Advances in Bioresearch
Adv. Biores., Vol 13 (1) January 2022: 157-166
©2022 Society of Education, India
Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.13.1.157166

Advances in Bioresearch

ORIGINAL ARTICLE

A Design of Manually Operated Single Row Planter for Groundnut Seeds

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ABSTRACT
Indian agriculture is lacking in cutting-edge technologies and farming methods. Precision farming technological instruments for precise techniques and input application are becoming more popular in the advanced world. It lowers prices, has a lower environmental impact, and produces more and higher-quality product. In comparison to the rest of the world, Indian agriculture is still dominated by low-tech agricultural techniques, a low level of mechanisation, and generally lower yielding cultivars.India is one among the most important producers of oilseeds within the world and occupies a crucial position within the Indian agricultural economy. Groundnut is also called as wonder nut and cashew nut of poor man. Groundnut is one among the foremost important cash crops of our country. Farm mechanization is an important element of agriculture. Mechanization of groundnut farming is an essential input in modern agriculture. Looking at the pattern of land ownership in India, it may be noticed that roughly 84 percent of holdings are below one hectare. In the present context of the land fragmentation and resultant ongoing decrease of average size of operational holdings, proportion of marginal, small and semi medium operational land holdings is projected to rise. Such tiny land holding makes private ownership farm machines uneconomic and operationally unavailable. In view of these points, a hand-operated single row planter for groundnut seeds was designed and intended to improve planting efficiency and minimize drudgery associated with the manual planting technique of groundnut seed. The major components of the planter were designed as seed hopper, seed metering device, jaw clutch, seed delivery tube, furrow opener, furrow covering wheels and drive wheel. The diameter of seed metering device was found as 11.66 cm and number of cells on the periphery of seed metering device was found as 6. The theoretical volume of designed seed hopper was found as 0.024472 m^3. The overall dimensions of the designed planter were found as 1474 × 960 × 330 mm. This planter is considered economical with ease of operation, requiring no special skill to operate and can be adopted by the farmers for the planting of groundnut seed.
Keyword: *Mechanization level, Groundnut, Groundnut Planter, Seed Hopper, Seed metering device.*

Received 21.08.2021 Revised 13.10.2021 Accepted 29.12.2021

How to cite this article:
U V Singh, S C Moses and R N Aalam . A Design of Manually Operated Single Row Planter for Groundnut Seeds. Adv. Biores. Vol 13 [1] January 2022. 157-166

INTRODUCTION

Agriculture is the backbone of the Indian economy. Agriculture development results in higher economic position of country. In India farmers are having issues owing to lack of labours, traditional style of farming utilising non effective agricultural equipment which takes lot of time and also raises labour cost. This project is all about enhancement in development of device for placing the seed of groundnut into the soil at proper depth and distance [1, 2].

The degree of farm mechanisation in India lies at approximately 40-45 percent with provinces such as UP, Haryana and Punjab having relatively high mechanisation levels, but north-eastern regions having little mechanization.This degree of agricultural mechanisation is still modest as compared to the nations such as the U. S. (95 percent), Brazil (75 percent) and China (57 percent). (57 percent) [3-8]. While the amount of automation lags behind other industrialised countries, it has had an average agriculture growth rate of

3.56 percent during the previous decade. According to the World Bank predictions, half of the Indian population will be urban by the year 2050.It is estimated that percentage of agricultural workers in total work force would drop to 25.7% by 2050 from 58.2% in 2001. Thus, there is a need to improve the amount of agriculture mechanisation in the nation. Due to intense participation of manpower in diverse agricultural activities, the cost of production of many crops is relatively expensive. Human power available in agriculture also rose from approximately 0.043KW/ ha in 1960-61 to about 0.077 KW/ ha in 2014- 15. [9-12]

Groundnut (*Arachis hypogaea* L.) is a legume also known as peanut, earthnut, monkey nut. It is a major oil seed crop and a popular source of food all over the world. Groundnut originates in South America and is mostly grown in tropical and subtropical locations across the world. On a dry seed basis, groundnut seed contains 44-56 percent oil and 22-30 percent protein, and it may be a good source of minerals [13, 8].

Even if farmers apply three or four times the required seed rate, traditional methods result in an insufficient and non-uniform plant stand. The traditional system also has the limitations of uneven depth of seed placement, delay in covering seeded rows, slow ground coverage, and high labour requirement (100-125man h/ha for cereals and about 250man h/ha for groundnut). The availability of a low-cost, easy to use mechanical planter for small-scale farmers could alleviate these problems substantially, and will also help to take care of timely seeding and reduce the farmers' drudgery [14].

Seed planting machine is a device which helps in the sowing of seeds in the desired position hence assisting the farmers in saving time and money.

The basic objective of planting operation is to place the seed in rows at desired depth and spacing, cover the seeds with soil and supply proper compaction over the seed. Seed sowing is traditionally performed by broadcasting by hand, opening furrows with a plough, and dropping seeds by hand. Agriculture has traditionally been the backbone of India's long-term growth. As the population of India continues to grow, the demand for produce grows also. Hence, there's a greater need for multiple cropping within the farms and this, in turn, requires efficient and time-saving machines [15].

Traditional Sowing Methods: Traditional methods include broadcasting manually, opening furrows with a rustic plough and dropping seeds by hand and dropping seeds within the furrow using a bamboo/metal funnel linked to a rural plough. For sowing in limited areas dibbling i.e., creating holes or slits with a stick or instrument and dropping seeds by hand, is practised. Multi row conventional seeding machines with manual measuring of seeds are highly fashionable experienced farmers. In hand seeding, it's hard to attain consistency in dispersion of seeds.A farmer may sow at desired seed rate but inter-row and intra-row distribution of seeds are likely to be uneven leading to bunching and gaps within the field [16, 17].

Traditional sowing methods have following limitations:

- It is impossible to obtain consistent seed dispersion while manually sowing by dibbling.
- A farmer may plant at the appropriate seed rate, but seed-to-seed and row-to-row lengths will most likely be unequal, resulting in bunching and gaps in the field.
- Inadequate control over seed placement depth.
- Labour requirement is high because more than one person is required for dropping seed and seed.

Manual technique of seed planting, leads to low seed placement, spacing efficiency and significant back ache for the farmer which restricts the dimensions of field which will be sown. The high cost of imported planters has pushed the bulk of our farmers out of the market. This project work focused on the planning and fabrication of a operated by hand planter sowing for various crop seed that's cheap, easily affordable by the agricultural farmers. They decided that the manual seed planter met the needs of a poor and small-land farmer. These planters allow farmers to simply and successfully sow their seed in the field [19].

Adisa and Braide [1], designed and constructed a operated by hand flute planter/fertilizer distributor which was found to be 94% efficient in seed spacing but couldn't be used on the ridged seed bed and requires quite some effort and time to vary seed drill size and seed spacing. Mechanization decreases the cost of manufacturing through increased productivity and input conservation.

Planters are typically used for seeds that are bigger in size. The core of the planter is the seed metering mechanism, and its job is to disperse seeds equally at the predetermined application rate. A revolving circular inclined plate with cells is the most typical device. Vertical and horizontal plates are also utilised in some planters. Horizontal and vertical plates have greater spillage and less precision. To minimise spilling and crushing of the seeds, inclined plate seed metering mechanism is recommended and also which leads in more precise seed positioning of seeds in the furrow. A power cut device, known as jaw clutch is used to disconnect the drive power and then stops the seed metering plate. This device helps to stop dropping of seed at turning and machine can be moved without movement of metering device.

The timely sowing is crucial in rain fed farming. Delayed planting beyond usual window period prolongs growth, putting moisture stress on developing crops. With the existing seeding techniques, farmers are unable to sow the crop at suitable time since the traditional devices are sluggish in operation, and need high manpower cost, therefore raising cost of production. Mostly unskilled labours drop the seed resulting in gaps and bunching of plants during a row which ends up in non-uniform cropping. The nonuniform cropping creates imbalance in utilization of nutrients and moisture which results in reduction in crop productivity.

Keeping the view to mechanize the farming system of groundnut and to overcome drudgery due to manual dibbling of groundnut, a manually operated single row planter was designed for the sowing of groundnut seeds.

MATERIAL AND METHODS

The planter for groundnut seeds was designed at the Department of Farm Machinery and Power Engineering, Vaugh Institute of Agricultural Engineering and Technology (VIAET), SHUATS, Naini, Prayagraj, UP. The planning of components of this planter includes Main frame, drive wheel, furrow covering wheel, seed hopper, seed metering device, furrow opener, handle. The designing consideration is described below with following heads:

2.1 Design Considerations

The design of operated by hand multi-crop planter supported the subsequent considerations.

- The simple fabrication of component parts.
- The safety of the operator.
- The operation of the machine should be simple for little scale or rural farmers.
- The materials available locally were utilized in the fabrication of the all components.
- Availability and price of the materials for construction.
- Easy to work both male and feminine are often operated.
- Easy to operate for both male and female worker.

Design Analysis and Calculation

Power developed by the operator of machine

Power of useful work done by an average human on the drive machine is given by [6]

$$Hp = 0.35 - 0.092 \log t \qquad (2.1)$$

Where, t = operation time in minutes.

Now, on the average a person can work on the sector 2-4 hour's continuous. Hence the power developed by the operator is 0.13 – 0.16 hp. Now if we take working time four hours then the power developed by a human is

HP = 0.35-0.092×log 240

= 0.35-0.092×1.60

= 0.13hp.

Now we all know that developed power by a sequence drive is:

$$Hp = \frac{Push\ Force\ (kgf) \times Speed\ of\ Machine\ (m/s)}{75} \qquad (2.2)$$

The Average operating speed of the machine is 2.0 km/h (0.56m/s).

$$0.13 = \frac{Push\ Force\ (kgf) \times Speed\ of\ Machine\ (m/s)}{75}$$

$$Push\ Force\ (kgf) = \frac{0.13 \times 75}{0.56}$$

= 17.41kgf

Speed of ground wheel (N_w), rpm

$$N_w = \frac{Speed\ of\ Machine\ in\ m\ per\ min}{\pi \times Diameter\ of\ ground\ wheel} \qquad (2.3)$$

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$$N_w = \frac{0.56 * 60}{3.14 \times 35}$$

= 30.57 rpm =31 rpm

Torque on ground wheel (T_w), N.m [15]

$$T_w = K_w \times W_t \times R_w \qquad \textbf{(2.4)}$$

Where, K_w= coefficient of rolling resistance (0.3 for the metallic wheel), W_t= active weight of the machine (32 kg) and R_w is the radius of ground wheel (17.5 cm =0.175m).
=0.3×32×0. 175
=1.68 kg-m

$$Hp = \frac{2 \times \pi \times N_w \times T_w}{4500} \quad (2.5)$$

$$= \frac{2 \times 3.14 \times 34 \times 1.68}{4500}$$

= 0.0726

Determination of maximum bending moment on the chain shaft

The power is conveyed to the machine by the chain drive system therefore for the measurement of the bending moment of the shaft or machine was measured by the theorem of the chain drive system [15]. Hence load on the chain or chain load (Q) is

$$Q = K_l \times P_t \quad (2.6)$$

where, K_l= coefficient of chain (1.15 for the mild steel), P_t = push force of the chain.
Q=1.15×17.41
=20.021 kgf

Now angle of chain drive is working at an φ (35^0) with the horizontal. Hence equivalent chain load on the machine was calculated as

$$Q_v = Q\ sin\varphi \quad (2.7)$$

= 20.021×sin 35
=11.48kgf

Now maximum bending moment (M_b)on the shaft given by the chain drive system is as

$$M_b = (Weight\ on\ wheel \times Overhung) + (Q_v \times Overhung) \quad (2.8)$$

Assume that overhung of wheel = 15 cm and so that the Overhung of sprocket = 5 cm.
Total weight of machine was 32 kg. Hence weight on one wheel is 16 kg.

M_b = (16×0.15) + (11.48 ×0.05)
= 2.974kgf

Hence;

$$Equivalent\ Bending\ Moment = \sqrt{(M_b^2 + M_t^2)} \quad (\because M_t = T_w)$$

$$Equivalent\ Bending\ Moment = \sqrt{(2.974^2 + 1.68^2)}$$

= 3.41 kg-m

Determination of rolling resistance of wheel (R_r) [15].

R_r= co-efficient of rolling resistance × weight on drive wheel
= 0.3×16 = 4.8

Allowable shear stress $(\tau_s) =$ in shaft is 5.01 kg/cm^2

$$M_{eq} = \frac{\pi}{16} d^3 \tau_s \quad (2.9)$$

So, from the equation the diameter of the shaft of the machine was calculated by following equation:

$$d^3 = \frac{16}{\pi \tau_s} M_{eq} \quad (2.10)$$

Where, d = diameter of shaft in cm.
d^3= (16/3.14) (1/5.01) × 3410=3468.22
d=15.13mm

Power transmission system of manually operated planter for groundnut seeds: The planter was operated manually to form it cost effective. Power is transmitted from the transported wheel to the seed metering wheel through pintle chain. Since an influence (HP) transmitted in manual seed planter is extremely low. So, for the amplification of the facility for desired power requirement of seed metering device, a sequence sprocket system was used which have two chain sprockets of multi speed ratio. The chain length is calculated by the following equation [15].

$$m = \frac{2C}{p} + \frac{Z_1 + Z_2}{2} + \frac{Z_2 - Z_1}{Znp} \quad (2.11)$$

Where, m = number of chain links, C = centre to centre distance between two sprockets(mm), P = Chain pitch (mm), Z_1 and Z_2 are the number of teeth in the driver sprocket and driven sprocket respectively.

$$m = \frac{2 \times 260}{13} + \frac{14 + 28}{2} + \frac{(28 - 14)^2}{2 \times 3.14 \times 13}$$

= 40+21+2.4=63.4 ≈ 63 links

Length of chain = m×p=63×13= 819mm=81.9 cm

Design of different components of the planter

Design of handle of the planter

The materials were used for handle was a mild steel circular pipe 200mm diameter. Length of the handle is calculated based on average standing elbow height of operator. So, the average standing elbow height is the 100cm. Distance of wheel centre from the operator (for operator height of 95-105 cm) in operating condition is that the 115 cm. So, the angle of inclination (θh) with the horizontal is as

$$tan\theta_h = \frac{a_1}{a_2} \qquad (2.12)$$

where, a_1= height of centre of wheel to the elbow (cm), a_2= horizontal distance between the normal to the centre of wheel and normal to the elbow line (cm). The average elbow height at standing position of male worker of Allahabad is 98.23 cm. [18].

$$tan\theta_h = \frac{80.73}{115} = 0.702$$

θ_h = tan^{-1} (0.702) = 35.07^0

Design of the furrow opener

Considering lower push/pull available and straight forward operation of the planter is chosen for the planter. The furrow opener includes:

- Selection of standard (tyne)
- Furrow opening portion (reversible type shovel)

For the choice of ordinary (tyne) the draft force on furrow opener is F kgf/ tyne and working at a height of h/3 from rock bottom of the furrow opener where the h may be a total length of furrow opener and tyne. Distance of draft application on furrow opener tyne,

a = h/3 (2.13)

= 225/3 = 75 mm

Moment arm length= h-a

225-75=150

Bending Moment (B.M.) in tyne = D (h-a)

= 63×150= 9450

Therefore, Maximum bending moment (M_b) in tyne = B.M. × F.O.S.

where, F.O.S.= factor of safety = 2

= 9450×2 = 18900kg -mm

$$Z_t = \frac{M_b}{f_b} \qquad (2.14)$$

where, Z_t = section modulus of tyne, M_b = maximum bending moment of tyne

M.S. flat tyne is used in planter (f_b = 56 N/mm^2 for mild steel)

$$Z_t = \frac{18900}{56} = 337.5$$

$$Z_t = \frac{1}{6} tb^2 \ (For\ rectangular\ section)$$

= (1/6) ×125×32^2

= 21333.33

Design of seed hopper [15]

The seed hopper should have enough capacity to carry the sufficient quantity of seed during experiment. The weight of the material to be filled and field efficiency of machine are important factors for deciding the capacity of the seed hopper as it affect the draft. Its shape should be such that the seed metering is easier and unimpeded. Shape of discharge opening should be designed in such a way that seeds of groundnut falls easily and quickly into the seed tube. Angle of inclination of seed hopper should be greater than the maximum angle of repose but less than 60^0. The shape should be such to allow seeds of groundnut easily towards the metering plate.

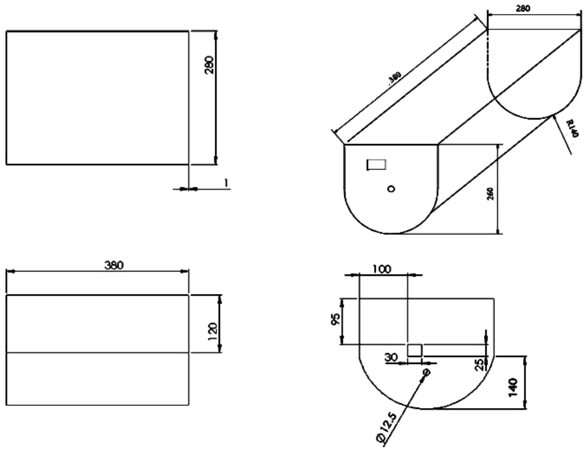

Figure:2.1 CAD views of seed hopper with all dimensions (mm)

Calculation of volume for the seed hopper

Assumption for design of seed hopper

- Seed hopper is kept horizontal.
- Seed box is filled up to centre of height, towards metering device.
- Volume of triangle is neglected, as the seed hopper will not be filled up to centre height on plateside.
- 70% of the total volume calculated was taken because the seed hopper will work in inclined position and to avoid overflow during operation due to jerk etc.

As per above assumptions the calculation was done

$$\textit{Volume of Semi}-\textit{Circular portion of seed hopper} = \frac{1}{2}\pi r^2 l$$

$$\textit{Volume of rectangular portion} = l \times w \times h$$

Where, r = radius, (140mm), l = length of the seed hopper, (380mm), h = height of the seed hopper, (120mm) w = width of the seed hopper (w =2r = 280)

Volume of semi-circular portion = 11704000mm^3

Volume of rectangular portion = 12768000mm^3

Total theoretical volume of seed box = (Volume of semi-circular portion) + (Volume of rectangular portion) = 24472000=0.024472m^3

Actual volume of seed box used to fill groundnut seed was 70% of total theoretical volume of seed box, thus the

Actual volume of seed box $= 0.024472 \times 0.7 = 0.01713$m^3

Capacity ofseedbox =Actual volume of seed box, m^3 x bulk density of groundnut seed, kg/m^3

= 0.01713 x 650 = 11.13kg

Design of seed metering device

The most important component of a manually driven planter is seed measuring apparatus. Metering equipment was used to manage the seed rate and spacing. The metering device should have enough holes to allow optimal seed fall without seed overlapping in the soil. The first and most important problem to consider when designing a seed metering system is how many cells are required for optimal seed spacing. The second issue is, what is the diameter of the seed metering device? As a result, the diameter of the seed metering device was determined using the equation below [15]:

$$D_m = \frac{V_r}{\pi N_r} \qquad (2.15)$$

where,D_m = diameter of seed metering wheel (cm), V_r= Peripheral velocity of seed metering wheel in m/min, N_r = rpm of seed metering device.

Peripheral length of drive wheel = 2πr

2×3.14×.175

=1.099m

Forward speed of the planter was varying 2.5 to 2.80 km/h and Forward speed of the planter was taken under study = 2.5 km/h

$$Speed\ of\ drving\ sprocket\ (rpm) = \frac{Forward\ speed\ of\ machine\ (m/min)}{Peripheral\ length\ of\ drive\ wheel}$$

$$= \frac{41.67}{1.099} = 37.92$$

Speed of driven sprocket (rpm) = Speed of driving sprocket × drive ratio

=37.92 × 1= 37.92 rpm.

So minimum speed for seed breakage and peripheral speed of metering device was considered as 16.5m/min and 45rpm respectively.

$$Diameter\ of\ seed\ metering\ device\ (D_m) = \frac{V_r}{\pi N_r} = \frac{16.5}{3.14 \times 45} = 0.1166\ m$$

=11.66cm

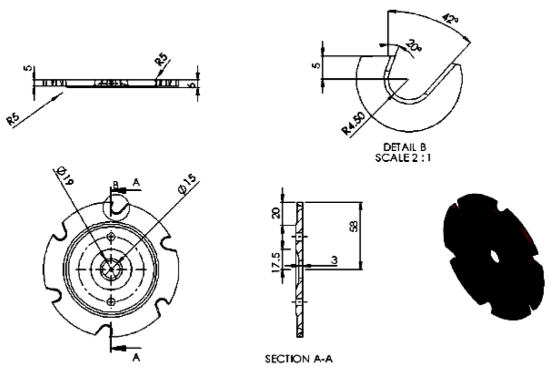

Figure:2.2 CAD views of seed metering device with all dimensions (mm)

Number of cells on metering device

The number of cells on the metering device for sowing of groundnut was obtained with the help of following equation

$$Number\ of\ cells\ on\ periphery\ of\ metering\ device = \frac{\pi \times D_g}{i \times X} \quad (2.16)$$

Where, D_g =Diameter of ground wheel (cm), i= speed ratio, X= plant to plant distance (cm) in groundnut crop. The speed ratio and plant to plant distance was selected as 1 and 20 cm respectively. Thus, the number of cells were obtained as

$$Number\ of\ cells\ on\ periphery\ of\ metering\ device = \frac{3.14 \times 35}{1 \times 20}$$

=5.495≈6

RESULTS AND DISCUSSION

The components of manually operated single row planter for groundnut seed were designed in the Department of Farm Machinery and Power Engineering, VIAET, SHUATS, Prayagraj, U.P. The complete CAD model of manually operated planter for groundnut seed is shown in the figure: 3.1. The different assembly of different components of manually operated planter for groundnut seed are shown in the figure: 3.3. After CAD design, the planter was fabricated in the Farm Machinery Lab and fabricated view of the planter is shown in figure 3.4. On the basis of design dimensions, theoretical volume of seed hopper was found as 0.024472m^3 and drawing shown in figure 2.1. The seed metering device for sowing the groundnut seeds was designed with 6 cells on its periphery and is shown in figure:2.2. On the basis of design, the overall dimensions of the manually operated planter for the groundnut seed were found as 1474 × 960 × 330 mm. The Isometric, Top, Front and Right view of designed manually operated planter for groundnut seeds shown in figure 3.2.

Figure: 3.1. CAD model of manually operated planter for groundnut seed

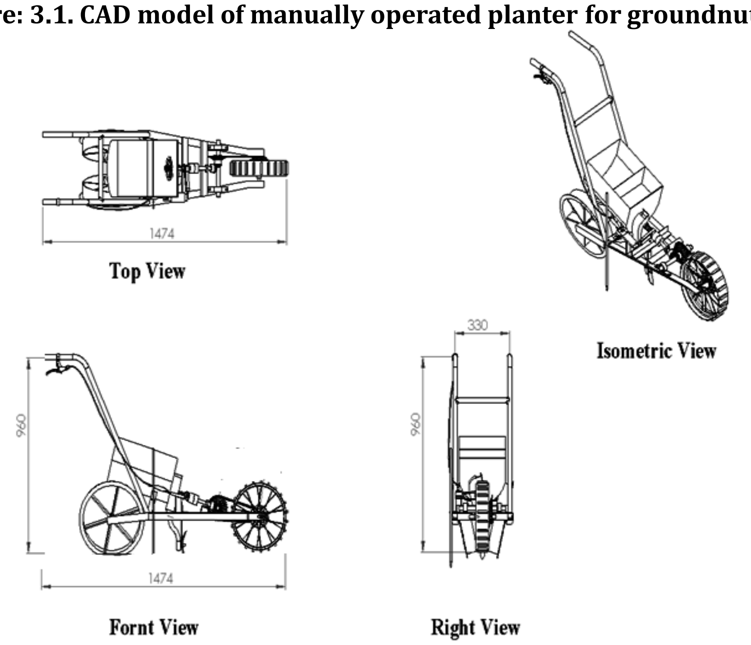

Figure: 3.2 Isometric, Top, Front and Right view of designed manually operated planter for groundnut seeds

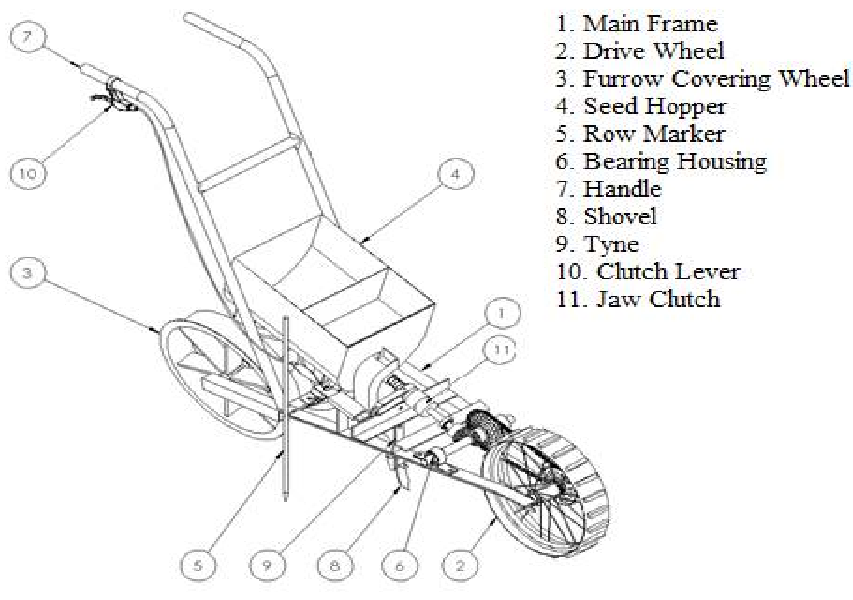

Figure: 3.3. Labelled diagram of manually operated planter for groundnut seeds

Figure: 3.4. Fabricated view of manually operated planter for groundnut seeds

CONCLUSION

On the basis of design consideration, the manually operated single row planter for groundnut seed was designed and fabricated in the Farm Machinery Laboratory, Department of Farm Machinery and Power Engineering, VIAET, SHUATS, Prayagraj, U.P. The different components of the planter were fabricated and assembled successfully. In designed seed metering device,6 cells were found on its periphery and the diameter of seed metering device was found as 11.66 cm. The seed hopper was designed and the theoretical volume of seed hopper was found as 0.024472m^3. The overall dimensions of the fabricated manually operated single row planter was found as 1474 × 960 × 330 mm.It is concluded that the planter can easily be operated for the sowing of groundnut seeds. The planter was found suitable for both male as well as female agriculture workers.

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