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Fabrication and Evaluation of Performance of Single Row Maize Planter: A Case Study

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Abstract

Maize cultivation gets popularity nowadays in our country because of multifarious use of maize in human food and especially in the poultry industries. Maize is cultivated manually which is time consuming, labour intensive and costly. A low cost manually operated push type maize planter was designed consisting of two supportive wheels. Power was transmitted from the ground wheels to the metering device through gear. Maize Seeds were used to test the planter. The seed planter was calibrated in the workshop of the department of Farm Machinery and Power Engineers to maintain the desired seed rate and seed rate was calculated as 20 kg/ha. In the field test the effective field capacity, field efficiency, and draft were calculated in three forward speed levels at 1km/hr, 1.5 km/hr and 2 km/hr for area of 100 m^2. The best performance of the maize planter effective field capacity, field efficiency and draft was found 4.5ha/h, 75.49%, 17.5 kgf at a 2 km/ha.

Keywords: *Maize Planter, Effective Field Capacity, Field Efficiency and Draft*.

Introduction

India is primarily an agriculture-based country and its economy largely depends upon agriculture. Presently, contribution of agriculture about one third of the national GDP and provides employment up to 65 %. Maize popularly known as “corn” is one of the most versatile emerging cash crops having wider adaptability under varied climatic conditions. Maize is an important source of carbohydrate, protein, iron, vitamin B, and minerals. It is called queen of cereals globally (Shah et al, 2016). In India, maize or corn is the third most important food cash crops after wheat and rice. In developed countries, maize is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products.

Manual sowing has the problem of not giving adequate spacing between row to row and plant to plant leading to less population of crops than recommended by the agronomists. Also there is the problem of placing the seeds at correct depth and correct soil coverage. Manual sowing is time consuming and costly. Hence, there is a need for appropriate seed drill for sowing. This paper deals the development and testing of a appropriate seed drill for sowing cereal crops like maize, beans and sorghum.

A recent study showed that seeding operation in maize is at low level as farmers still in the rural areas use machete or sticks use bare hands or hand tools to seed the furrow beds and then cover the seed by hand to use sowing seeds, often times more than the required numbers of the seed are dropped in a hole and covered. Planting seeds through this means is labour-intensive, more time consumption, the traditional planting method is tedious, causing fatigue and backache due to the longer hours required (Mebrhit *et al*, 2017). Sowing maize by hand increases production cost as extra man-hours is required for thinning operation as excessive seeds is inevitably sown per hole in addition to drudgeries and boring nature of the work.

The maize planters available in the market are imported, designed to operate in large farms, expensive and not suited to local conditions Therefore more profitable to developed a simple system that is manually operated single row maize planter it is easy to use less labour cost compare to traditional method (Y Li - (2016. It can be operated by one person, which completes its planting working within one passes on the prepaid field like seed to seed distance, preparing bed row to row. It had affordable and easy to maintain which had alleviate these difficulties and thus, increase maize production in the rural areas. This most improve their yields work focused on the design and fabrication of affordable manually operated single row maize. Plate planters are those that principally use a moving plate with indents, i.e. holes, cells or cups, around its periphery and metering performance is generally highly dependent on matching the size (length, breadth and thickness) of the indents to the size of the seed. Keeping the above view, specific objective had been selected.

Materials and Methods

The fabrication, calibration of maize planter, laboratory test, and field test principle and for determination of different parameters related to manually operate maize seed planter was done in the workshop of the department of farm machinery and power engineering in SHUATS Prayagraj.

Main Frame Design

The main frame is the skeletal structure of the maize seed planter on which all other components are mounted. The two design factors considered in the determination of the material required for the frame are the weight and strength. In this work, mild steel plate bar which is 760 mm length, 50 mm width and 5 mm thickness were used to give the required rigidity. The handle was used to provide the push force through a human operator to move the planter during planting operation. 950 mm long of handle and 20 mm diameter of handle was selected as pre weight considerations for operation.

Fig: 1 Design of main frame

Seed Metering Mechanism

Metering mechanism is the heart of machine and its function is to distribute seeds uniformly at the desired application rates. Seed metering device was made by nylon disc Diameter and thickness of disc 145 mm and 15 mm, respectively.

Number of cell =

$$\frac{\pi \times \text{Diameter of planter's ground wheel} \times \text{Gear ratio}}{\text{Intra row spacing of seeds}}$$

(1) (According to D.N Sharma)

There are four numbers of gears that is N_1, N_2, N_3, and N_4.

Where, N_1 is the ground wheel gear with 18 teeth, N_2 is the power transfer gear with 18 teeth, N_3 is the power transfer gear with 18 teeth and N_4 is the metering device power gear with 42 teeth. Ratio between ground wheel gear to power transfer gear is 1:1, Ratio between power transfer gear to metering device power gear is 1:2.4, There for gear ratio will be 1:1, and 1:2.4 and plant spacing 60 cm row to row 20 cm plant to plant taken from hand book of agricultural.

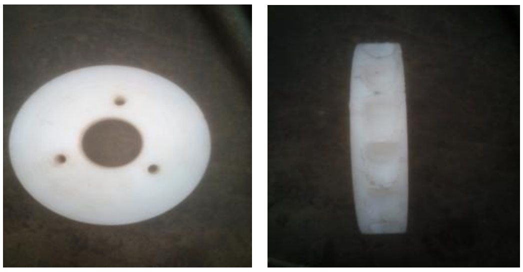


Fig: 2 Metering Device

The seed tube was made of rubber hose pipe 28.5mm outer diameter inner diameter 20.5 mm and 220 mm long. The Furrow opener was made of thin mild steel (angle bar). The angle bar iron was fabricated to shoe type like structure to facilitate an easy cut through the soil. Nut and bolt were used to fasten the device to the frame through a hole drilled on the frame for adjusting sowing depth. Wheel was made of cycle ring and it will cover with mild steel plate bar. The front wheel had many numbers of lugs on its periphery which increase traction and reduction slip. The front wheel had small sprocket transfer the power to seed metering wheel shaft sprocket with the help of chain, in such a way seed metering wheel rotate. Diameter of ground wheel is 42 cm. The seed hopper was made of sheet metal dimension 225 × 185 × 260 mm having length 225 mm width 185 mm and height 260 mm. and the volume are 0.010 meter cube. The capacity was based on the volume of seeds.

Fig: 3 Single Row Maize Planter

Determination of the nominal width (w) of drill

W = M X S

(2) (According to Jagdishwar Sahay)

Where, M is the number of furrow openers, S is the spacing between openers in meter, W is the width (m) and D is the diameter of ground wheel.

Table: 1. Measured data of ground wheel, distance between two row, supporting wheel and furrow

No of furrow	1
Spacing between two supporting wheel	30 cm
Distance between two row	60 cm
Diameter of ground wheel	42 cm

Area of one strip

$$A = L \times W \qquad (3)$$

Where, A is the **a**rea of one strip (m^2), L is the length of strip (m), W is the spacing between two supporting wheel (cm).

Seed rate

$$\text{Seed rate} = \frac{\text{Average weight of seed in kg}}{\text{Area of a strip in ha}} \qquad (4)$$

Independent parameter

Speed at three levels (1 km/h, 1.5 km/h, 2 km/h,) in the field test the effective field capacity, field efficiency, and draft are calculated in three speed level form area 100 m^2 and area was taken 10 m. ×10 m.

Moisture levels

To determine the moisture content, soil samples were taken up to the full depth of core sampler i.e. 115 mm and weighed. The soil samples were kept in an oven for 24 h at 105 ^{0}C. After this, the weight of the oven dried samples was taken and moisture content was calculated by using the following equation.

$$MC = \frac{W_1 - W_2}{W_2} \times 100 \qquad (5)$$

Where, MC is the moisture content, per cent on dry basis, W_1 is the weight of the wet sample in gram and W_2 is the weight of the oven dried sample in gram.

Effective field capacity

Effective field capacity was measured by the actual area covered by the implement, based on its total time consumed and its width. Effective field capacity was determined by the following relationship.

$$\text{Effective field capacity (Ce)} = \frac{W \times S}{10000} \times n_e \qquad (6)$$

The field efficiency was evaluated from equation (6) suggested by Kepner et al (1978).

Where, W is the effective width of implement (m), S is the forward speed (km/h) and n_e is the field efficiency (%).

Field efficiency

Field efficiency is defined as the percentage of time the machine operates at its full rated speed and width while in the field. Using the field efficiency compute the actual, or effective field capacity as follows.

$$\text{Field efficiency } (n_e) = \frac{100 \times Te}{Tt} \qquad (7)$$

The effective field capacity was evaluated from equation (7) suggested by Kepner *et al*, (1978).

Where, Te is the effective operating time (min), Tt is the total time (Te + Ts) and Ts is the total loss time during field operation.

Draft

The maximum draft on the planter is the horizontal component of push parallel to the line of motion in order to overcome the soil resistance on the planter, and is a function of the soil resistance on the machine and the area of contact of the furrow opener with the soil According to (Khan *et al*, 2015).

$$\text{Draft (kgf)} = \frac{HP \times 75}{forward\ speed\ of\ machine} \qquad (8)$$

According to (combell, 1990) useful work done by an average human on the drive Machine develops the horse power as HP = 0.35 – 0.092 Log t and Where, t is the operation time in minutes. Now, on average a human can work on the field 2 - 4 hours continuous. So power developed by the operator is 0.13 – 0.16 hp. Now if we take working time three hours then the power developed by a human is 0.14 hp.

Results and discussion

Manually operated single-row maize planter is cheap, easily affordable, easy to maintain and less laborious to used Seed metering mechanism. Physical properties of maize grain importance during fabrication and design, improvement and optimization for maize seed planter. In this study, some physical properties of corn seeds were determined as a function for sowing with fabricated maize planter.

Elevation angle of maize seed

Table: 2 data of Angle of repose of maize grain

S. No.	Angle
1	20°
2	18°
3	22°
4	22°
5	26°
Total	108°

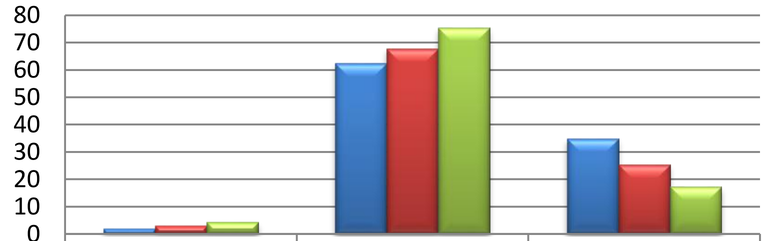
Therefore the average angle of repose is around 22° . Calibration of maize planter seed drill, we have to find length (L) strip in meter is 1333.33 m; number of revolution (N) is 1000 revolution and area of one strip (A) 0.04 ha, Moisture content is 19 %, and seed rate is 20.06 kg/h.

Table: 3 Calibration of maize seed planter for suitable seed rate

S.N	No. of revolution	time in (min)	Weight of seed in (gm)
1	500	36.16	427
2	500	37.01	401
3	500	36.50	381
4	500	31.09	399
5	500	29.57	380
6	500	35.09	420
Total	3000	205.42	2408

Table: 4 Effect of Forward speed on Effective field capacity, Field efficiency and Draft load

Forward speed (km/h)	Effective field capacity(ha/h)	Field efficiency (%)	Draft (kgf)
1	2	62.51	35
1.5	3.05	67.89	25.60
2	4.5	75.49	17.50



	Effective field capacity (ha/h)	Field efficiency (%)	Draft (kgf)
Forward speed (1km/h)	2	62.51	35
Forward speed (1.5km/h)	3.05	67.89	25.6
Forward speed (2km/h)	4.5	75.49	17.5

Fig: 4 Effect of Forward speed on Effective field capacity, Field efficiency and Draft load

Data presented in table 4 and figure 4 shows that field capacity increases as the forward speeds were increased. Field capacity recorded as 2.0, 3.05 and 4.5 ha/h when the speed was maintained 1 km/h, 1.5 km/h and 2 km/h respectively. The maximum field capacity was found as a 4.5 ha/h at 2 km/h.

Perusal of data presented in table 4 and figure 4 shows that field efficiency increases as the forward speeds were increased. Field efficiency recorded as 62.51 %, 67.89 % and 75.49 % when the speed was 1 km/h, 1.5 km/h and 2 km/h respectively. The maximum field efficiency was found as a 75.49 % at 2 km/h.

Perusal of data presented in table 4 and figure 4 shows that draft decreased as the forward speeds were increased. Draft recorded as 35 kgf, 25.70 kgf and 17.05 kgf when the speed was 1 km/h, 1.5 km/h and 2 km/h respectively. The minimum draft was found as 17.05 kgf at 2 km/h. the effect of forward speed as increases the draft decreased.

Conclusion

This work focused on the design and fabrication of a manually operated single-row maize planter that is cheap, easily affordable, easy to maintain and less laborious to use. In the field test the effective field capacity, field efficiency, and draft were calculated in three forward speed levels at 1km/hr, 1.5 km/hr and 2 km/hr for area of 100 m^2. The best performance of the maize planter effective field capacity, field efficiency and draft was found 4.5ha/h, 75.49%, 17.5 kgf at a 2 km/ha. This low cost technology can be promoted for increased farming efficiency and time management.

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