Indian Journal of Agriculture Engineering (IJAE)
ISSN: 2582-9319 (Online), Volume-4 Issue-1, May 2024

Design and Fabrication of a Tractor- Drawn Multi-Crop Planter

Bedasa Waldaho, Gutu Getahun

Abstract: ***The study was undertaken to design, fabricate multi-crop planter capable of planting maize, common bean and sorghum seeds at predetermined spacing and depths. Physical properties of seeds involved in the study were investigated to optimize the design of the planter's components. The planter, consists of a frame, seed hopper, seed metering devices, seed tube, adjustable furrow opener, adjustable furrow covering device, and drive wheels. The investigation revealed that the sphericity of maize, common bean and sorghum were 64.8, 72.4 and 81%, respectively. Percentages of mechanically seed damaged by the planter were zero for each crops. Germination test was conducted to assess the magnitude and extent of invisible seed damage inflicted by the planter indicated mean percentage seed germination of 98.5, 94.5 and 97.3% for maize, common bean, and sorghum, respectively. The reduction in percentage germination of maize, common bean and sorghum were zero, when compared with that did not passes through the machine for all the seeds tested. Based on the above results, it is concluded that the planter can be efficiently and effectively used by the majority of the farmers and other stakeholders in the study area.***

Keywords: Planter, Multi-Crop, Capacity, Efficiency

I. INTRODUCTION

Planting is an art of placing seeds in the soil to have good germination. It was began with the use of hands and later the use of stones, hand tools and mechanized form of planting [26].Manual methods of planting resulted in low seed placement, low spacing efficiency, and health issues for the farmer considering the size of the farm land [14,23]). Seed planting machine is a device which helps in sowing seeds in a desired position, there by assisting the farmers in saving time and reducing cost. The basic objective of sowing operation is to put the seed in rows at desired depth and seed to seed spacing, cover the seeds with soil and provide proper compaction over the seed [23]. However, in fabricating the form of this mechanized planting equipment, some properties of the plant which is to be planted must be determined in order to accurately specify the design considerations [11]. The physical properties such as seed size, shape, axial dimensions, roundness and sphericity helps to determine the maximum size of the cup in the seed plate, the weight help in the material selection for the frame of the planter, the bulk density and moisture content helps to know the interaction between the seed and the material used for the hopper of the planter at maximum heat level [10]. The design and manufacture of tractor-mounted planters has eliminated most of the limitation attached to the manual methods. Thus, the need for appropriate technology to deliver optimal yield while using fewer resources is very essential. Hence, this research project is intended to bridge the existing technology gaps in the area of crop establishment. The objectives of this thesis research was to design, fabricate and characterize the physical properties of selected seeds for tractor- drawn multi-crop planter.

Manuscript received on 01 May 2024 | Revised Manuscript received on 12 May 2024 | Manuscript Accepted on 15 May 2024 | Manuscript published on 30 June 2024.
***Correspondence Author(s)**
Bedasa Waldaho*, Oromia Agricultural Research Institute, Fedis Agricultural Research Center P.O. Box 904, Harar, Ethiopia. E-mail: bedasawaldawo12@gmail.com, ORCID ID: 0009-0000-0872-3463
Gutu Getahun, Oromia Agricultural Research Institute, Fedis Agricultural Research Center P.O. Box 904, Harar, Ethiopia. E-mail: gutugetahun@gmail.com

II. MATERIALS AND METHODS

A. Experimental Site and Experimental Crops

Fabrication of the prototype planter was done at Fadis Agricultural Research Center (FARC) metal workshop (Harar) maize, common bean and sorghum seeds were used to design the planter that was fabricated at FARC metal workshop. The crops, maize, common bean and sorghum, were selected for the study because of their dominance among row planted crops in the study areas. Hence, the planting machine was designed to plant these seeds. The varieties of maize, common bean and sorghum seeds were Melkassa-2, Awash-2 and Melkem, respectively. Selected seeds were taken from Fedis Agricultural Research Centre, crop research process and the seeds had germination percentages of 98.5%, 94.5%, and 97.33%, for maize, common bean and sorghum, respectively

B. The Planting Machine

The machine was designed for four wheels 30 hp tractor and has three different replaceable seed metering cups that were designed to handle maize, common bean and sorghum seeds. Since the planter was designed for three different crops and was adjustable as particular crop's row spacing requirements.

C. Physical Properties of Selected Crops

The physical properties of seeds are important factors for the design of crop planter. Performance of seed metering mechanism in terms of picking, metering and dropping was influenced by the physical and Mechanical properties of seeds. Therefore, seed properties relevant to the design of planter were identified and determined. The general procedure was used in determining seed physical parameters i.e. Geometric mean diameter (Ds), Sphericity (S) and Volume were computed by taking a specified number of randomly selected seed.

Then their three principal diameters (major, intermediate and minor lengths) denoted as mean length (L), mean width (W) and mean thickness (T) respectively were measured using a micrometer of 0.01 mm accuracy. The measured values were then used to determine Geometric mean diameter (Ds) using equation (1) by [23] as well as Mean volume (V) and mean seed sphericity (Sm). Thirty (30) grain samples were selected randomly from the sample and dimensions were measured. Length, width and thickness of the seed were taken using digital vernier caliper. The mean and standard deviation of dimensions were calculated.

D. Size, Sphericity and Surface Area

The volume and sphericity of the individual seeds were calculated using the measured larger diameter, medium diameter and smaller diameter of the seeds and equations given below [4].

E. Physical Property, that is, Geometrical Mean

$$Dg=\sqrt[3]{L \times W \times T} \quad (1)$$

$$V=\frac{\pi}{6}\ (L \times W \times T) \quad (2)$$

$$S_m=\frac{\sqrt[3]{L \times W \times T}}{L} \times 100 \quad (3)$$

Where: L=Length (mm)
W=width (mm)
T=Thickness (mm)
V = volume (mm^3)
Dg = geometric diameter (mm)
Sm = seed sphericity

a. *Bulk density of the crops*

The bulk density was found by taking crops in a container of cylindrical shape. The volume of the container was found by measuring diameter and height for cylindrical container. The weight of the grain in the container was found separately. The bulk density was calculated, three samples from each selected crops were taken and average bulk density was calculated as shown equation (4)

$$B_d = \frac{W_C}{V_C} \quad (4)$$

Where: Bd = Bulk density in kg/m^3 or g/cm^3
Wc = Weight of sample in kg or g
Vc = Volume of sample in m^3 or cm^3

b. *Angle of repose of the crops*

The equipment used for measuring angle of repose consisted of a funnel with an adjustable throat opening mounted on a stand. The funnel was filled with seeds by keeping its adjustable throat closed. The throat was fully opened to allow free flow of seeds over and around the plate mounted beneath the funnel. At the end of process, a heap-cone of the seed was formed on the plate. From the heap-cone, base diameter and height of cone were measured. For free-flowing agricultural grains, angle repose is assumed to be approximately 28. For free-flowing grains the angle of repose can be assumed to be equal to that of the angle of internal friction. The angle of repose was calculated using the equation (5)

$$\theta=\tan^{-1}\left(\frac{2H}{D}\right) \quad (5)$$

Where: θ = is angle of repose, degree
H =is height of cone, mm
D =is base diameter of cone, mm

c. *Thousand grain mass*

In the laboratory thousand (1000) grains were selected randomly and then weighed on the sensitive weight balance to obtain the thousand grain mass in gram. The ten sample of each crop was weighed and mean thousand grain mass of each crop was found out.

d. *Moisture content of soil*

The samples were collected from 0 to 15 cm depth of soil surface before operations for determination of moisture content and bulk density. The soil moisture was determined by oven dry method. Five samples were collected randomly from the test plots. The samples were kept in oven for 24 hours at temperature of 105°C and weighed before and after drying. The moisture content (Dry basis) was determined by the following formula [17].

$$Mc\ (\%) = \frac{W_s - W_d}{W_d} * 100 \quad (6)$$

Where: Mc=Moisture content of the Soil sample
Ws= Weight of the soil sample, and
Wd= Weight of dry soil sample

e. *Bulk density of soil*

To determine bulk density of a soil, metallic core sampler was used to take sample from field having 8cm diameter and 12 cm height. The samples were weighed and dry weights of the samples were calculated with the help of moisture content (d.b.). The ratio of dry weight of soil to the volume gave the bulk density. Bulk density of soil was calculated by using following formula [17].

$$Bds = \frac{W_S(g)}{V_S} \quad (7)$$

Where : Bds= Bulk density of soil in (g/cm^3)
Ws = weight of soil samples (g)
Vs= volume of soil in core sampler (cm^3)

F. Description of the Machine and Design Considerations

a. *Overall Structure of the Machine*

The developed Tractor drawn multi-crop planter consists of the frame, seed hoppers, drive/ transport wheels, seed metering devices seed discharge tubes, furrow openers, and furrow covering devices. Tractor drawn multi crop planter was designed as a functional and experimental unit. The design of machine components were based on the principles of operations. It was compared with the conventional method, to give a correct shape of the planter components. The mechanical design details were also given with due attention so that it gave adequate functional strength for the design of the machine. To achieve the best performance from the planter, the important factors were optimized by proper design and selection of the components required to suit the requirements of the crop needs and Figure 2 and Figure 3 shows assembly parts and detail views of the planter respectively.

Retrieval Number:100.1/ijae.E449113050624
DOI:10.54105/ijae.E4491.04010524
Journal Website: www.ijae.latticescipub.com

Published By:
Lattice Science Publication (LSP)

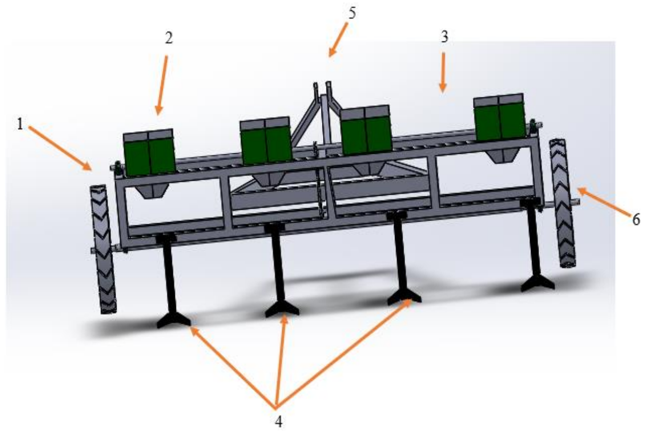

Figure 1: Assembly Drawing of the Prototype Planter

1) Ground wheel (2) Hopper (3) Frame (4) Furrow covering (5) Tractor hitching position (6) Ground wheel shaft.

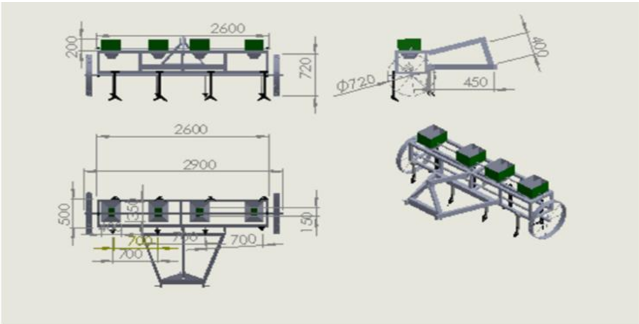

Figure 2: Detail Views (Top, Front and Side) of the Prototype Planter

G. Working Principles of the Machine

The seed metering mechanism of the planter is a cup type vertical drive. As the tractor moved forward the seed-metering device is rotated by a chain-sprocket arrangement through drive wheels. One operator was required to operate the machine. Seed to seed spacing in the field is regulated by the rate of rotation of the seed-metering plates. As the metering plate rotated i.e. the seed spacing of crops were maintained by the planter drive wheel diameter and the size of sprockets attached to the planter drive wheel and shaft of the seed-metering plate and the teeth ratio was 2:1 drive to driven sprocket.

a. Design Considerations for the Machine

The following factors were considered in the design of the planter, such as the physical properties of the agricultural material like length, width, thickness etc. which varies in shape, density and size. The ease of fabrication of component parts, the safety of the operator, Resistivity of metering device to corrosion and, the operation of the machine shall be simple for small scale or rural farmers. Availability of the component parts shall also be available at the local market.

H. Design of Machine Components

a. Determination of Machine Width

In order to show design of the functional components of the planting machine, working width of the machine needs to be determined as a base parameter. According to Sharma and Mukash,[21]. the drawbar horsepower required for the machine was calculated by equation (8) as follows.

$$D_{bhp} = \frac{D_f \times S_f}{270} \quad (8)$$

Where: D_{bhp} = Drawbar horsepower (hp)

D_f = Draft (kg)

S_f = Speed (km/hr) and $D_{bhp} = 0.6 \times D_{bshp}$

Where: D_{bshp} = selected horse power

Giving that a Tractor of 30hp was selected to drive the machine and substituting the value into above equation. Hence $D_{bhp} = 0.6 \times 30 = 18hp$

The speed of sowing with the developed planter is in the range of 2km/h-6km/hr.Assume the tractor drawn multi crop planter can be operated at 6km/h speed for sowing.

Likely the speed of the machine for sowing operation as 6km/hr and substituting the value into equation (8), hence

$$18hp = \frac{D_f \times 6km/hr}{270}$$

$$Df = 810kg$$

According to CFMT, T1and Bundi, the draft requirement per meter width of the planter is given by equation (9) as 150kg/m.

$$Ds = \frac{D_f}{W} \quad (9)$$

Where: D_s = Specific draft (kg/m)

W = working width of the machine

Df= Draft required to pull the machine (kg)

Giving that the specific draft of a planting machine is 150kg/m (CFMT and Bundi) and substituting the value into equation(9). Therefore, width of planter is $\frac{810kg}{150kg/m} = 5.4m$

But designing a 5.4 m width of the planter will have a buckling effect and will also create problem in transportation and handling. Therefore, it is better to design a planter having 4 furrow openers and 70cm spacing between furrow openers for both maize and sorghum. The maximum working width of the planter = 4 furrow opener x 70cm spacing for both crops =280 cm

I. Hopper design

a. Grain Weight Determination

The Seed weight in the hoppers was determined from the net volume of the hopper and bulk density of the seeds. The net volume of hopper is the maximum volume of hopper which able to hold the seed at full load, and the mass of grain was estimated using the following equations [8].

$$M_G = V_S \times \rho_G \quad (10)$$

$$V_S = \frac{Sr}{n \times \rho_G} \quad (11)$$

$$W_G = M_G \times g \quad (12)$$

Where : Assume n=4 number of refill was assumed per hectare

Sr = seeding rate for selected grain

ρ_G = Bulk density of selected grain

Vs = volume of the seed

MG= mass of the seed in the hopper

b. Hopper Description

The hopper was designed to feed the metering devices in vertical direction and have two compartments; one for seeds and the other one for granular fertilizer.

The material used for the construction was mild steel sheet metal with thickness of 1.5 mm, which is readily available in the market and relatively affordable. The hopper has a shape of inverted frustum of rectangular pyramid truncated with square bottom (150 mm x 150 mm having a height of 200 mm) and rectangle at the top (400 mm x 350 mm) and divided into two parts for selected crops and fertilizer. The recommended angle of repose, for gravity discharge for maize, common beans and sorghum, at a moisture content of 15%, were 28^0, 30^0 and 33^0, respectively [25]. The hopper, from its design, is a gravity discharged due to the fact that side slopes of the hoppers were greater than the minimum requirement to discharge any one of the crop's seeds by the action of gravity only. In this case, side slope of 35^0 to the horizontal was selected to ensure free flow of all seeds.

The bulk densities of maize, common bean and sorghum seeds, at a moisture content of 15%, were taken as 720, 725 and 745 kg/m^3, respectively [25]. Seeding rates of 42, 100 and 12 kg/ha for maize, common bean and sorghum, respectively, were considered in the design of hopper capacity. Based on the above stated rates of seeding, the volume of the hopper was estimated using the equation given by [16] as follows:

$$V_m = \frac{Sr}{n \times BD} \quad (13)$$

Where: Sr = seeding rate (kg/ha)

n = number of refilling per hectare

BD = bulk density of the seeds (kg/ m^3)

V_m = Volume of hopper for maize (m^3):

Then the maximum volume of the hopper designed was $V_c = 33.56\times 10^{-3}$m^3

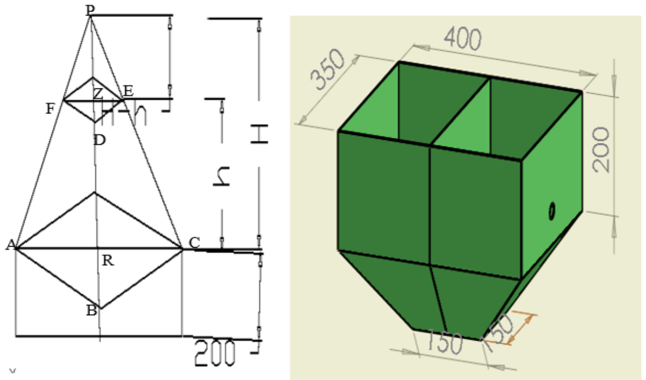

Figure 3: Schematic Drawing of the Hopper Designed in its Inverted Position and Isometric View (All Dimensions are in Mm)

Applying the principle of similar triangles, overall height of the frustum was calculated as follows

$$\frac{PZ}{ZE} = \frac{PR}{RC} \quad (14)$$

$$PZ = ZE\times \frac{PR}{RC}$$

$$H\text{-}h = ZE\times \frac{H}{RC}$$

$$H\text{-} ZE\times \frac{H}{RC} = h$$

$$H\left(1-\frac{ZE}{RC}\right) = h$$

$$H = \frac{h}{\left(1-\frac{ZE}{RC}\right)}$$

$$ZE = \frac{1}{2}\sqrt{FD^2 + DE^2} = \frac{1}{2}\sqrt{150^2 + 150^2} = 106\text{mm}$$

$$RC = \frac{1}{2}\sqrt{AB^2 + BC^2} = \frac{1}{2}\sqrt{350^2 + 400^2} = 266.7\text{mm}$$

$$\text{So}\quad H = \frac{h}{\left(1-\frac{106}{266.7}\right)} = \frac{h}{0.6} = 1.67h$$

$$V = \left[\frac{H}{3} \times (AB \times BC)\right] - \left[\frac{H-h}{3} \times (FD \times DE)\right] + [AB \times BC \times CK]$$

h=76.26mm let say =100mm

J. Design of Seed Metering Device

a. Number of Cells and Distance Between Cells

The metering devices were made from sheet metal with cells on the periphery. The size and number of cells on the plate depended on the size and shape of seeds and desired rate of planting for the particular crop under consideration, respectively. The cells, on circumference of plate, were spaced to give plant spacing of 25, 15 and 25 cm when planting maize, common bean and sorghum, respectively. Fertilizer metering, to effect spot dropping of fertilizer and seed side by side was made possible by providing cells on the separate plate adjacent to seed metering cells. The metering plate, with cells on their circumferences are parallel to each other, one for seed and the other for fertilizer, were mounted and locked in place on the driving shaft. The ground wheel, through the shafts, provided the desired torque to drive the metering devices. The diameter and numbers of cells were determined on the basis of mean size of individual seeds, recommended intra-row spacing of seeds and economical and efficient size (diameter) of driving wheel. Three different seed cups on the plate were used to handle the seeds of three different crops. The plate had the size 3 x 200mm (thickness x diameter). The diameter of the ground wheel was 72cm.The size of the cells in a plate was decided on the basis of the largest seeds size of a given crop. The largest dimension/diameter for maize, common bean and sorghum varied between 8.2 and 12.39, 8.52 and 10.32 and 4.57 and 4.92 mm respectively. The cells to meter maize, common bean and sorghum had 16, 12 and 6 mm diameters and 13, 10.5 and 5 mm depths, respectively. The number of cells and distance between consecutive cells on the seed metering plate were obtained using the following expressions:

$$m = \frac{\pi D_2}{i \times I_{rss}} = \frac{\pi \times 72}{2 \times 25} = 4.52 = 5 \quad (15)$$

$$t = \frac{\pi D1}{m} = \frac{\pi \times 20}{5} = 12.56\text{cm} \quad (16)$$

Where: D_1 = Diameter of seed metering plate (20 cm)

D_2 = Diameter of ground wheel (72 cm)

m = number of cells on a plate (minimum value)

Irss = Intra-row spacing of seeds

t = distance between consecutive cells

i=gear ratio

Therefore the number of cells is 5 and distance between the cells is 12.56 cm for both maize and sorghum.

The number of cells on metering plate was found to be 5, 8 and 5 for maize, common bean and sorghum crops at the predetermined seed spacing, respectively. Similarly, the consecutive distance between cells on each metering plates were determined to be 12.56, 7.85 and 12.56 cm for maize, common bean and sorghum seeds respectively and Figure 4 shows detail view of seed metering device.

Retrieval Number:100.1/ijae.E449113050624
DOI:10.54105/ijae.E4491.04010524
Journal Website: www.ijae.latticescipub.com

Published By:
Lattice Science Publication (LSP)

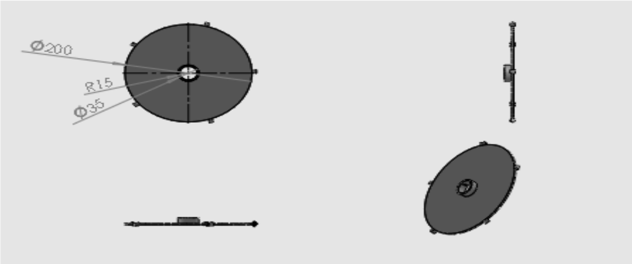

Figure 4: The Seed Metering Device

b. Design of Adjustable Furrow Opener

Furrow openers were used to place the seed at the desired depth with minimum dispersion. The depth of placement at which seed is placed in the soil depends on the crop variety and the soil moisture level. Furrow openers should form a neat groove in the moist zone of soil with minimum soil disturbance to avoid mixing the top dry soil with the underlying moist soil at seed level. For seed placement, shoe type furrow openers was used as uniform depth of sowing is required. The furrow opener assembly consists of shank and share.

A shovel type furrow opener fitted at one end of the shank and the other end of the shank was attached with frame by bolt and nuts for adjusting depth. The depth of sowing varies from 3 cm to5 cm. The thickness, width and length of the shank were decided on the assumption given below.

Let,

b x h = Shank cross-section area, mm^2

L = length of breast of shovel

The draft force exerted on the opener was determined using the following equation [15] [27] [28] [29] [30] [31].

$D = k_o \times n \times w \times d$ (17)

D –draft force, kg

Ko-Specific Soil Resistance – 0.25 kg/cm2, when the condition is very heavy

w– Width of opener, cm

d– Depth of furrow opener, cm

n--number of furrow openers

Table 1 Specific soil resistances at a depth of 15 cm

S. NO	Soil Type	Specific Resistance kg/cm^2
1	Light	0.12
2	Medium	0.15
3	Heavy	0.20
4	Very heavy	0.25

Source: [3].

Assume and take the values of the cross sections of the furrow opener

Width=2cm depth=5cm number of furrow opener=4 and k_o = 0.25 for very heavy soil

$D = k_o \times n \times w \times d = 0.25 kg/cm^2 \times 4 \times 2cm \times 5cm = 10kgf$

Take factor of safety – 3 (Assumed)

D=3 x10kgf =30kgf

=30kgf ×9.81N/kgf =294.3.N (Total draft of the planter)

294.3N/4 =73.58N (For each furrow opener)

It is assumed that the draft force on the furrow opener is 73.58.N/furrow and acting at a height of h/3 from the bottom of the furrow opener [22].

Distance of draft application of furrow opener shank [21]. is given as,

a = h/3 where, h is total length of furrow opener.

a = 42cm/ 3 = 14cm

Moment arm length = (h-a) = (42 – 14) = 28cm=280mm

Maximum bending moment for a cantilever length of 28 cm is:

Bending moment (M) = draft (kgf) x Moment arm length (cm) (18)

M=73.58N x 28cm=2060.24Ncm=20602.4Nmm

Take factor of safety =3

Maximum bending moment (M) =3 x20602.4N-mm =41204.8Nmm

Flat mild steel was used for the design of furrow opener and fb=56N/mm^2 was used for mild steel [21].

Section modules of each furrow opener or tynes (Z) = Mb/fb =41204.8Nmm /56N/mm^2 = 1103.8mm^3

Take, b=40mm size flat mild steel

t=thickness of flat Mild Steel

Section modulus of the furrow opener, was calculated by using the formula [18][19].

$$Z=\frac{1}{6} \times t \times b^2 = \frac{1}{6} \times t \times (40^2) \quad (19)$$

$1103.8mm^3 = \frac{1}{6} \times t \times (40^2) = 4.14 \approx 5mm$

So, M.S flat type of 40mm x 5mm size was quite safe and was also used a 40mm X 5 mm size mild steel

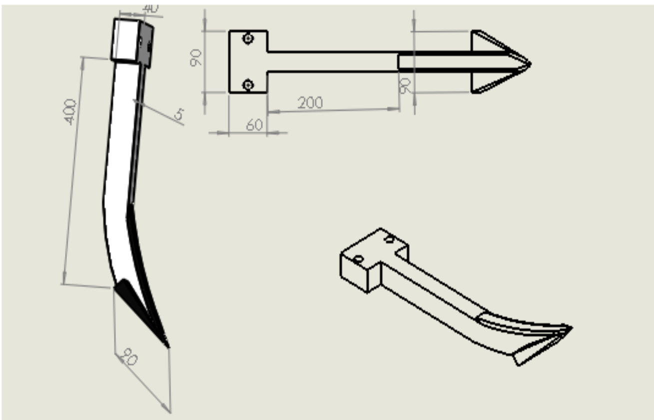

Figure 5 isometric view of Furrow Opening Devices

K. Adjustable Furrow Covering

The furrow covering devices were adjustable and they were covering the seeds by dragging folded sheet metal over the opened furrows

a. Weights Determination

Weight of the Hopper

$V_{HM} = A_{HM} \times t_{hm}$ (20)

$M_{HM} = V_{HM} \times \rho_{HM}$ (21)

$W_{HM} = M_{HM} \times g$ (no of hopper)

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

ρ_{HM} = Density of the hopper material

W_{HM} = Weight of the hopper material

Therefore using the above equation weight of the hopper was 144N

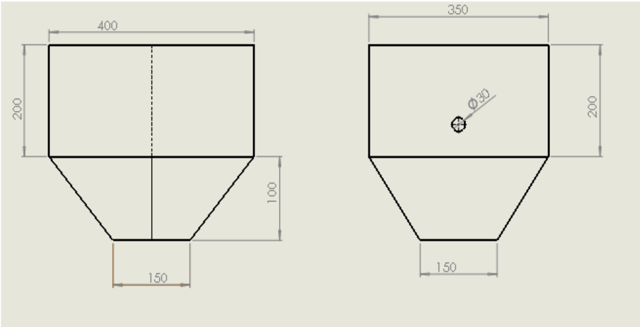

Figure 6 Cross Sectional Area of the Hopper

L. Ground Wheel Design

The planter's ground wheel, with external diameter was designed as an integral part of the seed metering mechanism connected to the seed metering device directly. The rim of wheel was made from mild steel flat iron. Each wheel had spokes made from mild steel rods and the spokes were welded to the rim and hub at the center of the wheel that served as bushing or shaft bearing, at equal interval. [24]. was used to analyze the shear strength (τ) of the ground wheel considering the wheel as thin-walled vessels.

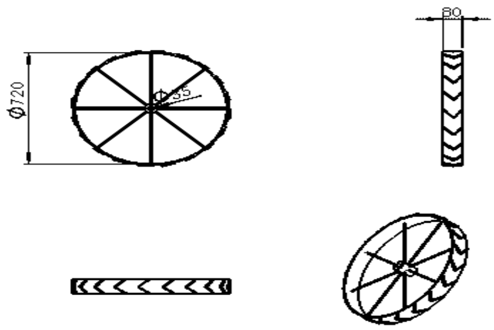

Figure 7: Isometric View of Ground Wheel

M. Wheel Strength

The wheel of the planter was made from a 6mm thick mild steel metal. the maximum shear strength of mild steel metal is 80MPa. The lugs were provided on outer periphery of drive wheel. Considering the lug diameter of 10 mm, 46 lugs were provided. The hub diameter was selected as 70 mm. The hub was made hollow from shaft for inserting axle shaft. Round iron of size 450×12 mm were used as spokes for drive wheel. The wheel was placed on wheel axle of 35 mm diameter.
Shear stress on the wheel is estimated as the shear stress analysis formula as given below.

$$\tau = \frac{T}{2A_m t_w} \quad (22)$$

$$T = F \times \left(\frac{Wd}{2}\right) \quad (23)$$

$$T = 97.94\text{N} \times \left(\frac{0.72}{2}\right) = 35.25\text{N}$$

$$A_m = \pi \times r^2{}_m = \pi(r - 0.5t_m)^2 \quad = 0.40\text{m}^2 \quad (24)$$

$$\tau = \frac{35.25Nm}{2 \times 0.40 \times 0.006} \quad 7343.75\text{N/m}^2$$

Where: - T = the torque produced by the wheel (Nm)

A_m = the area of the wheel calculated based on the median diameter of the wheel

t_w = thickness of the wheel wall (m).

r_m = the median radius of the wheel

r = the outer radius of the wheel (m)

Comparing the maximum allowable shear stress of the metal, $7.344kpa << \tau_{max}$,, 80 MPa, the wheel was safe from failure. That means the calculated shear stress was much less than the maximum allowable shear stress of the mild steel that used in the construction of the ground wheel. Hence the wheel is safe for design.

N. Draft and Power Requirements for the Planter

Draft requirements

The American society of Agricultural & Biological Engineers [2] issued the standard (497), for estimating the draft requirements for different implements at different working condition as follows:

$$D = Fi\,[A + B(S) + C(S^2)]\,wd \quad (25)$$

Where: D = implement draft (N),

F = a dimension less soil texture adjustment parameter

i = 1 for fine, 2 for medium and 3 for coarse texture

A, B & C = machine specific parameters

S = field speed (km/hr),

W = machine working width, (m),

d = tillage depth (cm)

Draft depends upon Sharpness of cutting edge, Working speed, Working width, Working depth Type of implement, and Soil condition

a. Power Requirements

The power of the tractor measured at the end of drawbar. Friction power is the power required to run the engine at any given speed without production of useful work. It is usually measured with a suitable electric dynamometer which runs "motors" or engine. The drawbar power requirement is product of implement draught and operating speed. Whilst the same rate of work can be maintained either by pulling a wide implement at low speed or a narrower implement at higher speed, the drawbar pull demand varies substantially. Excessive drawbar pulls from wide equipment may look impressive with but can cause high wheel slip. Equally, however, working with narrower at higher speed usually involves a disproportionate rise in draught. Between two extremes, there is an optimum operating point which is dependent on the sensitivity of the implement draught to changes in the operating speed [7].

The tractor drawn planter was operated at a recommended speed of less than 6km/h. Centre of resistance is the point at which the resultant of all the horizontal and vertical forces act. The center lies at a distance equal to $3/4^{th}$ size of the planter from the share wing. Line of pull is an imaginary straight line passing from the center of resistance through the clevis to the center of pull (power).
Pull is the total force required to pull an implement.
Draft: It is the horizontal component of the pull, parallel to the line of motion.
D = P ×cosθ where D is draft (kgf) and P = pull in (kgf)

θ= angle between line of pull and horizontal.

$$HP = \frac{\text{Draft(kgf)XSpeed(m/s)}}{75} \quad (26)$$

Retrieval Number:100.1/ijae.E449113050624
DOI:10.54105/ijae.E4491.04010524
Journal Website: www.ijae.latticescipub.com

Published By:
Lattice Science Publication (LSP)

Indian Journal of Agriculture Engineering (IJAE)
ISSN: 2582-9319 (Online), Volume-4 Issue-1, May 2024

O. Drive Shaft Design

The shaft is decided to be fabricated from ductile material (mild steel rod). Hence, the design is based on ductile material whose strength is controlled by maximum shear stress of 28 MPa. For a shaft having little or no axial loading, the diameter of the shaft was obtained using the code equation (Eq. 27), [2] given

$$d^3 = \frac{16}{\pi S_s}\left[(K_b M_b)^2 + (K_t M_t)^2\right]^{\frac{1}{2}} \quad (27)$$

Where: d = diameter of the shaft; mm

Mt= torsional moment; Nm

Mb= bending moment; Nm

Kb= combined shock and fatigue factor applied to bending moment;

Kt= combined shock and fatigue factor applied to torsional moment;

Ss= allowable stress; MN/m^2

For rotating shafts, when load is suddenly applied with minor shock, [13] recommended that values of Kb = 1.2 to 2.0 and Kt = 1.0 to 1.50 to be used. Furthermore, it is noted that for shaft without key way, the allowable stress (Ss) must be 55 MN/m^2, and for the shaft with key way the allowable stress (Ss) should not exceed 40MN/m^2

Torsional moment (Mt) on the shaft was calculated using Eq. (26 and 27) [20].

$$M_t = \frac{P \times 60}{2\pi \times N} \quad (28)$$

$$M_t = \frac{156.7 \times 60}{2\pi \times 26.54\text{rpm}} = 56.4\text{Nm}$$

$$P = V \times F \quad (29)$$

$$P = 1.6\text{m/sec} \times 97.94\text{N} = 156.7\text{W}$$

Where: P = power required to drive the machine;

N = speed of the shaft, (rpm)

V = forward speed (m/s)

F = force required to drive the machine (N)

The maximum bending moment on the shaft is determined from the following Figure 13:

$$M_b = (M_v^2 + M_h^2)^{\frac{1}{2}} \quad (30)$$

Where: Mv = vertical bending momentum, Nm

Mh = horizontal bending momentum, Nm

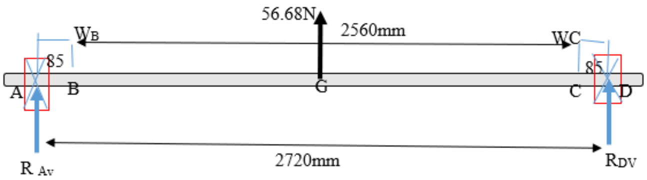

Figure8 :Vertical Load Distribution on the Shaft (All Dimensions Are in Mm)

Where : R_{Av} and R_{Dv} = Reactions at the support

W_B = Half of total weight = 457N

W_C = Half of total weight = 457 N

The reactions, R_{Av} and R_{Dv} were determined by taking moment about A;

To know the unknown forces of R_{Av} and R Bv, it is necessary to use equilibrium equations methods.

$$\sum M_A = 0$$

$$R_{DV} \times 2720 = 457 \times 85 + 457 \times 2635 - 56.68\text{N} \times 1360$$

$$R_{DV} \times 2720 = 457 \times 85 + 457 \times 2635 - 56.68 \times 1360$$

$$R_{DV} = 1165955.2/2720 = 428.66\text{N}$$

$$\text{Also } \sum F_Y = 0$$

$$R_{AV} + 428.66\text{N} = 457 + 457\text{N}$$

$$R_{AV} = 914\text{N} - 428.66\text{N} = 485.34\text{N}$$

Thus, the maximum vertical bending moments (*BM*) on the shaft were computed using

Figure 12 as follows:

BM at A and D = 0

BM at B, R_{AV} × 85-56.68×1360 = 485.34 × 85-56.68×1360 = −35830.9 N mm

BM at C, R_{AV}×2635 −(W_B× 2550)+56.68N×1275−428.66×85 =150134.4Nmm

Thus the maximum vertical bending moment on the shaft is 150134.4Nmm=150.13Nm

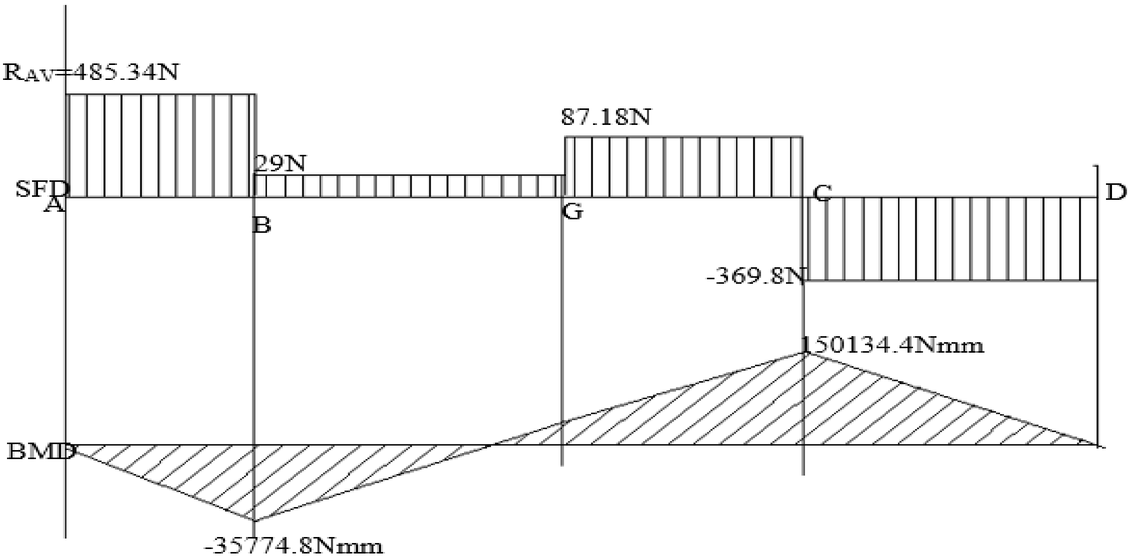

Figure 9: Shear force and Bending Moment Diagrams on the Shaft Due to Vertical Force

Retrieval Number:100.1/ijae.E449113050624
DOI:10.54105/ijae.E4491.04010524
Journal Website: www.ijae.latticescipub.com

Published By:
Lattice Science Publication (LSP)

The reaction forces on horizontal plane are shown on the Figure 10.

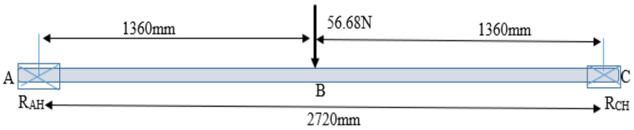

Figure 10: Forces on Horizontal Plane

The forward driving force through wheel is 56.68 N horizontally and resolving the forces horizontally

$$R_{AH}+R_{CH}=56.68N$$

$$R_{AH}=R_{CH}=56.68N/2=28.34N$$

Hence bending moment on the shaft due to horizontal forces was calculated as follows:

Bending moment at x = 1360mm from A

$$28.34N \times 1360mm = 38542.4Nmm$$

Bending moment at x = 2720mm from A is zero

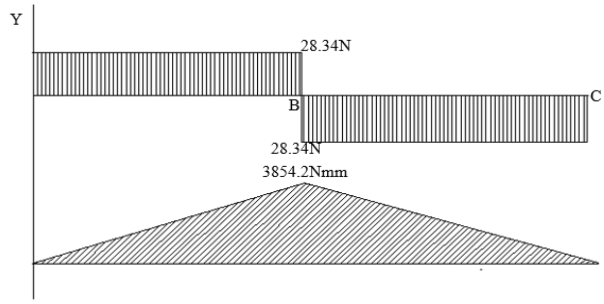

Figure 11: Shear and Bending Moment Diagrams on The Shaft on Horizontal Plane

The total resultant components of horizontal and vertical bending moments on the shaft can be obtained as follows:

$$M_b=\left((M_v^2+M_H^2)\right)^{\frac{1}{2}}$$

$$M_b=(150.13^2+38.54^2)^{\frac{1}{2}}=155Nm$$

$$d^3=\frac{16}{\pi Ss}\left[(K_bM_b^2)+(K_tM_t^2)\right]^{\frac{1}{2}}$$

Where: Kb = 2, Kt = 1.5,

S_s = 40MN/m^2

M_b = 155Nm

M_t =56.4Nm

$$d^3=\frac{16}{\pi\times40\times10^6N/m2}\left[(2\times155)^2+(1.5\times56.4)^2\right]^{\frac{1}{2}}$$

d=0.034m = 35mm standard shaft

But for more rigidity and to buckling effect of the shaft and to safeguard from faller a mild steel of 40mm was selected for the design of shaft of the machine.

P. Performance Test and Evaluation

After the fabrication and assembly of the machine a preliminary test run was conducted to check acceptability of the machine. Fortunately, the planter had good stability in terms of operation and performed the intended job accordingly. Two sets of tests were performed; laboratory investigation to calibrate the machine in terms of seed rate, seed damage, and seed spacing, and field test carried out to obtain actual overall performance of the machine.

Q. Field Capacity and Field Efficiency

When the implement has been satisfactorily set, each test plot should be completed without stopping unless this is necessary due to adjustments, breakdowns. Measurements were made of draft, forward speed and wheels slip. Where applicable, width and depth of work and total working area and time should be recorded. The time lost in the field due to turning and other factors including failure to use the full width of the implement will affect field efficiency [5][6]. This is calculated as follows: Field capacity: Field capacity was determined using the following formula [9].

Theoretical field capacity, C_{th} = $\frac{W\times S}{10}$, (ha/h) (31)

Where: W = rated width of the planter (m)

S = rated forward speed of machine (km/h)

Effective field capacity, C_{eff} = $\frac{A}{10{,}000T}$, (ha/h) (32)

Where: T = total time for the planting operation, hr

A = total area planted, ha

Field Efficiency:-

Field efficiency,(%) e =$\frac{C_{eff}}{C_{th}}\times 100$ (33)

Where : e= field efficiency

C_{th}= theoretical field capacity

C_{eff} = effective field capacity

3.6.2.7 Wheel Slip

The wheel slip was calculated by recording total number of revolutions at no load and total number of revolutions at full load. Wheel slip represents a loss of forward motion of the implement and it represents the loss of power. Wheel slip for any given load is determined by the expression of [17].

Wheel slip=$\frac{m_o-m_1}{m_o}\times 100$ (34)

Where: m_o = wheel revolution with no load

m_1 = wheel revolution with load

R. Experimental Design

The experimental design was a split-plot design according to the principle of factorial experiment with three replications. The three levels of seed types was assigned to main plot, and the three levels of forward speed of planter was assigned to sub plot, and each with three replications. The experiment design was laid as 3^2 with three replications and had total of 27 test runs (3x3 x3 = 27).

S. Statistical Analysis

The data were subjected to analysis of variances following a procedure appropriate for the design of the experiment and using SAS statistical software. The treatment means that were different at 5% levels of significance were separated using least significant difference (LSD 5%) test. The least significant difference (LSD) test was performed for the mean values of actual seed spacing, seed miss index, seed multiple index, quality of feed index and precision spacing in relation to seed type, and forward speed.

III. RESULTS AND DISCUSSIONS

This study was undertaken to design, fabricate and evaluate the performance of the planter capable of planting maize, common bean and sorghum seeds at predetermined spacing and depths. Physical properties of seeds involved in the study were investigated to optimize the design of the planter's component parts.

Retrieval Number:100.1/ijae.E449113050624
DOI:10.54105/ijae.E4491.04010524
Journal Website: www.ijae.latticescipub.com

Published By:
Lattice Science Publication (LSP)

Performance indicators such as row spacing, plant spacing and plant uniformity were used to assess performance of the planter. This section provides the physical properties of the seeds, soil and the results of the performance evaluation of the machine.

A. Physical Properties of Soil of Experimental Site

a. Moisture content and bulk density of soil

During conducting the experiments, the soil conditions of the experimental field were studied and different parameters were calculated (Table 2). Moisture content on dry basis of soil was measured by oven dry method. Five soil samples were taken randomly at 5 different locations in the plot using core sampler of 8.0 cm diameter and 12 cm height.

Table 2: Moisture Content and Bulk Density of Soil

Observations	Weight of a Soil(gm)	Weight of Soil after Oven Dried(gm)	MC (%)		Bulk Density (gm/cm^3)
			%Wb	%Db	
1	875.25	712.05	17.43	21.1	1.41
2	892.26	730	18.18	22.2	1.48
3	886.2	728.5	17.8	21.65	1.47
4	890.32	729.5	18.0	22.04	1.48
5	892.2	731	18.0	22.05	1.48
Average	887.24	724.21	17.88	21.1	1.46
SD	9.08	8.26	0.23	0.81	0.31

Moisture content at 5 different places was found to be 17.43, 18.18, 17.8, 18 and 18% on wet basis. The average moisture content of the experimental field was 17.88%. Bulk density of soil was calculated from data obtained by core sampler. Bulk density of soil was found to be 1.41,1.48,1.47 ,1.48 and 1.48 gm/cm^3, respectively (Table:2). Average value of bulk density of experimental plot was obtained 1.46gm/cm^3.

b. Physical Properties of the Seeds

The varieties of crops used in the study were Melkassa-2 (maize), Awash 2 (common bean) and Melkem (sorghum). Table 3 gives the mean values and the standard deviations of Length, width, thickness, volume, geometric diameter, sphericity, and thousands seed weight.

Table 3: Physical Properties of Maize, Common Bean and Sorghum Seeds

Physical Properties	Sample Size	Maize	Common Bean	Sorghum	Unit
Larger dia (x)	30	10.84±0.15	9.26±0.07	4.72±0.1	Mm
Medium dia (y)	30	8.48±0.15	6.36±0.12	4. 27±0.18	Mm
Smaller dia(z)	30	3.66±0.11	5.11±0.66	2.78±0.10	Mm
Volume (V)	30	175.95±54.50	157.58±21.04	29.34±4.70	mm^3
Geometric dia	30	6.95±0.46	6.70±0.29	3.83±0.16	Mm
Sphericity	30	64.8± 7.14	72.4±2.87	81±2.8	%
Thousands seed weight	10	294±3.14	161±1.44	29±0.70	Gm

The sphericity of maize, common bean and sorghum were 64.8, 72.4 and 81 %, respectively (Table 3), indicating that all seeds had more or less spherical shape. Hence, it was decided to have metering devices with cells of circular shape with depths equal to the length or major diameters of the seeds of the crops. In general, the dimensions of metering device cells were dependent up on length or major diameter of maize, common bean and sorghum seeds.

B. Field Performance Evaluation

Planter performance indicators such as plant spacing and depth of planting

Table 4: Effects of Planter Forward Speeds on Plant Spacing, Row Spacing, and Depth Planting and Operating Time

Parameter	Source of Variation				Measure of Differences	
	Speed Level (km/hr.)	Crop Type				
		Maize	Common bean	Sorghum	LSD (5%)	SE
Plant spacing (cm)	2	22.91^{c}	16.30^{a}	19.16^{abc}	3.3	1.90
	4	22.01^{abc}	14.32^{ab}	16.50^{ab}		
	6	22.18^{bc}	15.22^{a}	17.92^{abc}		
Row spacing (cm)	2	69.58^{b}	40.50^{a}	70.50^{b}	1.44	0.87
	4	69.77^{b}	39.83^{a}	69.83^{b}		
	6	70.33 ^{b}	39.33^{a}	69.33^{b}		
Depth of planting(cm)	2	6.67ab	7.33 b	4.67a	1.11	0.76
	4	6.53ab	5.67^{ab}	6.33^{ab}		
	6	5.17a	6.17^{ab}	5.00^{a}		
Time of planting(sec)	2	54.17^{c}	51.67^{c}	52.83^{c}	3.09	1.67
	4	27.33^{b}	27.67^{b}	28.00^{b}		
	6	19.53^{a}	19.73^{a}	19.57^{a}		

Means followed by the same letter (or letters) do not have significant difference at 5% level of probability

The proposed plant spacing for both maize and sorghum crops were 20-25cm and the result obtained were 22.01cm and 16.50 cm and the proposed depth of planting was 5cm and the result obtained were 5.17cm and 6.33cm respectively. The proposed row spacing for both maize and sorghum were 70 cm and result obtained were 69.77cm and 69.83 cm for maize and sorghum that is all most similar to the proposed results.

Wheel Slip

The wheel slip of tractor drawn multi crop planter was determined by using the method mentioned earlier and the results obtained for wheel slip data obtained at different operating speed was shown in the graph below. The wheel slip increased with increase in speed. The minimum wheels slip i.e. 4.94 % and maximum wheel slip i.e. 8.66 % was observed at speed of 2 km/h and 6 km/h, respectively. The Fig: 12 show that the wheel slip increased with increase in speed. The same results were obtained by [1].

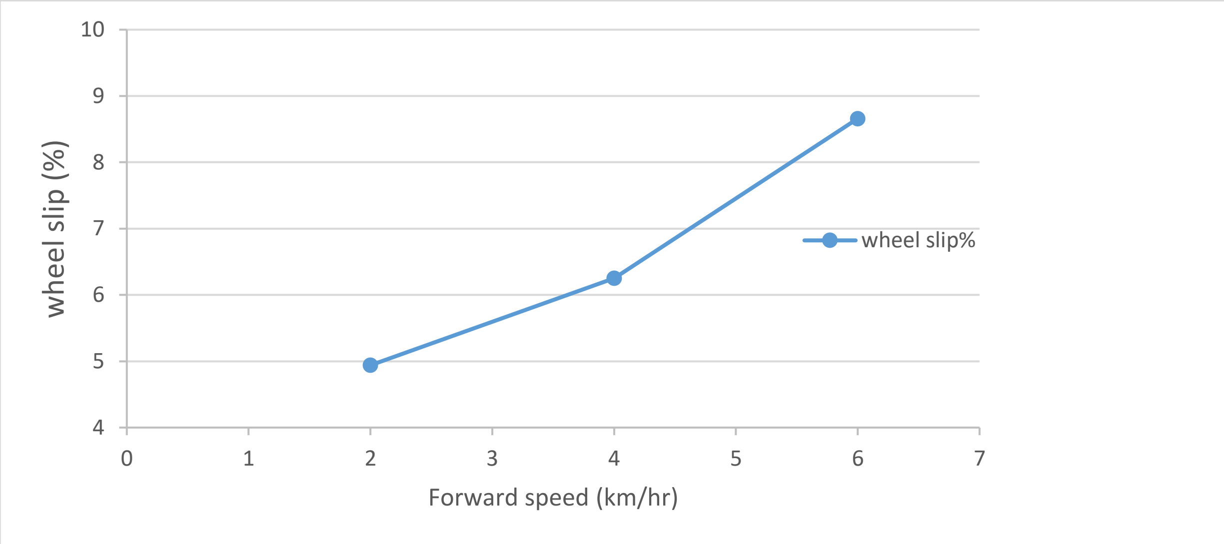

Figure 12: Effect of Forward Speed on Wheel Slip

C. Field Efficiency and Field Capacity of the Planter

Field test was conducted on a well prepared soil using tractor. The depth of planting was measured along the row the length of every 2 m at three randomly selected rows from each plot. Field capacity and efficiency were determined in accordance to the recommendation made by [12]. and using relevant parameters that included effective operation time, turning time and time losses due to obstructions on the field.

A plot of 20 m by 30 m requiring, on average, about 9 passes with inter-row spacing of 70 cm was used each crops to assess field capacity and field efficiency both for Maize and Sorghum. From the data gathered, working speed (km hr $^{-1}$), and effective field capacity (ha hr.$^{-1}$) and field efficiency (%) was estimated using the expressions in equation (31,32 and 33) and Table5 shows field capacity and field efficiency of the planter.

Table 5: Field Performance Indicators of the Planter

Crop Types	Field Length(m)	Width Field (m)	Time Taken (min)	Time Lost (min)	Theoretical Field Capacity (ha hr^{-1})	Effective Field Capacity (ha hr^{-1})	Field Efficiency (%)
Maize	30	20	4.09	1.5	0.84	0.65	77.3
Common bean	30	20	5.52	2.15	0.64	0.46	71.8
Sorghum	30	20	4.23	1.23	0.84	0.66	78.5
Mean	30	20	4.61	1.63	0.77	0.59	75.87

The mean field capacity and efficiency of the planter were 0.59 ha/hr. (1.73 hr. /ha) and 75.87 %, respectively. This shows that the planter can plant a hectare of land in slightly in less than two working hours. In another words, the planter can best suit majority of the Ethiopian farmers who have opportunity to use the tractor. The field efficiency of the planter, as recommended by [12]. is within the acceptable level. The mean depth of planting was 5.95 cm with coefficient of variation of 0.128 (12.8%). The time taken to finish one hectare of land was 1:55 hr. that means by taking 8 hr. working hour per day, the farmer can plant about 5.16 hectare of land in one day by using this planter. Table 5 result the proposed plant spacing was 20 cm-25cm and the maximum result obtained from the experiments was 22.91 cm from Maize so it is good in terms of plant spacing which was with the proposed range. This depth of planting was greater than the desired depth of planting of 5 cm as recommended for Maize by agronomists. Nonetheless, the deviation and the variability being too small and with acceptable range, also, it can be adjusted to the desired depth of planting.

Retrieval Number:100.1/ijae.E449113050624
DOI:10.54105/ijae.E4491.04010524
Journal Website: www.ijae.latticescipub.com

Published By:
Lattice Science Publication (LSP)

The stand count made after 15 days of planting gave mean number of plants of 7.87,12 and 16 plants within rows of 2 m length for maize, common beans, and sorghum, respectively. The design or desired number of plants, within a row of 2 m long, for maize, common bean and sorghum were 8, 13 and 10, respectively. Hence the planter reasonably satisfied the requirement for the establishment of optimum plant population for all seed types.

IV. CONCLUSIONS AND RECOMMENDATIONS

This work focused on the design, fabrication and performance evaluation of a tractor drawn multi-crop planting machine that easy to use, easy to maintain, less labor requirement and costs. From the design and results values obtained in the study; it has been found that the designed planter gives:

- The designed planter work effectively in planting maize, common bean and sorghum at a given study area.
- A high significant field capacity was obtained by using the designed machine when compared to manual planting methods.
- Hence, one can note that the time requirement per hectare is reduced by 1/16 amount and labor requirement reduced by the same amount when this planter was used, when compered to manual planting.
- However, the speed of the planter should be limited to less than 6 km/hr in order not to seriously and negatively affect the percentage of recommended plant population of experimental crops.

Performance evaluations made indicated that the planter can be used successfully on farms at home for farmers. Nevertheless, the following issue must be addressed to make the planter popular, adaptable and usable among the farmers

- ✓ The machine can be operated at six rows for common bean in order to increase field capacity as that of both maize and sorghum because row spacing for maize and sorghum were 70 cm while row spacing for common bean was about 40 cm
- ✓ The operating speed of the planter should be limited to less than 6km/h to have better performance in terms of plant population.
- ✓ Adjustment and Operation awareness should be provided to the user before operating the machine.

DECLARATION STATEMENT

Funding	No Funding.
Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not relevant.
Authors Contributions	All authors having equal contribution for this article.

REFERENCES

1. Abiy Solomon Haile. 2017. Design, Fabrication and Performance Evaluation of Two Wheel Tractor Drawn Six Row Wheat Seed Drill (Doctoral dissertation, Adama Science and *Technology University).*
2. ASME, 1995. Design of transmit ion shafting. *American Society of Mechanical Engineering*, New York, USA.
3. Dubey, A.K. 2003. Design of sowing machine. Teaching material for training on computer aided design and design methodology for agricultural machinery. *Technical bulletin no CIAE/AMD/2003/296*, pp.92-102.
4. El-Raie, A.E., Hendawy, N.A. and Taib, A.Z. 1996. Study of physical and engineering properties for some agricultural products. Misr. Journal of Agricultural Engineering 13(1):211-226.
5. FAO .1994. *Testing and evaluation of agricultural machinery and equipment: Principles and practices*.
6. Gupta, R. A., Mohnot, P., Satasiya, R. M. and Marvia, R. B. 2004. Development and testing of a seed-cum-fertilizer drilling attachment to tractor-driven cultivator. J. of Agril. Mechanization in Asia, Africa and Latin America
7. Hunt, D. 1995. Farm Power and Machinery Management, 9th- edition, Iowa State University Press, Ames, Iowa50014 .4-6 & 65-75.
8. ITSI-SU, January 26 (2011): Mass, volume and density of regularly and irregularly shaped object. Internet: http://www.pdesas.org/module/content/resources/14756/view.ashx.
9. Janke, J. and Erbach D.C. 1985. Seed depth distribution in no till and strip till. *ASAE Paper*, 85–1013. ASAE, St Joseph, MI.
10. Jayan, P.R. and Kumar, V.J.F. 2004. Planter design in relation to the physical properties of seeds. *Journal of Tropical Agriculture*, *42*.69-71.
11. Jouki, M. and Khazaei, N. 2012. Some physical properties of rice seed (Oryza sativa). *Research journal of applied sciences, engineering and technology*, *4*(13),.1846-1849.
12. Kepner, R.A., Bainer, R., Barger, E.L.1978. Principles of Farm Machinery, 3rd edition .Inc. AVI Publishing Company, Westport, USA.
13. Khurmi, R.S. and Gupta, J.K.2005. A Textbook of Machine Design. Eurasia Publishing House (Pvt.) Ltd., Ram Nagar, New Delhi, India.
14. Kumar, A., S. C. Moses, and K. Khan. 2015. A survey on the design, fabrication and utilization of different types of foods and vegetables dryer. *IOSR Journal of Agricultural and Veterinary Science I*, 8(4): 2319–2372
15. Kurtz, Gary; Thompson, Laster and Clwar, Paul. 1984. Design of agricultural machinery. *John Willey and Sons, Singapore, 245 - 255.*
16. Olaoye, J.O. and Bolufawi, S.J., 2001. Design, fabrication and performance of multipurpose row planting machine. J. Sustain. Agric. Environ, 3(1): 7-20.
17. Rangapara, D. and Jaimin, P. 2014. Performance Evaluation of Manually Operated Single Row Cotton Planter. *International Journal of Engineering Sciences and Research Technology*, *3*(9) 40-44.
18. Ryder G.H.1989. Strength of Materials, 3rd ed. Macmillan, Nigeria.
19. Seely, F. B., and Smith, J. O. (1995): Advanced mechanics of materials (IInd Ed.). John Wiley and Sons Inc. London
20. Senger, S.M. 2002. Design and development of animal drawn seeder for rice cum green manure crops for biasi cultivation system. M. Tech. *Agril. Engg.) Thesis, Indira Gandhi Agricultural University. Raipur, Chhattisgarh*.
21. Sharma, D.N. and Mukesh, S. 2010. *Farm machinery design: Principles and problems* second edition Jain brothers.
22. Singh, R.C, Singh, G., Saraswat, D.C. 2005. Optimization of design and operational parameters of a pneumatic seed metering device for planting cottonseeds. *Biosystems Engineering*, 92(4): 429–438. https://doi.org/10.1016/j.biosystemseng.2005.07.002
23. Soyoye, B. O., O. C. Ademosun, and E. O. Olu-Ojo. 2016. Manually operated vertical seed-plate maize planter. *CIGR Journal*, 18(4): 70-80.
24. Thomas, H. and Brown, J. 2005. *Marks Calculation for Machine Design*, McGraw-Hill, New York.
25. Waziri, A.N. and Mittal, J.P., 1983. Design related physical properties of selected Agricultural Products. Agri. *Mechanization in Asia, Africa and Latin America*, 14(4): 59-62.
26. Yasir, H, Q. Liao, J. Yu, and D. He. 2012. Design and test of a pneumatic precision metering device for wheat. *CIGR Journal*, 14(1): 16-25.
27. Sanodiya, G. (2022). Efficient Solar Air Heater Absorber Plate for Crop Drying Application. In Indian Journal of Agriculture Engineering (Vol. 2, Issue 1, pp. 1–4). https://doi.org/10.54105/ijae.c1507.051322
28. K, S., N, M., & S, P. (2019). Design of Manure Spreader Machine for agricultural farm field. In International Journal of Innovative Technology and Exploring Engineering (Vol. 9, Issue 1, pp. 4280–4284). https://doi.org/10.35940/ijitee.a4877.119119

29. Vorotnikov, I. L., Petrov, K. A., Esin, O. A., Gutuev, M. Sh., & Ermolova, O. V. (2019). Organization for repair technology and maintenance of agricultural machinery. In International Journal of Recent Technology and Engineering (IJRTE) (Vol. 9, Issue 2, pp. 4685–4690). https://doi.org/10.35940/ijrte.b3511.078219
30. N C, C., V U, C. K., G B, M., & M, S. K. (2021). Advanced Solar Operated Multi-Purpose Agricultural Equipment. In International Journal of Engineering and Advanced Technology (Vol. 10, Issue 3s, pp. 40–43). https://doi.org/10.35940/ijeat.c1009.02103s21
31. Agidi, G., Muogbo, C., & Mohammed, G. I. (2021). Field Capacity and Efficiency of a Turmeric Rhizome Planter in Response to Machine Speeds and Some Selected Crop Parameters. In Indian Journal of Design Engineering (Vol. 1, Issue 2, pp. 1–5). https://doi.org/10.54105/ijde.b8002.081221

AUTHORS PROFILES

Bedasa Waldaho Duga is currently an associate researcher at the Oromia Agricultural Research Institute of Fedis Agricultural Research Center. Mr. Bedasa received his MSc degree in Agricultural Machinery Engineering from Haramaya University, Ethiopia. Mr. Bedasa published a number of papers in preferred journals and participated in a range of scientific research review forums at regional and national levels on agricultural engineering research. In addition to his research career, Mr. Bedasa held several managerial positions in the Oromia Agricultural Research Institute of Fedis Agricultural Research Center.

Gutu Getahun Muke is currently an assistant researcher at Oromia Agricultural Research Institute of the Fedis Agricultural Research Center in the Renewable Energy Engineering research case team. Mr. Gutu received his B.Sc. in Mechanical Engineering from Jimma University, Ethiopia. Currently, Gutu has implementing different agricultural engineering and renewable energy research projects at different locations in the eastern Hararghe zone of Oromia, Ethiopia, to serve the community living around the lowlands. This is aimed at reaching large communities with new and improved technologies, especially in increasing agricultural mechanization technologies to increase crop production and productivity under low moisture stress that can tackle food insecurity in lowland communities.

Retrieval Number:100.1/ijae.E449113050624
DOI:10.54105/ijae.E4491.04010524
Journal Website: www.ijae.latticescipub.com

Published By:
Lattice Science Publication (LSP)