Developing of manually operated single row planter for groundnut seed

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ABSTRACT

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 one among the foremost important oilseed crops of India. 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 per cent 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 landholdings is projected to rise. Such tiny landholdings make private ownership farm machines uneconomic and operationally unavailable. In view of these points, a manual operated single row planter for groundnut seed was designed 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 11.66 cm and number of cells on the periphery of seed metering device was found 6. The theoretical volume of designed seed hopper was found 0.024472 m^3. The overall dimensions of the designed planter were found 1,474 mm × 960 mm × 330 mm. This planter is considered economical with ease of operation, requiring no special skills to operate and can be adopted by the farmers for the planting of groundnut seed.

Keyword: Precision farming; mechanization level; groundnut planter; seed metering device

INTRODUCTION

The agricultural sector is the backbone of the Indian economy. It is backbone of the Indian economy since agriculture development results in higher economic position of country. In India, farmers are having issues owing to lack of labour, traditional style of farming and utilising non-effective agricultural equipment which take a lot of time and also raise 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.

The degree of farm mechanisation in India lies at approximately 40-45 per cent with provinces such as Uttar Pradesh, Haryana and Punjab having relatively high mechanisation levels but northeastern regions having little mechanization. It is estimated that percentage of agricultural workers in total work force would drop to 25.7 per cent by 2050 from 58.2 per cent 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 0.043 KW/ha in 1960-61 to about 0.077 KW/ha in 2014-15 (Anon 2018).

Groundnut (*Arachis hypogaea* L) is a major oilseed crop and a popular source of food all over the world. It originated 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 per cent oil and 22-30 per cent protein and is a good source of minerals (Ingale and Shrivastava 2011).

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 (100-125 man h/ha for cereals and about 250 man 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 (Awadhwal and Babu 1994).

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 seed 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. Hence, there is a greater need for multiple cropping within the farms and this in turn requires efficient and time saving machines.

The high cost of imported planters has pushed the bulk of our farmers out of the market. This project work was focused on the planning and fabrication of an operated by hand planter for sowing various crop seeds which is cheap and easily affordable by the agricultural farmers. The manual seed planter met the needs of a poor and small farmer. These planters allow farmers to simply and successfully sow their seed in the field (Khan et al 2015).

Adisa and Braide (2012) designed and constructed an operated by hand flute planter/fertilizer distributor which was found to be 94 per cent efficient in seed spacing but couldn't be used on the ridged seed bed and required quite some effort and time to vary seed drill size and seed spacing.

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.

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, SHUATS, Naini, Prayagraj, Uttar Pradesh. The planning of components of this planter included main frame, drive wheel, furrow covering wheel, seed hopper, seed metering device, furrow opener and handle.

Design considerations

The design of operated by hand multi-crop planter supported the considerations like simple fabrication of component parts, safety to the operator, simple operation of the machine for small scale or rural farmers, materials for fabrication of all components available locally at low price and easy to be operated by both male and female workers.

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 Campbell (1990):

$$Hp = 0.35 - 0.092 \log t \quad (1)$$

where t= Operation time in minutes

On an average a person can work on the sector for 2-4 hours continuously. Hence, the power developed by the operator is 0.13 – 0.16 hp. If working time is taken four hours, the power developed by a human is:

$$HP = 0.35 - 0.092 \times \log 240 = 0.35 - 0.092 \times 1.60 = 0.13 \text{ hp}$$

It is known that developed power by a sequence drive that is:

$$H_p = \frac{\text{Push force (kgf) x Speed of machine (m/s)}}{75} \quad (2)$$

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

$$0.13 = \frac{\text{Push force (kgf)} \times \text{Speed of machine (m/s)}}{75}$$

$$\text{Push force (kgf)} = \frac{0.13 \times 75}{0.56} = 17.41 \text{ kgf}$$

Speed of ground wheel (N_w), rpm:

$$N_w = \frac{\text{Speed of machine in m/min}}{\pi \times \text{Diameter of ground wheel}} \quad (3)$$

$$N_w = \frac{0.56*60}{3.14 \times 35} = 30.57 \text{ rpm} = 31 \text{ rpm}$$

Torque on ground wheel (T_w) (Sharma and Mukesh 2010):

$$T_w = K_w \times W_t \times R_w \quad (4)$$

where K_w= Coefficient of rolling resistance (0.3 for the metallic wheel), W_t= active weight of the machine (32 kg), R_w= Radius of ground wheel (17.5 cm= 0.175 m)

$$= 0.3 \times 32 \times 0.175 = 1.68 \text{ kg/m}$$

$$H_p = \frac{2 \times \pi \times N_w \times T_w}{4500} \quad (5)$$

$$= \frac{2 \times 3.14 \times 34 \times 1.68}{4500} = 0.0726$$

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, it was measured by the theorem of the chain drive system (Sharma and Mukesh 2010). Hence load on the chain or chain load (Q) is:

$$Q = K_l \times P_t \quad (6)$$

where K_l= Coefficient of chain (1.15 for the mild steel), P_t= Push force of the chain

$$Q = 1.15 \times 17.41 = 20.021 \text{ kgf}$$

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

$$Qv = Q \sin\varphi \quad (7)$$
$$= 20.021 \times \sin 35^o = 11.48 \text{ kgf}$$

The maximum bending moment (M_b) on the shaft given by the chain drive system is:

$$M_b = (\text{Weight on wheel} \times \text{Overhung}) + (Q_v \times \text{Overhung}) \quad (8)$$

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

$$M_b = (16 \times 0.15) + (11.48 \times 0.05)$$
$$= 2.974 \text{ kgf}$$

Hence, equivalent bending moment=

$$\sqrt{(M_b^2 + M_t^2)} \qquad (\because M_t = T_w)$$
$$= \sqrt{2.974^2 + 1.68^2} = 3.41 \text{ kg-m}$$

Determination of rolling resistance of wheel (R_r) (Sharma and Mukesh 2010):

R_r = Coefficient of rolling resistance × Weight on drive wheel
= 0.3 × 16 = 4.8

Allowable shear stress (τ_s) in shaft:

5.01kg/cm^2

$$M_{eq} = \frac{\pi}{16} d^3 \tau_s \quad (9)$$

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

$$(\tau_s) = 5.01 \text{ kg/cm}^2$$

$$d^3 = \frac{16}{\pi \tau_s} M_{eq} \quad (10)$$

where d = Diameter of shaft in cm

$d^3 = (16/3.14)(1/5.01) \times 3410 = 3468.22$

d = 15.13 mm

Power transmission system of manually operated planter for groundnut seeds: The planter was operated manually to form it cost effective. Power was transmitted from the transported wheel to the seed metering wheel through pintle chain. Since an influence (HP) transmitted in manual seed planter was extremely low; for the amplification of the facility for desired power requirement of seed metering device, a sequence sprocket system was used which had two chain sprockets of multi-speed ratio. The chain length was calculated by the following equation (Sharma and Mukesh 2010):

$$m = \frac{2C}{p} + \frac{Z_1 + Z_2}{2} + \frac{Z_2 + Z_1}{Znp} \quad (11)$$

where m = Number of chain links, C = Centre to centre distance between two sprockets (mm), P = Chain pitch (mm), Z_1 and Z_2 = 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= 63.4H" 63 links

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

Design of different components of the planter

Design of handle of the planter: The material used for handle was a mild steel circular pipe of 200 mm diameter. Length of the handle was calculated based on average standing elbow height of operator. Thus the average standing elbow height was 100 cm. Distance of wheel centre from the operator (for operator height of 95-105 cm) in operating condition was 115 cm. Therefore, the angle of inclination (θ_h) with the horizontal is:

$$tan\theta_h = \frac{a_1}{a_2} \quad (12)$$

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 (Lata and Parvez 2014).

$$tan\theta_h = \frac{78}{104} = 0.702$$

$\theta_h = \tan^{-1}(0.75) = 36.09^o$

Design of the furrow opener: Considering lower push/pull available, straight forward operation of the planter was chosen for the planter. The furrow opener included selection of standard tyne and 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:

$$a = h/3 \quad (13)$$

= 225/3 = 75 mm

Moment arm length = h – a = 225 – 75 = 150

Bending moment (BM) in tyne = D (h – a)

= 63 × 150 = 9450

Therefore, maximum bending moment (M_b) in tyne:

M_b = BM × FOS

where FOS= Factor of safety= 2

= 9450 × 2 = 18900 kg-mm

$$Z_t = \frac{M_b}{f_b} \quad (14)$$

where, Z_t = Section modulus of tyne, M_b = Maximum bending moment of tyne

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

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

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

= (1/6) ×125×32 ^{2} = 21333.33

Design of seed hopper (Sharma and Mukesh 2010): 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 affects 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 fall 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^o. The shape should be such to allow seeds of groundnut easily towards the metering plate.

Calculation of volume for the seedhopper

Assumptions for design of seed hopper: The assumptions are that seed hopper is kept horizontal, seed box is filled up to centre of height towards metering device and volume of triangle is neglected as the seed hopper will not be filled up to centre height on plate side. Here 70 per cent of the total volume calculated was taken because the seed hopper does not work in inclined position and to avoid overflow during operation due to jerk etc.

As per above assumptions the calculation was done as:

Volume of semicircular portion of seed hopper

$$= \frac{1}{2} \pi r^2 l$$

Volume of rectangular portion = l × w × h

where r = Radius (140 mm), l = Length of the seed hopper (380 mm), h = Height of the seed hopper (120 mm), w = Width of the seed hopper (w = 2r = 280)

Volume of semi-circular portion = 1,17,04,000 mm^3
Volume of rectangular portion = 1,27,68,000 mm^3
Total theoretical volume of seed box =

(Volume of semicircular portion) + (Volume of rectangular portion) = 2,44,72,000 = 0.024472 m^3

Actual volume of seed box used to fill groundnut seed was 70 per cent of total theoretical volume of seed box, thus:

Actual volume of seed box

= 0.024472 × 0.7= 0.01713 m^3

Capacity of seed box

= Actual volume of seed box (m^3) × Bulk density of groundnut seed (kg/m^3)

= 0.01713 × 650= 11.13 kg

Design of seed metering device: The most important component of a manually driven planter is seed metering device. Metering device 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 (Sharma and Mukesh 2010):

$$D_m = \frac{V_m}{\pi N_m} \quad (15)$$

where D_m = Diameter of seed metering plate (cm), V_m= Peripheral velocity of seed metering plate in m/min, N_m= rpm of seed metering device

Peripheral length of drive wheel = 2πr

2 × 3.14 × .175 = 1.099 m

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

Speed of driving sprocket (rpm)

$$= \frac{\text{Forward speed of machine (m/min)}}{\text{Peripheral length of drive wheel}}$$

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

Speed of driven sprocket (rpm) = Speed of driving sprocket × Drive ratio = 37.92 × 1= 37.92 rpm

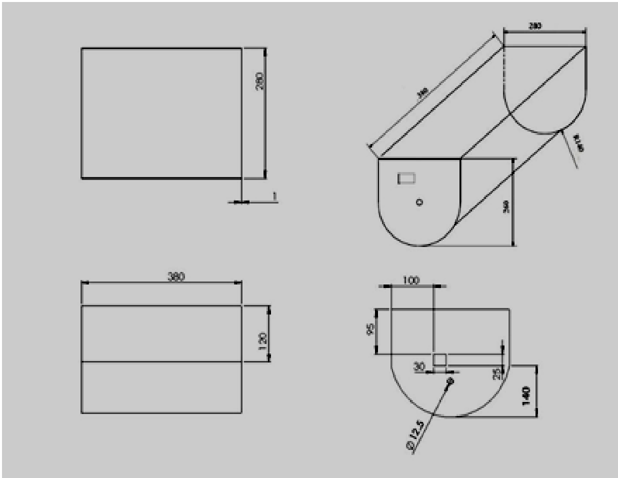

Fig 1. CAD views of seed hopper with all dimensions

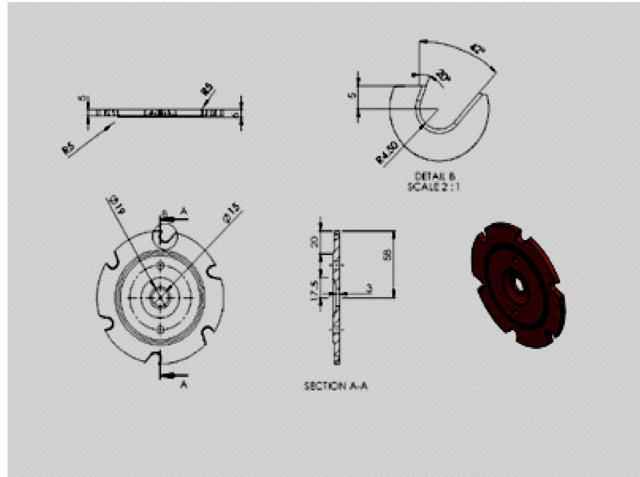

Fig 2. CAD views of seed metering device with all dimensions

Fig 3. CAD model of manually operated planter for groundnut seed

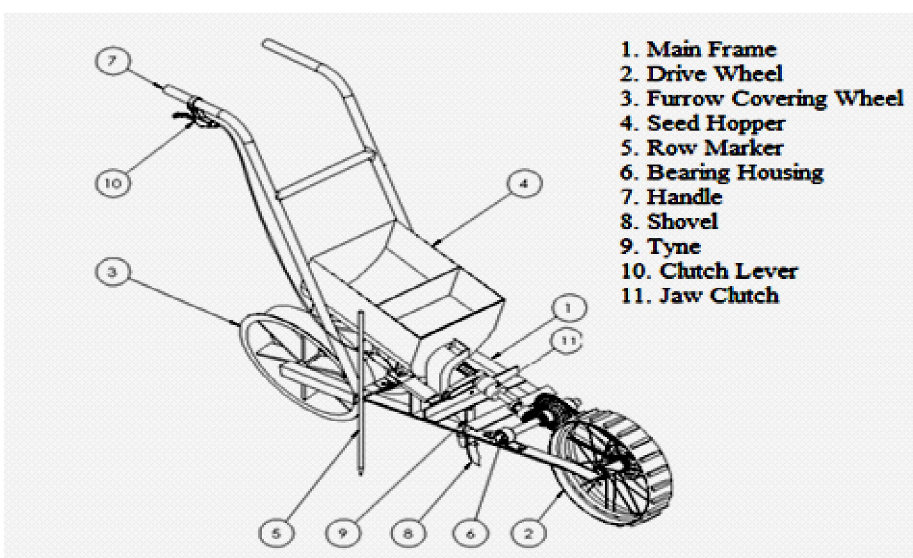

Fig 4. Labelled diagram of manually operated planter for groundnut seeds

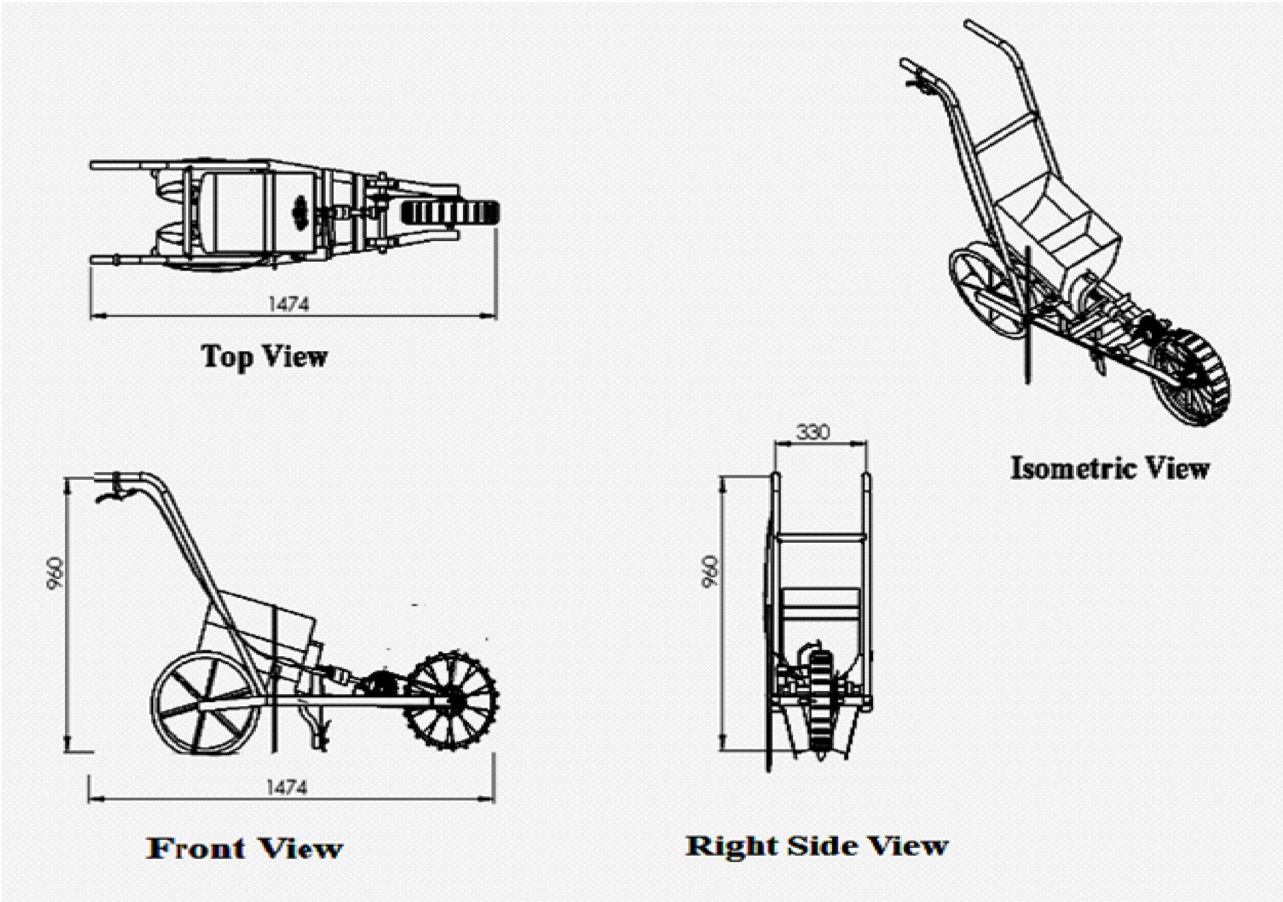

Fig 5. Isometric, top, front and right view of designed manually operated planter for groundnut seeds

Plate 1. Fabrication process of manual operated single row planter for groundnut seed

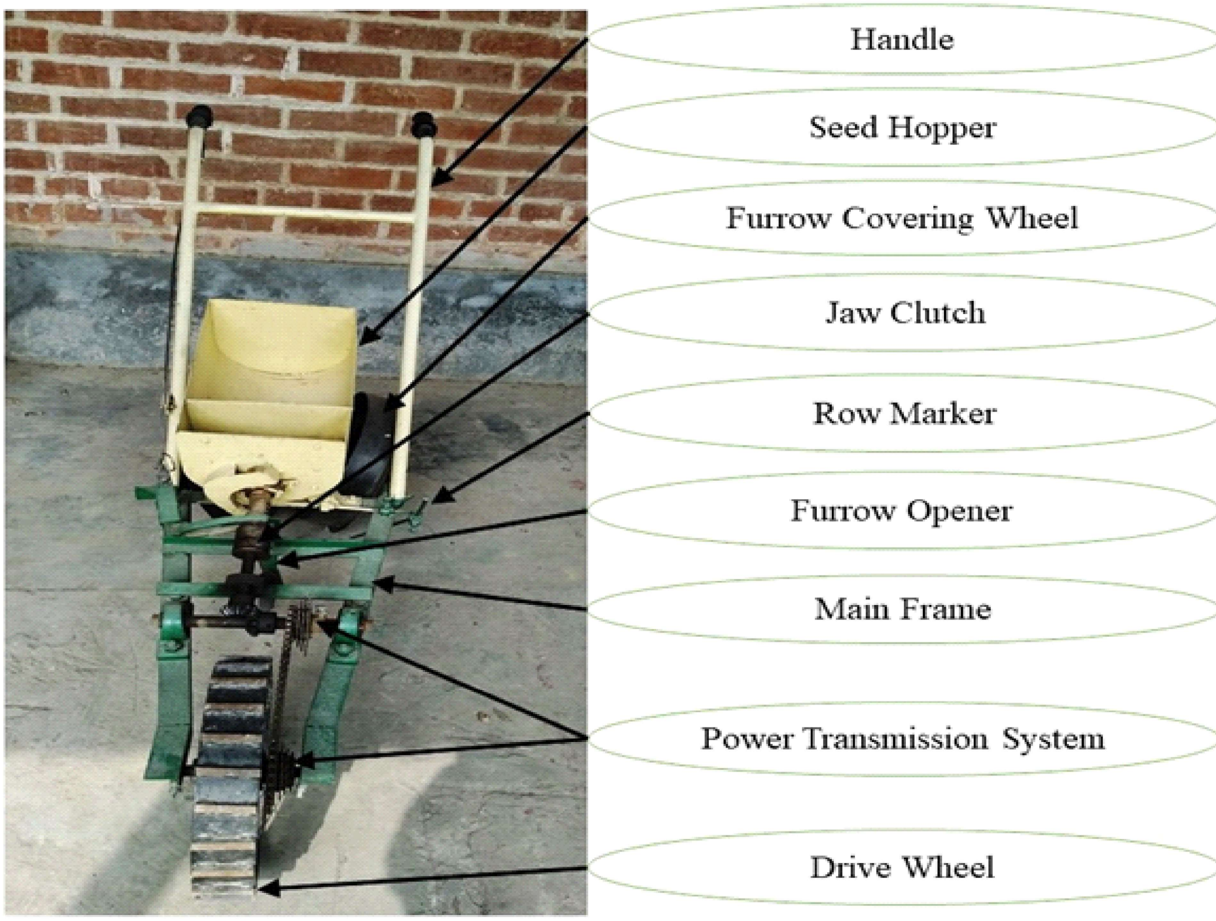

Plate 2. Manual operated single row planter for groundnut seeds developed in the Farm Machinery Laboratory

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

Diameter of seed metering device (D_m):

$$D_m = \frac{V_r}{\pi N_r} = \frac{16.5}{3.14 \times 45} = 0.1166\text{ m} = 11.66\text{ cm}$$

Number of cells on metering device: The number of cells on the metering device for sowing of groundnut was obtained as per Vaishnavi et al (2017):

Number of cells on periphery of metering device

$$= \frac{\pi \times D_g}{i \times X} \qquad (16)$$

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 were selected as 1 and 20 cm respectively. Thus the number of cells were obtained as:

Number of cells on periphery of metering device =

$$= \frac{3.14 \times 3.35}{1 \times 20} = 5.495 \approx \mathbf{6}$$

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, Uttar Pradesh. The CAD views of the seed hopper with all dimensions are shown in Fig 1 and CAD views of seed metering device with all dimensions are shown in Fig 2. After CAD design, the planter was fabricated. The

CAD model of manually operated planter is shown in Fig 3. On the basis of design dimensions, theoretical volume of seed hopper was found as 0.024472 m^3. The seed metering plate of diameter of 11.66 cm for sowing the groundnut seeds was designed with 6 cells on its periphery. Labelled diagram of manually operated planter is given in Fig 4. Isometric, top, front and right view of designed manually operated planter is given in Fig 5. On the basis of design, the overall dimensions of the manually operated planter for the groundnut seed were found as 1,474 mm × 960 mm × 330 mm. Fabrication process of manual operated single row planter for groundnut seed is shown in Plate 1 and the Plate 2 show the manual operated single row planter for groundnut seed developed in the Farm Machinery Laboratory.

CONCLUSION

On the basis of design consideration, the manually operated single row planter for groundnut seed was designed and fabricated. 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 0.024472 m^3. The overall dimensions of the fabricated manually operated single row planter was found as 1474 mm × 960 mm × 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 agricultural workers.

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