

Volume =  $lbh$

$$\begin{aligned}&= 0.9 \times 0.1 \times 0.01 \\ &= 9 \times 10^{-3} \text{ m}^3\end{aligned}$$

$$\begin{aligned}\text{Volume of two bars} &= 2 \times 9 \times 10^{-3} \\ &= 0.018 \text{ m}^3\end{aligned}$$

Mass of the bars

$$m_b = \rho V$$

Where  $V$  = volume of the bar

$\rho$  = density of steel

$$\begin{aligned}m_b &= 7.992 \times 10^3 \times 0.018 \\ &= 143.856 \text{ kg}\end{aligned}$$

Weight of bars

$$w_b = m_b g$$

Where  $g$  = acceleration due to gravity

$$m_b = \text{mass of bars}$$

$$w_b = 143.856 \times 9.81$$

$$= 1411.2\text{N}$$

$$\approx 1.4 \text{ kN}$$

## APPENDIX II

### STATISTICAL ANALYSIS OF TABLE 5.2

#### Forward speed compared with Field capacity

<i>Regression Statistics</i>	
Multiple R	0.963344885
R Square	0.928033368
Adjusted R Square	0.91004171
Standard Error	0.012614983
Observations	6

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-0.066025196	0.032249219	-2.047342514	0.11002184	-0.155563382	0.023512989	-0.155563382	0.023512989
1.9	0.073557704	0.010241934	7.182013242	0.001990771	0.045121537	0.101993871	0.045121537	0.101993871

---

RESIDUAL OUTPUT

<i>Observation</i>	<i>Predicted 0.1125</i>	<i>Residuals</i>
1	0.104628677	0.015371323
2	0.142143106	-0.013543106
3	0.147292145	-0.008792145
4	0.170095033	-0.006495033
5	0.191426767	0.008573233
6	0.220114272	0.004885728

---

**Forward speed compared with Field efficiency**

---

<i>Regression Statistics</i>	
Multiple R	0.388706066
R Square	0.151092406
Adjusted R Square	-0.061134493
Standard Error	7.948206125
Observations	6

---



	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	82.59605932	20.31896754	4.064973241	0.01528601	26.18156137	139.0105573	26.18156137	139.0105573
1.9	-5.444844823	6.453040677	-0.843764218	0.446306169	-23.36135802	12.47166838	-23.36135802	12.47166838

RESIDUAL  
OUTPUT

<i>Observation</i>	<i>Predicted 68.77</i>	<i>Residuals</i>
1	69.96401934	0.045980665
2	67.18714848	0.672851524
3	66.80600934	2.443990662
4	65.11810744	3.051892557
5	63.53910244	-13.53910244
6	61.41561296	7.324387037

Forward speed compared with Average spacing

<i>Regression Statistics</i>	
Multiple R	0.535624204
R Square	0.286893288
Adjusted R Square	0.10861661
Standard Error	1.7578763
Observations	6

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	54.0390552	4.493873323	12.02505085	0.000274184	41.56206261	66.51604779	41.56206261	66.51604779
1.9	1.810491623	1.427195909	1.268565592	0.273397188	-2.152039474	5.77302272	-2.152039474	5.77302272

---

**RESIDUAL  
OUTPUT**

<i>Observation</i>	<i>Predicted 58</i>	<i>Residuals</i>
1	58.23939577	1.76060423
2	59.1627465	-1.162746498
3	59.28948091	-2.289480912
4	59.85073332	0.149266685
5	60.37577589	1.624224114
6	61.08186762	-0.081867619

---

**Forward speed compared with Planting depth**

---

*Regression Statistics*

---

Multiple R	0.696957048
R Square	0.485749127
Adjusted R Square	0.357186409
Standard Error	0.865996068
Observations	6

---

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	18.91469377	2.213851241	8.543796176	0.001030125	12.76805732	25.06133021	12.76805732	25.06133021
1.9	-1.366657512	0.703090454	-1.943786185	0.123837567	-3.318749561	0.585434538	-3.318749561	0.585434538

RESIDUAL  
OUTPUT

<i>Observation</i>	<i>Predicted 14</i>	<i>Residuals</i>
1	15.74404834	0.255951662
2	15.04705301	-0.047053007
3	14.95138698	0.548613018
4	14.52772315	-1.527723153
5	14.13139247	0.368607525
6	13.59839605	0.401603955

### Forward speed compared with Number of corms dropped

#### Regression Statistics

Multiple R	0.200200002
R Square	0.040080041
Adjusted R Square	-0.199899949
Standard Error	1.496600561
Observations	6

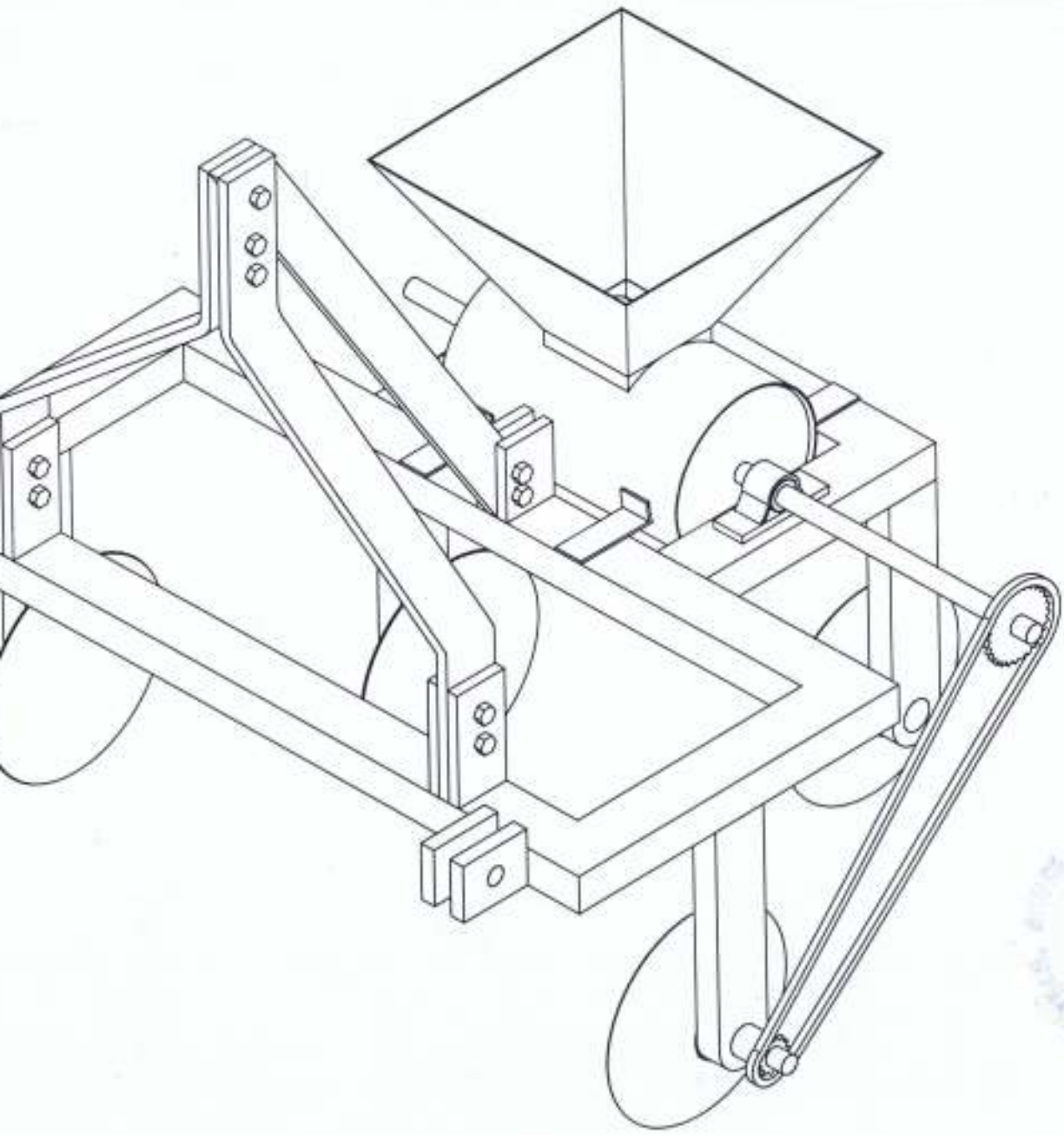
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	28.21016204	3.825942323	7.373389262	0.001803099	17.58764321	38.83268088	17.58764321	38.83268088
1.9	-0.496566877	1.215069683	-0.40867358	0.703712009	-3.870141151	2.877007396	-3.870141151	2.877007396

---

RESIDUAL  
OUTPUT

<i>Observation</i>	<i>Predicted 28</i>	<i>Residuals</i>
1	27.05812689	-1.058126888
2	26.80487778	2.195122219
3	26.7701181	0.229881901
4	26.61618237	-1.616182367
5	26.47217797	0.527822027
6	26.27851689	-0.278516891

---



ISOMETRIC VIEW



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AKURE

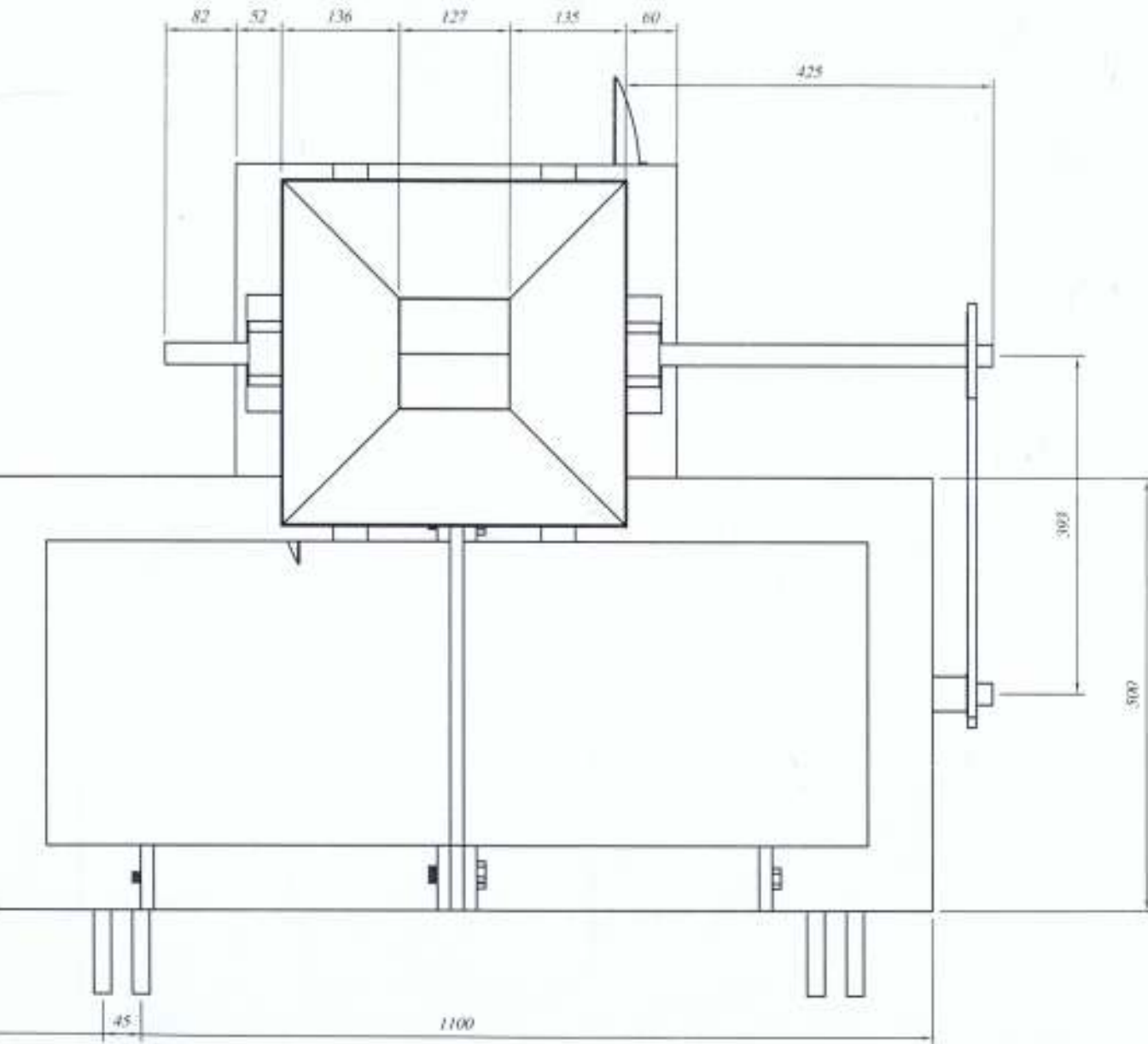
**DEPARTMENT**  
AGRICULTURAL ENGINEERING

**PROJECT TITLE**  
DEVELOPMENT OF A COCOYAM PLANTER

**SUPERVISOR**

PROF. L.A.S. AGBETOYE

<b>NAME</b>	FALEYE, TOPE
<b>MAT. NO</b>	AGE/93/4466
<b>SCALE</b>	1 : 16
<b>UNIT</b>	MILLIMETRE
<b>CHECKED AND APPROVED BY</b>	PROF. L.A.S. AGBETOYE



PLAN VIEW

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AKURE

**DEPARTMENT**  
AGRICULTURAL ENGINEERING

**PROJECT TITLE**  
DEVELOPMENT OF A COCOYAM PLANTER

**SUPERVISOR**

PROF. L.A.S. AGBETOYE

**NAME** FALEYE, TOPE

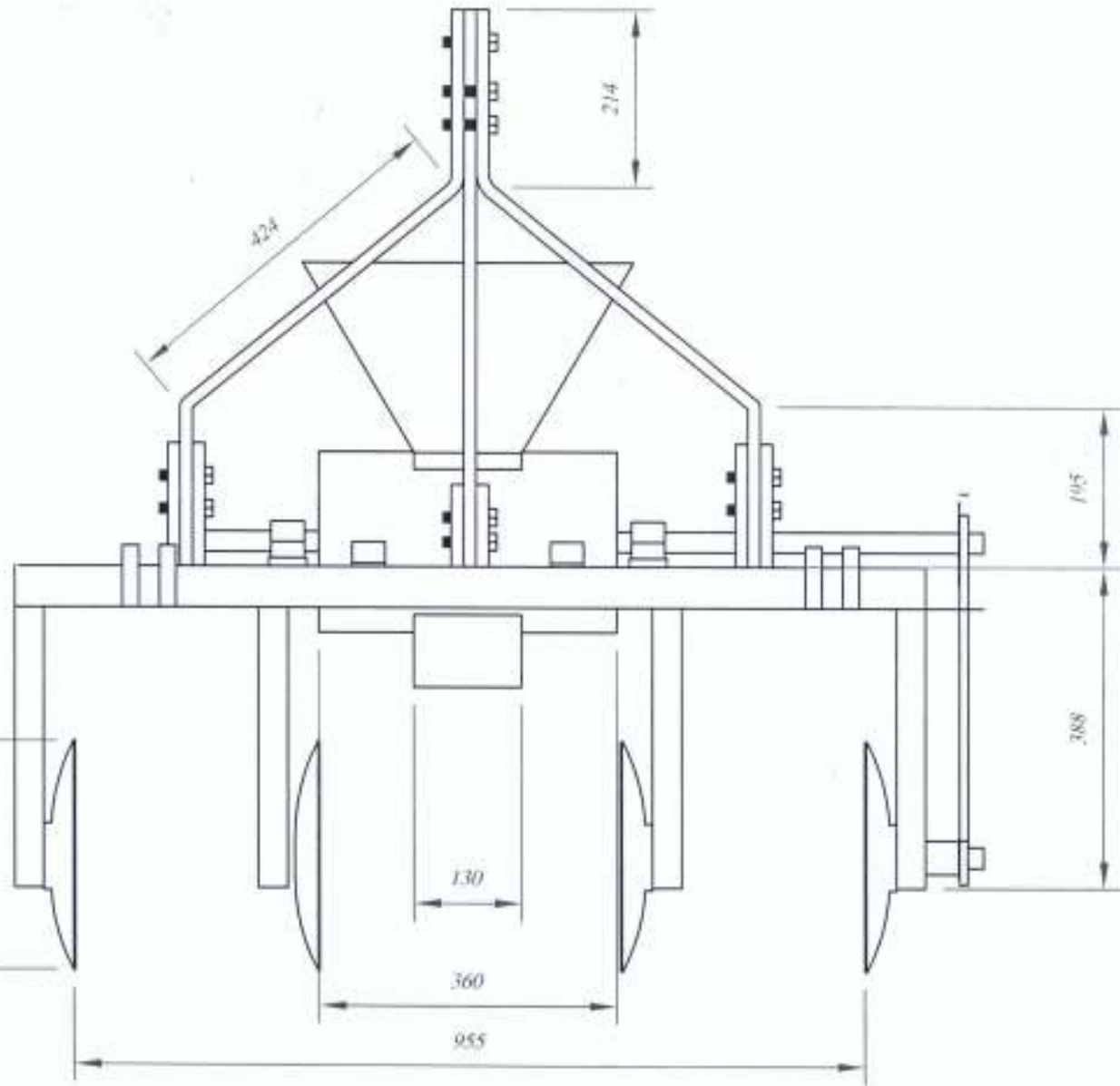
**MAT. NO** AGE/93/4466

**SCALE** 1 : 16

**UNIT** MILLIMETRE

**CHECKER AND APPROVED BY** PROF. L.A.S. AGBETOYE

FRONT VIEW



**DEPARTMENT**  
AGRICULTURAL ENGINEERING

**PROJECT TITLE**  
DEVELOPMENT OF A CONCERN PLANTER

**SUPERVISOR**

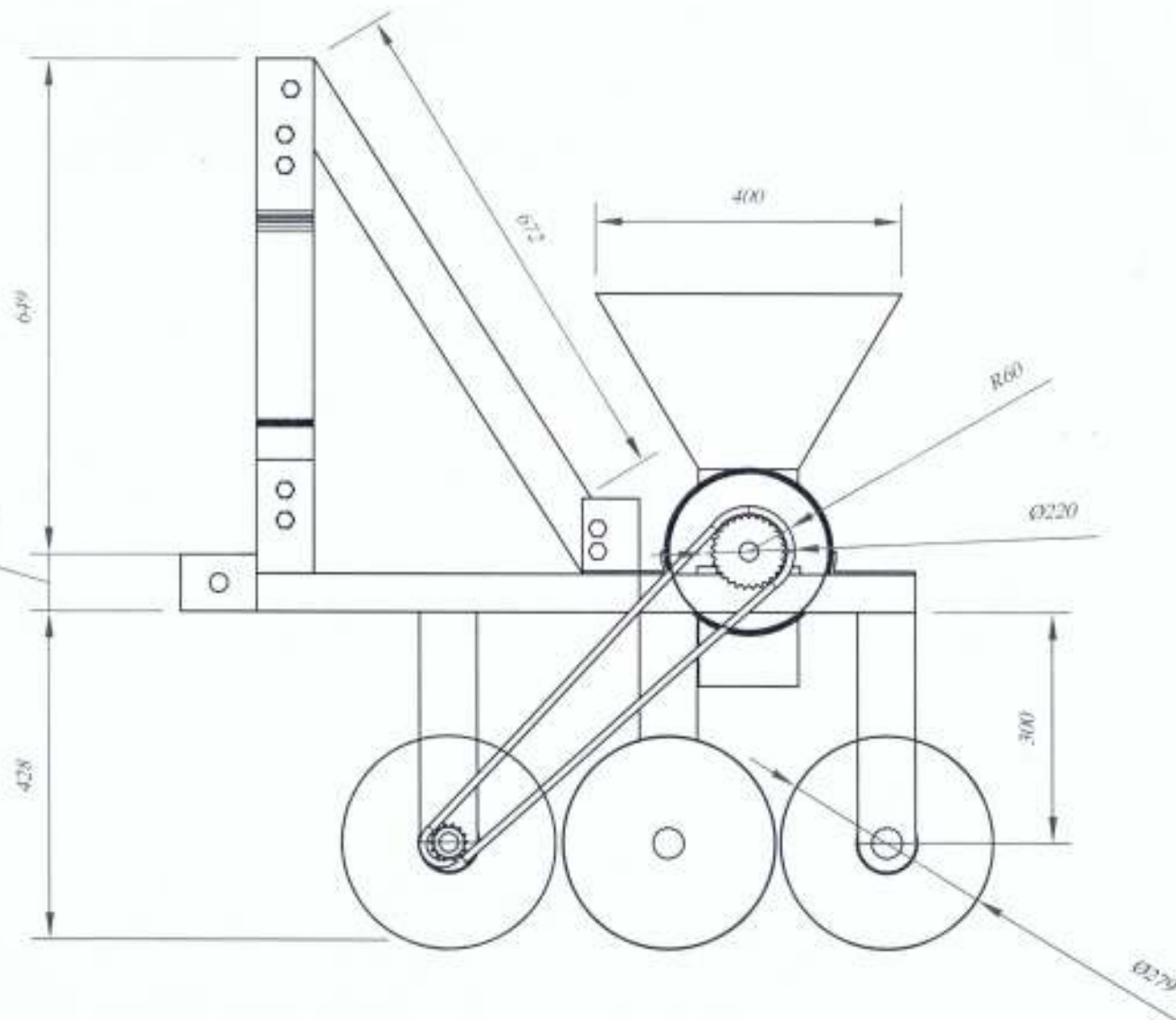
PROF. L.A.S. AGBETOYE

<b>NAME</b>	FALEYE, TOPE
<b>MAT. NO</b>	AGE93-4466
<b>SCALE</b>	1 : 16
<b>UNIT</b>	MILLIMETRE
<b>ENGINEER AND APPROVED BY</b>	PROF. L.A.S. AGBETOYE

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AKURE.

**DEPARTMENT**  
AGRICULTURAL ENGINEERING

**PROJECT TITLE**  
DEVELOPMENT OF A CYCLOAM PLANTER



SIDE VIEW

**SUPERVISOR**

PROF. L.A.S. AGBETOYE

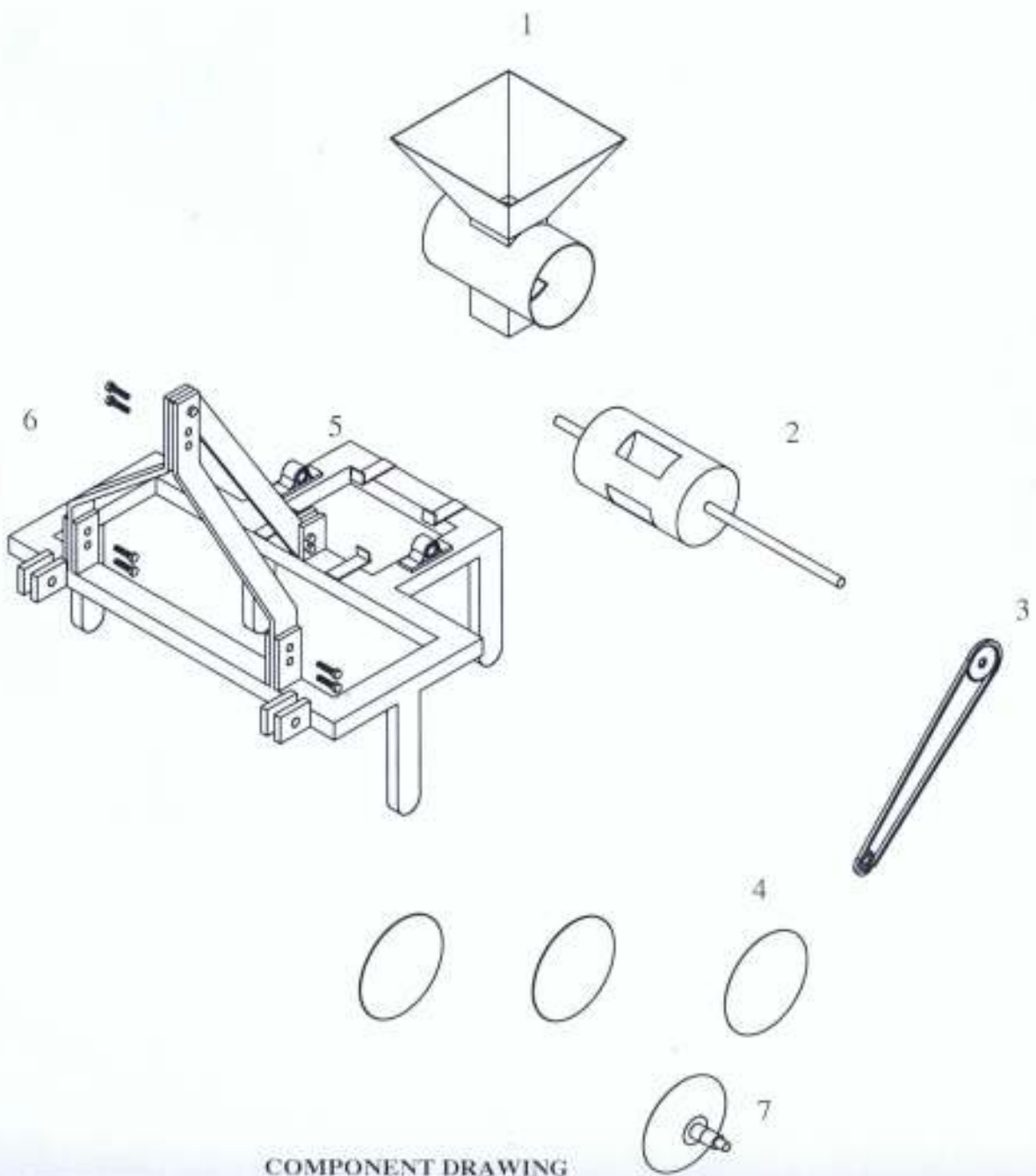
**NAME** FALEYE, TOPE

**MAT. NO** AGE934466

**SCALE** 1 : 10

**UNIT** MILLIMETRE

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COMPONENT DRAWING

FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE.	
<b>DEPARTMENT</b> AGRICULTURAL ENGINEERING	
<b>PROJECT TITLE</b> DEVELOPMENT OF A COCKYAM PLANTER	
<b>COMPONENTS</b>	
<b>ITEM NO.</b>	<b>DESCRIPTION</b>
1	Hopper
2	Metering device
3	Chain and Sprocket
4	Ridging disc
5	Frame
6	Coupling pin
7	Stud for sprocket
<b>SUPERVISOR</b>	
PROF. L.A.S. AGBETOYE	
<b>NAME</b>	FALEYE, TOPE
<b>MAT. NO</b>	AGE/93/4466
<b>SCALE</b>	1 : 16
<b>UNIT</b>	MILLIMETRES
<b>CHECKED AND APPROVED BY</b>	PROF. L.A.S. AGBETOYE