JOURNAL OF ADVANCEMENT IN
ENGINEERING AND TECHNOLOGY

Journal homepage: http://scienceq.org/Journals/JAET.php

Research Article Open Access

Design and Fabrication of a Single Row Maize Planter for Garden Use

Ibukun B. IKECHUKWU[1], Agidi GBABO[2], Ikechukwu C. UGWUOKE[3]

1,3. Department of Mechanical Engineering, Federal University of Technology, Niger State, Nigeria.
2. National Cereals Research Institute, Badeggi, Niger State, Nigeria.

*Corresponding author: Ikechukwu C. UGWUOKE,
Department of Mechanical Engineering,
Federal University of Technology,
PMB 65, Minna, Niger State, Nigeria.
E-mail: ugwuokeikechukwu@yahoo.com

Received: APRIL 8, 2014, Accepted: April 22, 2014, Published: April 24, 2014.

ABSTRACT

This work focused on the design and fabrication of a manually operated single row maize planter capable of delivering seeds precisely in a straight line with uniform depth in the furrow, and with uniform spacing between the seeds. The work demonstrates the application of engineering techniques to reduce human labour specifically in the garden. The results obtained from the trial tests showed that the planter functioned properly as expected with a planting capacity of 0.0486 hectare/hr. Visual inspection of the seeds released from the planter's metering mechanism showed no visible signs of damage to the seeds.

Keyword: *Design, fabrication, manually operated, single row, maize planter.*

INTRODUCTION

Maize has been in the diet of Nigerian's for centuries. It started as a subsistence crop and has gradually become a more important commercial crop [1]. In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products. Maize is an important source of carbohydrate, protein, iron, vitamin B, and minerals. Africans consume maize as a starchy base in a wide variety of porridges, pastes, grits, and beer. Green maize (fresh on the cob) is eaten parched, baked, roasted or boiled; playing an important role in filling the hunger gap after the dry season [2]. In Africa, especially in the sub-Saharan Africa countries, the use of hoes and cutlasses for crop cultivation is still prevalent due to abject poverty within the region. A seed planter is simply a device or tool used to sow seeds. In small scale landscaping and gardening, manually operated seed planters can be used, while in large farm cultivations, the planter can be a massive device usually attached to the back of a tractor. Seed planters depend on both human and machine effort for its operation.

Research indicates that most growers could improve their yields by just improving on the planter's performance [3-5]. This work focused on the design and fabrication of an affordable manually operated single row maize planter specifically for garden use. The design was to improve on seed spacing and depth uniformity in the seed planting process. The benefits of this particular design includes: Increased agricultural output; Reduced production cost, which makes the planter affordable; Makes crop cultivation less laborious; Makes farming more attractive to the youths; Reduces urban migration by youths in search of white collar jobs; Ensures capacity utilization of available farm land; Saves tremendous amount of time during farming.

DESCRIPTION, DESIGN ANALYSIS, AND MATERIAL SELECTION

The function of a well-designed seed planter is to meter seeds of different sizes and shapes, place the seed in the acceptable pattern of distribution in the field, place the seed accurately and uniformly at the desired depth in the soil and cover the seed and compact the soil around it to enhance germination and emergence [6]. The recommended row to row spacing, seed rate, seed to seed spacing and depth of seed placement vary from crop to crop and for different agro-climatic conditions to achieve optimum yields. Seed flow through a planter is dependent on size, shape, sphericity, true density and angle of repose of seeds. In addition, the impact of seeds on the internal components of the planter is influenced by the coefficient of restitution of seeds on various impinging surfaces [7].

Main Frame

The main frame is the skeletal structure of the seed planter on which all other components are mounted. The two design factors considered in the determination of the material required for the frame are the weight and strength. In this work, mild steel angle bar of 50.8mm x 50.8mm and 4mm thickness were used to give the required rigidity.

Adjustable Handle

The handle of the seed planter was designed to be adjustable for the different height of individuals thereby reducing drudgery. The handles help the operator to push the planter while in operation. The material used for the handle was a combination of 1 inch mild steel square pipe, ¾ inch mild steel square pipe, and 1 inch mild steel angle bar.

Seed Hopper

The seeds container as the name implies is a device in which the seeds to be planted are kept (transitionally) before their gradual release into the furrowed tunnel. The hopper has the shape of a frustum of a pyramid truncated at the top as shown in Figure 1. To ensure free flow of seeds, the slope of the hopper was fixed at 30o, which is modestly higher than the average angle of repose of the seeds. The seed container also has a lid, with a handle on top to ease opening. The material used for the design was 2mm thick mild steel sheet metal.

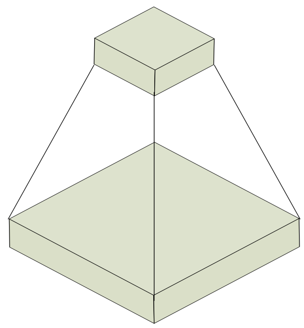

Figure 1: Diagram of the hopper in its inverted form

Seed Metering Mechanism

Metering mechanism is the heart of sowing machine and its function is to distribute seeds uniformly at the desired application rates [6]. In planters it also controls seed spacing in a row. A seed planter may be required to drop the seeds at rates varying across wide range [6]. Proper design of the metering device is an essential element for satisfactory performance of the seed planter. The seed metering device used for this work is the wooden roller type with cells on its periphery. The size and number of cells on the roller depends on the size of seed and desired seed rate. In this design, the wooden roller lifts the seeds in the cells and drops these into the seed funnel which is conveyed to the open furrow through the seed tube. For varying the seed rate and sowing different seeds, three separate rollers were provided. The number of cells on the seed metering device may be obtained from the following expression

$$Number\ of\ cells = \frac{\pi \times Diameter\ of\ the\ planter's\ ground\ wheel}{Intra-row\ spacing\ of\ seeds} \quad (1)$$

Recommended intra-row spacing for maize are [6]

Adjustable Furrow Opener

The design of furrow openers of seed planters varies to suit the soil conditions of particular region. Most seed planters are provided with pointed tool to form a narrow slit in the soil for seed deposition. The adjustable furrow opener permits planting at each variety's ideal ground depth. The type used for this work is the pointed bar type. These types of furrow openers are used for forming narrow slit under heavy soils for placement of seeds at medium depths. The material used for the design was 50mm x 5mm mild steel flat bar.

Adjustable Furrow Closer

The furrow closer was also designed to be adjustable. The type used for this design is the shoe type furrow closer. It was designed to allow for proper covering and compaction of the soil over the seeds in the furrows. The material used for the design was 50mm x 5mm mild steel flat bar.

Drive Wheel

The wheels are located at both ends of the frame. They are circular in shape containing 1 inch square pipes which serves as spokes. These spokes are used to support the centre bushing or hub. The spokes are arranged in such a way that it braced the wheels circular circumference and also gives it necessary radial support. Material used for the design was a combination of both 1 inch mild steel square pipes and 3mm thick mild steel flat bars.

Seed Tube

This was the channel through which seeds are conveyed to the furrow. The material used was a conical funnel with a rubber hose. The outlet diameter is 1 inch.

Bearing Selection

Bearings are selected based on their load carrying capacity, life expectancy and reliability. Ball bearings are fixed in the bushing provided at the two ends of the frame in other to support the eccentric shaft on which the wheels are attached. They allow the carrying of an impressive load without wear and tear and with reduced friction. This device ensures the smooth operation of the wheels. The material for the bearing is high speed steel.

Determination of the Weight of the Hopper Material

From Figure 2, using Pythagoras theorem, the length EK is obtained as follows

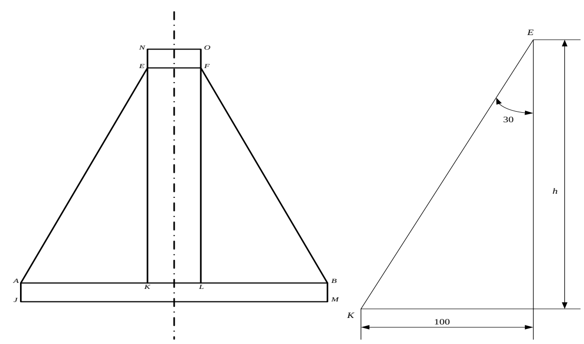

Figure 2: Diagram showing one part of the hopper in its inverted form

$$EK^2 = FL^2 = 0.1^2 + h^2 \quad (2)$$

$$EK = FL = \sqrt{0.1^2 + h^2} \quad (3)$$

$$Area\ EAK = Area\ FBL = \frac{1}{2} \times AK \times FL \quad (4)$$

$$Area\ EKLF = KL \times FL \quad (5)$$

$$Area\ EFON = EF \times EN \quad (6)$$

$$Area\ ABMJ = AB \times BM \quad (7)$$

$$A_{HM}\ \ for\ one\ side = 2 \times \frac{1}{2} \times AK \times FL + KL \times FL + EF \times EN + AB \times BM \quad (8)$$

$$A_{HM} = 4 \times A_{HM}\ \ for\ one\ side\ of\ hopper\ material \quad (9)$$

$$V_{HM} = A_{HM} \times t_{HM} \quad (10)$$

$$M_{HM} = V_{HM} \times \rho_{HM} \quad (11)$$

$$W_{HM} = M_{HM} \times Acceleration\ due\ to\ gravity \quad (12)$$

Where,

A_{HM} = *Surface area of the hopper material*

V_{HM} = *Volume of the hopper material*

t_{HM} = *Thickness of the hopper material*

$M_{HM} =$ *Mass of the hopper material*

$\rho_{HM} =$ *Density of the hopper material*

$W_{HM} =$ *Weight of the hopper material*

From computations, the weight of the hopper material $W_{HM} = 112$N

Determination of the Weight of the Main Frame Material

From Figure 3, the weight of the main frame material may be obtained from the following expressions

$$A_{MFM} = [w_{MFM} + (w_{MFM} - t_{MFM})](6 \times L + 4 \times l) \quad (13)$$

$$V_{MFM} = A_{MFM} \times t_{MFM} \quad (14)$$

$$M_{MFM} = V_{MFM} \times \rho_{MFM} \quad (15)$$

$$W_{MFM} = M_{MFM} \times Acceleration\ due\ to\ gravity \quad (16)$$

Where,

$A_{MFM} =$ *Surface area of the main frame material*

$w_{MFM} =$ *Width of the main frame material*

$V_{MFM} =$ *Volume of the main frame material*

$t_{MFM} =$ *Thickness of the main frame material*

$M_{MFM} =$ *Mass of the main frame material*

$\rho_{MFM} =$ *Density of the main frame material*

$W_{MFM} =$ *Weight of the main frame material*

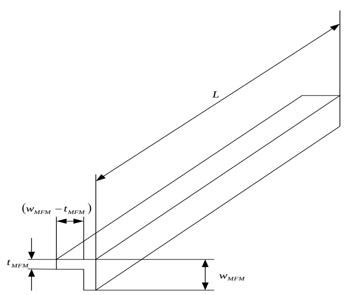

Figure 3: Diagram of the angle bar used for the main frame

Determination of the Weight of Grain

From Figure 4, using Pythagoras theorem, the lengths QG and AC are determined as follows

$$EG^2 = EF^2 + FG^2 \quad (17)$$

$$EG = \sqrt{EF^2 + FG^2} \quad (18)$$

$$QG = \frac{1}{2} EG = \frac{1}{2} \times \sqrt{EF^2 + FG^2} \quad (19)$$

$$AC^2 = AB^2 + BC^2 \quad (20)$$

$$AC = \sqrt{AB^2 + BC^2} \quad (21)$$

$$RC = \frac{1}{2} AC = \frac{1}{2} \times \sqrt{AB^2 + BC^2} \quad (22)$$

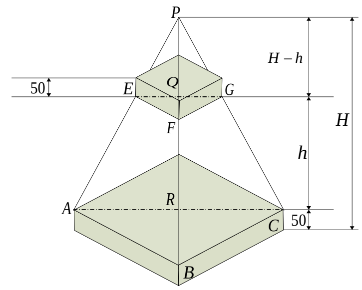

Figure 4: Schematic diagram of the hopper in its inverted position

Application of the principle of similar triangles to the triangles , one obtains the overall height of the frustum as follows

$$\frac{PQ}{QG} = \frac{PR}{RC} \quad (23)$$

$$PQ = QG \times \frac{PR}{RC} \quad (24)$$

$$H - h = QG \times \frac{H}{RC} \quad (25)$$

$$H - \frac{QG}{RC} H = h \quad (26)$$

$$H\left(1 - \frac{QG}{RC}\right) = h \quad (27)$$

$$H = \frac{h}{\left(1 - \frac{QG}{RC}\right)} \quad (28)$$

The volume of the hopper may be obtained from the following expression

$$\begin{aligned} V_H &= \frac{1}{3}[(area\ of\ \ frustum\ base) \times overall\ height\ of\ \ frustum] \\ &\quad - \frac{1}{3}[(area\ of\ truncated\ \ frustum\ base) \times height\ of\ truncated\ \ frustum] \\ &\quad + volume\ of\ the\ square\ extension\ at\ the\ top\ and\ bottom\ of\ hopper \\ &= \frac{1}{3}[(AB \times BC)H - (EF \times FG)(H - h)] + [(AB \times BC) + (EF \times FG)] \times 0.05 \end{aligned} \quad (29)$$

$$M_G = V_H \times \rho_G \quad (30)$$

$$W_G = M_G \times Acceleration\ due\ to\ gravity \quad (31)$$

Where,

$V_H =$ *Volume of hopper*

$M_G =$ *Mass of grain*

$\rho_G =$ *Density of grain*

$W_G =$ *Weight of grain*

From computations, the weight of the grain $W_G = 204$N

Determination of the Maximum Bending Moment

Figure 5 shows the load distribution on the shaft. The maximum bending moment may be determined from the following expressions

$$R_1 + R_2 = 2 \times \frac{1}{2}(W_{MFM} + W_{HM} + W_{GRH}) + W_{GRS} \quad (32)$$

$$R_1 = \frac{1}{0.5}\left[\frac{1}{2}(W_{MFM} + W_{HM} + W_{GRH}) \times 0.45 + W_{GRS} \times 0.25 + \frac{1}{2}(W_{MFM} + W_{HM} + W_{GRH}) \times 0.05\right]$$

Where,

$R_1, R_2 =$ *Reactions at the support*

$W_{GRH} =$ *Weight of grain resting on the hopper*

$W_{GRS} =$ *Weight of grain resting on the shaft*

Using the method of sectioning, the following expressions were obtained for the bending moment

$$M_{b1} = R_1 \times 0.05 \quad (34)$$

$$M_{b2} = R_1 \times 0.25 - \frac{1}{2}(W_{MFM} + W_{HM} + W_{GRH}) \times 0.20 \quad (35)$$

$$M_{b3} = R_1 \times 0.45 - \frac{1}{2}(W_{MFM} + W_{HM} + W_{GRH}) \times 0.4 - W_{GRS} \times 0.2 \quad (36)$$

The maximum value in equation (36), (37), and (38) is taken as the maximum bending moment for the shaft.

$$V_{GRS} = 0.45 \times (EF \times FG) \quad (37)$$

$$M_{GRS} = V_{GRS} \times \rho_G \quad (38)$$

$$W_{GRS} = M_{GRS} \times Acceleration\ due\ to\ gravity \quad (39)$$

$$W_{GRH} = W_G - W_{GRS} \quad (40)$$

Where,

$V_{GRS} =$ *Volume of grain resting on the shaft*

$M_{GRS} =$ *Mass of grain resting on the shaft*

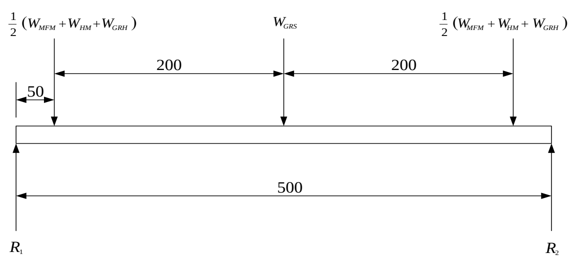

Figure 5: Load distribution on shaft

From computations, the maximum bending moment $M_b = M_{b2} =$ 12.91Nm

Determination of the Shaft Diameter

Shaft design consists primarily of the determination of the correct shaft diameter to ensure satisfactory strength and rigidity when the shaft is transmitting power under various operating and loading conditions. Design of shafts of ductile material based on strength is controlled by maximum shear theory. The material for the shaft is mild steel rod. For a shaft having little or no axial loading, the diameter may be obtained using the ASME code equation [9] given as

$$d^3 = \frac{16}{\pi S_a}\sqrt{(k_b M_b)^2 + (k_t M_t)^2} \quad (41)$$

Where,

$d =$ *Diameter of the shaft*

$M_b =$ *Bending moment*

$M_t =$ *Torsional moment*

$k_b =$ *Combined shock and fatigue factor applied to bending moment*

$k_t =$ *Combined shock and fatigue factor applied to torsional moment*

$S_a =$ *Allowable stress*

For rotating shafts, when load is suddenly applied (minor shock) [9]:

$$k_b = 1.5\ to\ 2.0 \qquad k_t = 1.0\ to\ 1.5 \quad (42)$$

For shaft without key way, allowable stress $S_a = 55MN/m^2$

For shaft with key way, allowable stress $S_a = 40MN/m^2$

From computations, the diameter of shaft d = 14.87mm

Determination of the Planter Push Force

Figure 6 gives the free body diagram showing all the forces acting on the planter. The force required to push the planter may be obtained from the following expressions

$$\sum F_x = F_P \cos\theta - R_S \cos\phi - F_R = 0 \quad (43)$$

$$\sum F_y = R_S \sin\phi - F_P \sin\theta - W_P = 0 \quad (44)$$

Where,

$F_P =$ *Planter push force*

$F_R =$ *Horizontal soil resistance force*

$R_S =$ *Soil frictional resistance force*

$\phi =$ *Angle of friction*

$\theta =$ *Angle between planter handle and the horizontal plane*

$W_P =$ *Weight of planter*

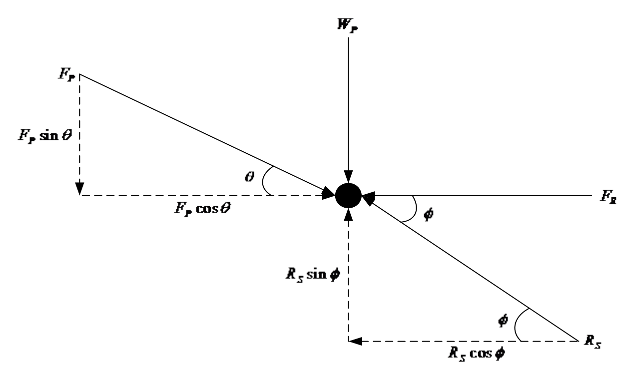

Figure 6: Free body diagram showing all the forces acting on the planter

From equation (43)

$$F_P = \frac{R_S \cos\phi + F_R}{\cos\theta} \quad (45)$$

Substituting equation (45) into equation (44), we get

$$R_S = \frac{F_R \tan\theta + W_P}{(\sin\phi - \cos\phi\tan\theta)} \quad (46)$$

Determination of the Maximum Draft on the Planter

The maximum draft on the planter is a function of the soils resistance on the machine and the area of contact of the furrow opener with the soil. The maximum draft on the planter is the horizontal component of push parallel to the line of motion in order to overcome the soil resistance on the planter [8]. The maximum draft may therefore be obtained from the following expression

$$D_{FM} = R_S \times A_{FO} \times Acceleration\ due\ to\ gravity \quad (47)$$

$D_{FM} =$ Maximum draft

$A_{FO} =$ Surface area of furrow opener in contact with soil

$A_{FO} = Recommended\ depth\ of\ cut \times Thickness\ of\ furrow\ opener$ (48)

For sandy soil, $D_{FM} = 0.210kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 10.816N$

For sandy moist soil, $D_{FM} = 0.245kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 12.618N$

For sandy loam dry soil, $D_{FM} = 0.315kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 16.223N$

For silt loam moist soil, $D_{FM} = 0.385kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 19.828N$

For silt loam dry soil, $D_{FM} = 0.455kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 23.434N$

For clay loam moist soil, $D_{FM} = 0.455kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 23.434N$

For clay loam dry soil, $D_{FM} = 0.525kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 27.039N$

For heavy clay dry soil, $D_{FM} = 0.665kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 34.249N$

For heavy clay sod soil, $D_{FM} = 0.735kg/cm^2 \times 5.250cm^2 \times 9.81m/s^2 = 37.854N$

Determination of Planter Capacity

The capacity of the planter may be determined in terms of the area of land covered per time during planting or the number of seeds planted per time of planting. The capacity of the planter in terms of the area of land covered per time may be obtained from the following expression

$$C_{PA} = \frac{Area\ covered\ by\ planter}{10000m^2} \quad (hectare/time) \qquad (49)$$

$C_{PA} =$ Capacity of planter in hectare/time

$$Area\ covered\ by\ planter = (Inter-row\ spacing) \times (Distance\ covered\ by\ planter)\ (m^2/time) \qquad (50)$$

$$Distance\ covered\ by\ planter = (Speed\ of\ planter) \times (Time\ of\ planting)\ (m/time) \qquad (51)$$

The speed of the planter may be obtained from raw experiment. The capacity of the planter for maize is therefore obtained as follows:

$$C_{PA}\ for\ maize = \frac{Area\ covered\ by\ planter\ for\ maize\ in\ m^2/time}{10000m^2/hectare} \quad (hectare/time)$$

$$= \frac{486m^2/hr}{10000m^2/hectare} = 0.0486hectare/hr$$

The capacity of the planter in terms of number of seeds planted per time may be obtained from the following expression

$$C_{PN} = \frac{Distance\ covered\ by\ planter\ per\ time}{Intra-row\ spacing} \times Number\ of\ seeds\ per\ hole\ (seeds/time) \qquad (52)$$

$C_{PN} =$ Capacity of planter in terms of number of seeds/time

For 0.2 intra-row spacing, $C_{PN} = \frac{540m/hr}{0.2m} \times 2seeds = 5400seeds/hr$

For 0.25 intra-row spacing, $C_{PN} = \frac{540m/hr}{0.25m} \times 2seeds = 4320seeds/hr$

For 0.3 intra-row spacing, $C_{PN} = \frac{540m/hr}{0.3m} \times 2seeds = 3600seeds/hr$

Time required cultivating a hectare of land

The time required to cultivate 1 hectare of land is therefore obtained as follows

$$Time\ required = \frac{1}{0.0486} = 20.576hrs$$

Number of days required to plant on a hectare of land

Assuming 8hrs is used per day for planting, the number of days required to plant on 1 hectare of land is obtained as follows

$$Number\ of\ days\ required = \frac{20.576hrs}{8hrs/day} = 2.572\ days \approx 2.6\ days$$

FABRICATION AND TESTING

As shown in Figure 7, all the parts of the maize planter were fabricated from mild steel material, except for the metering mechanism which was fabricated from good quality wood (mahogany), the seed funnel which was made from rubber material, and the seed tube which was also made from rubber material. The choice of rubber material for the seed funnel and seed tube was because the coefficient of restitution for rubber material is lower than that of a mild steel sheet of the same thickness. The rubber material will go a long way in minimizing seed bouncing, thereby protecting the seeds from damage due to impact.

The hopper was fabricated using 2mm thick mild steel metal sheet. The metering mechanism was fabricated from good quality wood material (mahogany). The main frame which supports every other component of the multi-crop planter was fabricated using 2 inch angle bar of 4mm thickness. The adjustable handle for the planter was fabricated using a combination of 1 inch mild steel square pipe, ¾ inch mild steel square pipe, and 1 inch mild steel angle bar. The adjustable furrow opener and furrow closer were both fabricated using a 50mm x 5mm mild steel flat bar. The planter's ground wheels were fabricated using a combination of both 1 inch mild steel square pipes and 3mm thick mild steel flat bars. Furrow opener and closer were designed to be interchangeable. For this design, the drive shaft directly controls the seed metering mechanism which eliminates completely attachments such as pulleys, belt systems, and gears thereby eliminating complexities which increase cost, and increasing efficiency at a highly reduced cost.

Figure 7: Photograph of component parts of the fabricated maize planter

Figure 8 shows the diagram of the seed planter indicating necessary dimensions. Trial tests were conducted to see if the seed metering mechanism, furrow opener, and furrow closer are functioning properly. The results show that they are functioning properly as expected. For a furrow opener, the ability to place the seed at a given sowing depth in the soil is an important factor in evaluating its performance. For the planter operation, the hopper was filled with seeds. The filling of the hopper depends on how much area of the field to be covered. As the multi-crop planter was pushed forward in the direction of travel at an average speed of

0.15m/s, the pointed bar type furrow opener penetrated the soil creating a furrow for seeds to be placed. The planter's ground wheel is connected directly to the seed metering device, and as the ground wheel rotates, the seed metering device placed at the bottom of the hopper also rotates, thereby releasing two or three seeds depending upon the size of the cells or the size of the seeds. These seeds are then conveyed to the furrow through the seed tube. The furrow was then closed by the shoe type furrow closer. A close visual inspection of the seeds that were released from the planter's metering mechanism shows no visible sign of damage.

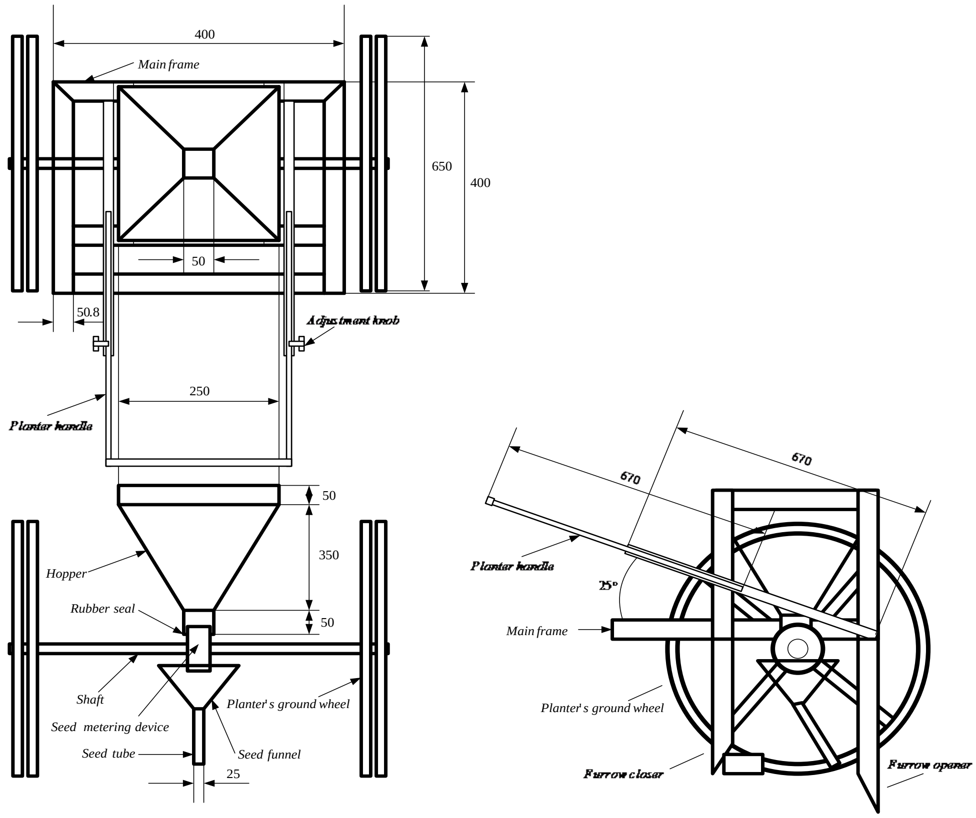

Figure 8: Diagram of the seed planter indicating necessary dimensions

CONCLUSION

This work focused on the design and fabrication of a manually operated single-row maize planter that is cheap, easily affordable, easy to maintain and less laborious to use. The planter will go a long way in making farming more attractive and increasing agricultural output. All parts of the planter were fabricated from mild steel material, except for the metering mechanism which was made from good quality wood (mahogany) and the seed funnel and tube, which were made from rubber material. The seed metering mechanism used for this work was the wooden roller type with cells on its periphery. For this design, the drive shaft directly controls the seed metering mechanism which eliminates completely attachments such as pulleys, belt systems, and gears thereby eliminating complexities which increase cost, and increasing efficiency at a highly reduced cost. The results obtained from the trial tests showed that the planter functioned properly as expected with a planting capacity of 0.0486 hectare/hr. Visual inspection of the seeds that were released from the planter's metering mechanism showed no visible signs of damage to the seeds.

REFERENCES

1. J.E. Iken and N.A. Amusa, Maize research and production in Nigeria. African Journal of Biotechnology, Vol. 3 (6), 2004, pp. 302-307.
2. Maize, http://old.iita.org/cms/details/maize_project_details.aspx?zoneid=63&articleid=273, 18/4/2014.
3. C.G. Carlson, T.A. Doerge and D.E. Clay, Estimating Corn Yield Losses from Unevenly Spaced Planting. SSMG, pp. 1-4. http://nue.okstate.edu/CORN/Corn_YieldLoss.pdf, 18/4/2014.
4. S. Butzen and T. Hall, Planter Maintenance and Calibration, DuPont Pioneer, https://www.pioneer.com/home/site/us/template.CONTENT/guid.03EDD6D3-84B2-4E5F-A6C6-005380C343F0/, 18/4/2014.
5. New Research Confirms Benefits of Improved Plant Spacing in Corn, DuPont Pioneer, https://www.pioneer.com/home/site/us/template.CONTENT/guid.DBC8CF40-30FC-4923-824C-3C9F3581B22B/, 18/4/2014.
6. Sowing and Planting Equipment, http://agricoop.nic.in/dacdivision/machinery1/chap2a.pdf, pp. 46-79, 11/4/2014.
7. P.R. Jayan and V.J.F. Kumar, Planter design in relation to the physical properties of seeds. Journal of Tropical Agriculture, 42(1-2), 2004, pp. 69-71.
8. A. Gbabo, Design and construction of a two-row cowpea and maize planter. Maintenance and Repair Unit, Agricultural Engineering Section, National Cereals Research Institute, Badeggi 1988.
9. R.S. Khurmi, and J.K. Gupta, A textbook of machine design. Eurasia Publishing House (Pvt.) Ltd., Ram Nagar, New Delhi-110055, India, 2005, pp. 509-557.

Citation: Ikechukwu C. UGWUOKE, et al (2014) Design and Fabrication of a Single Row Maize Planter for Garden Use. J. of Advancement in Engineering and Technology. V1I2