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Design Modification and Development of Vertical Plate Cup Type Metering Device for Onion Bulblet Planter

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Abstract:
A vertical plate cup metering having 8 numbers of cups for onion bulblet planter was developed in the laboratory of College of Agricultural Engineering, JNKVV, Jabalpur.Performance indices namely elevating error, bulblet damage, cell fill,mean planting distance, actual planting distance, planting errors, quality of feed index, rated planting distance, misses and accumulations was evaluated for angular position of cup 80^o, 90^o and 100^o with different peripheral speed of rotor. Minimum elevating error of 2.22 % was obtained at minimum peripheral speed of 9.97 m/min for 80^0 cup position and maximum elevating error (14.39 %) at maximum peripheral speed for 100^0 cup position. Minimum bulblet damage (0.7 %) was obtained at minimum peripheral speed of 9.2 m/min at 100^0 cup position and maximum bulblet damage (7.86 %) was obtained at maximum peripheral speed of 29.13 m/min at80^0 cup position.Cell fill was maximum (107.79 %) at 28.75 m/min of peripheral speed at full seed box fill and for 80^0 cup position. Cell fill was minimum (78.44 %) at30.67 m/min of peripheral speed at half seed box fill and for 100^0 cup position. Actual and mean planting distances increased with increase in travel speed. Actual planting distance (10.92 cm) was minimum and close to rated planting distance i.e.10 cm, at travel speed of 0.85 km/h and maximum (12.65 cm) at 2.4 km/h. Planting error was maximum (4.70 cm) at travel speed of 2.4 km/h and was minimum (2.14 cm) at travel speed of 0.85 km/h. Planting error increased as misses and accumulation increased with speed. Feed index was maximum (94.03 %) at the speed of 0.85 km/h and was minimum (84.42 %) at the speed of 2.0 km/h.

Keywords:*Planter, vertical plate, bulblet, rotor, peripheral speed, angular position*

1. Introduction

Onion is an important commercial vegetable crop having characteristic pungent, spicy and flavour grown on a large area in India for local consumption as well as for export purpose. The onion *(Allium Cepa L.)*, or bulb onion is the most widely cultivated species of the genus *Allium* and onion bulbs are planted from late February at 2-3 cm deep and 10 cm apart. Planting onion bulbs are beneficial because onion seeds obtained from this can grow in wide range of climatic condition. Planting small red onion bulbs allow farmers to grow and harvest onion seeds more quickly. As far as seed production of onion is concerned the bulbs are planted to get quality seeds.The main constraint to increase the productivity, crops quality in India could be attributed to the inadequacies in variety and seed quality and inefficient methods of applying inputs like fertilizers, pesticides and seeds as well as not accomplishing the operation in proper time (Rajan and Sirohi, 2006).The onion is grown for consumption in the green stage as well as mature bulb.In India onion is widely cultivated in Maharashtra, Gujarat and Maharashtra stood first in onion production,producing about 4, 660.00 tons of onions per year, (NHM, 2012) whereas Madhya Pradesh has the annual onion production of 2,691.00 tons, (NHM, 2012).During cultivation of onion transplanting of seedlings, weeding and harvesting are labour intensive operations that are presently done manually in India. The labour requirement in manual transplanting of onion seedlings is as high as 100-120 man-day/ha as 8.9 lakh seedlings per ha are to be transplanted (Rathinakumari et al., 2003). It is unfortunate that besides onions being essential vegetable crops used every day, not much development has been made in mechanizing cultivation practices in onion production. Mechanization will lead to reduction of labour demand, uniform rate of production and high yield that occurs over a relatively short period of time in each growing season. However, onion can also be grown by direct placement of onion bulblet which is an evolving technology and this can also help in saving labour, time and economy. Considering the above points, a study was conducted to develop manually operated mechanical planting mechanism for direct sowing of onion bulblet.

2. Material and Methods

A vertical plate cup type meteringdevice with 8 numbers of cups was modified from the previous existing onion bulblet planter. The planter has 4 wheels (2 drive, 2 towed) and was operated manually by pushing in forward direction with the help of handle. The schematic view of onion bulblet planter an Experimental set – up is shown in figure 1.

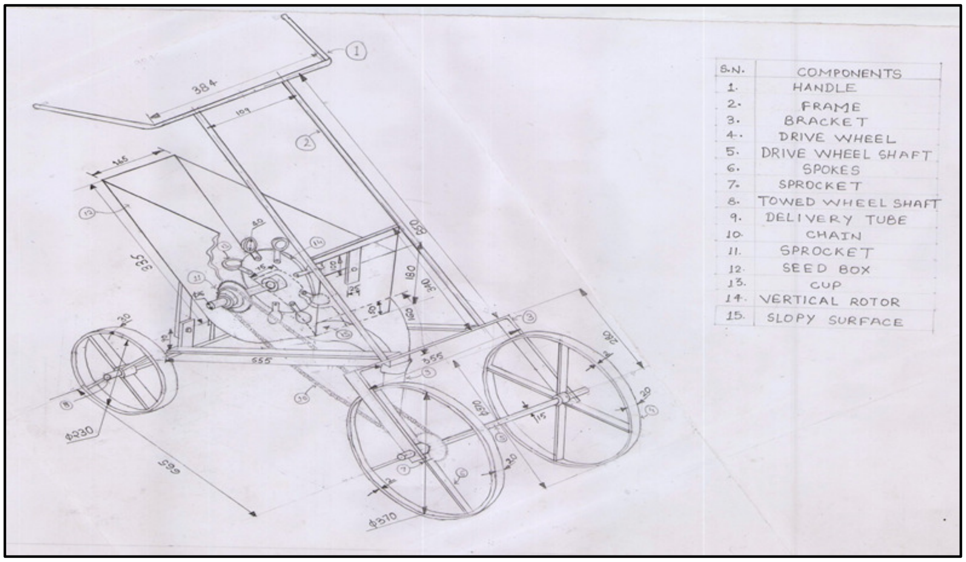

Figure 1: Schematic view of onion bulblet planter (Experimental set – up)

2.1. Design Modification of Metering Device

The metering device consisted of following components:

- Seed box
- Cup type vertical rotor
- Shaft.

2.2. Seed Box

The seed box should have enough capacity to carry sufficient quantity of seeds i.e. 4-5kg. The seed box was fabricated with 2mm thickness MS plate having a length 550 mmand width of 165mm. The bottom of seed box was fabricated in rounded shape with a radius of 145 mm as the taper portion resulted in extra accumulation of the bulblets in one side resulting in chokes during rotation of rotor.Sloppy surface was provided in the seed box which has cut section in the centre of its surface shown in Figure 2. This cut section was provided so that the vertical rotor plate can be brought in the centre of the seed box. Bringing rotor in the centre of the seed box helped in its easy rotation and also minimized the damaging of bulblets. Provision of flap was removed as it did not serve its purpose of not allowing onion bulblets to pass throughit also it choked the movement of rotor. Figure 3 and 4 shows the existing and newly modified seed box base.

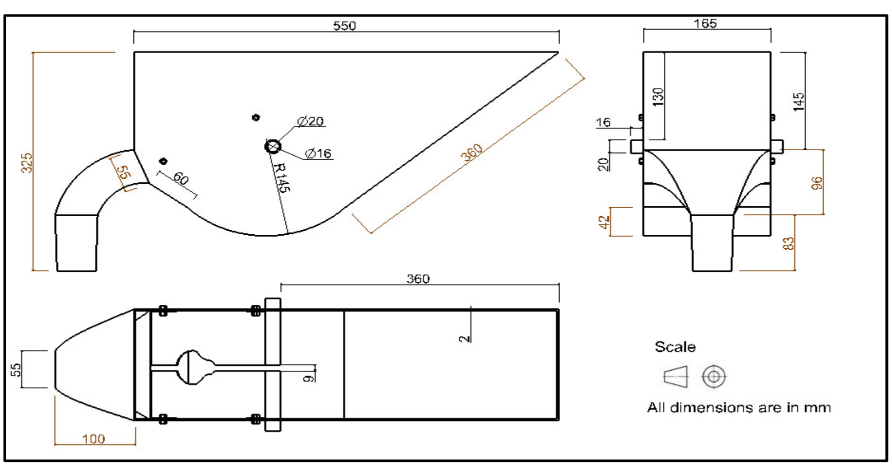

Figure 2: Orthographic view of seed box

Figure 3: Previous seed box base

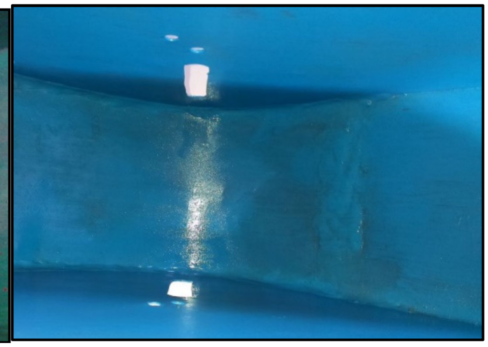

Figure 4: Seed box with base

2.3. Cup Type Vertical Rotor

A 176mm dia having a thickness of 3mm vertical plate rotor was used for the experimental purpose. Here 8 number of 40mm dia circular cups are attached equidistantly at right angle at the periphery of the vertical plate mounted on the main shaft of 20 mm dia MS rod.Cups can pick any type of onion bulblets either circular or elongated shaped. (Polar diameter 1 – 3 cm and equatorial diameter 1 – 3 cm). The shaft is mounted at the distance of 145mm below from the top of the seed box. The metering plate is mounted on the shaft in such a way that the cups should not touch the rounded bottom of the seed box. The orthographic view is shown in figure 5. Provision for lateral movement of rotor over shaft while rotating was given so that rotor can slide laterally over the shaft and can shift its position in either direction.

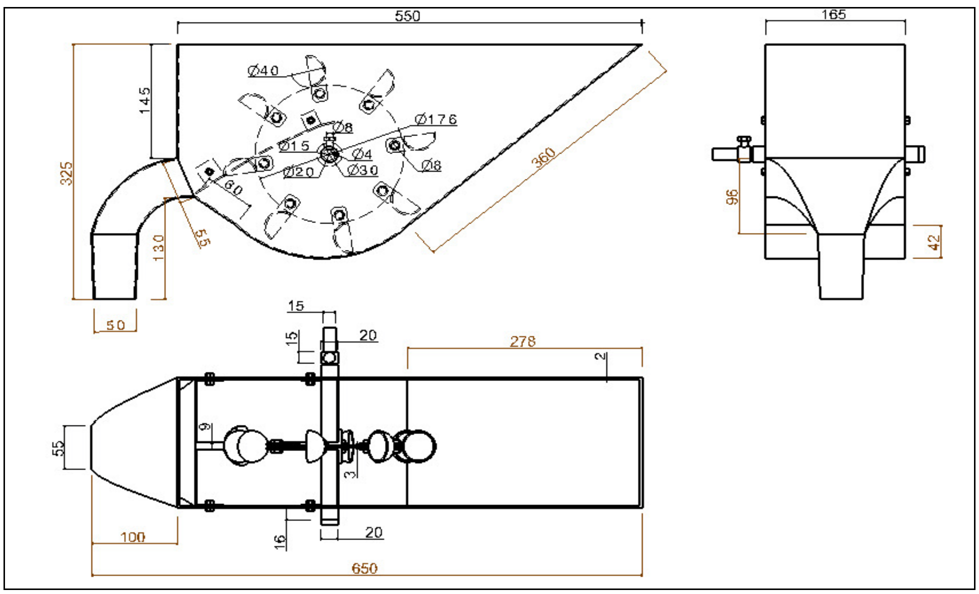

Figure 5: Orthographic view of seed meetering device

Figure 6: Previous rotor

Figure 7: Newly modified rotor

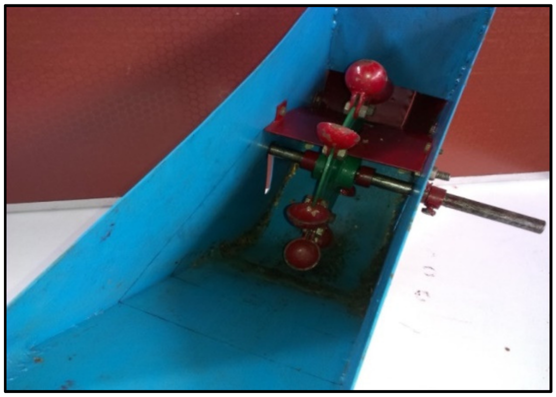

Figure 8: Modified seed box having rotor at center of seed box

Figure 6, 7 and 8 shows the existing and newly modified cup type vertical rotor metering mechanism.

2.3. Shaft

Since it was not possible to predict the load on the metering shaft in terms of hp transmitted and the speed of rotation, N_s. Empirical formula was adopted for the design of shaft. Metering shaft received power from drive wheel i.e. ground wheel with speed ratio of 0.7: 1.Empirical formula used here is:

$$d = \sqrt[3]{\frac{hp*c}{Ns}} \text{... (1)}$$

Where,

d= diameter of the metering shaft in cm

C= constant with a value of 810 for transmission shafts subjected to torsion only

N_s = rpm of metering shaft

2.4. Assumptions for the Design

hp to be transmitted= 0.033 (hp assumed is 1/3 of the average hp of the healthy person)

Also, when drive shaft rpm is multiplied with speed ratio it will give metering shaft rpm i.e. N_s. Drive wheel rpm taken here is 28 as the onion planter (experimental set-up) undergo maximum of 28 rpm which is corresponding to 2 km/h.Therefore, after putting the values, above equation will give following result

$$d = \sqrt[3]{\frac{0.033*810}{28*0.7}} = 1.11 \text{ cm} = 11.1 \text{ mm}$$

Figure 9, 10 and 11 shows the existing shaft having no keyway, modified shaft and orthographic view of the shaft. As the keyway was to be designed on the shaft of the metering device and to suit other fabrication requirements and limitations, the diameter of metering shaft was selected to be 15 mm.

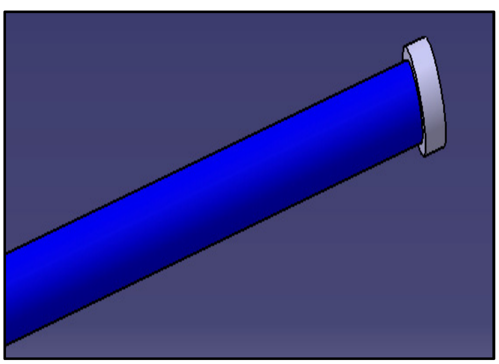

Figure 9: Existing shaft with no keyway

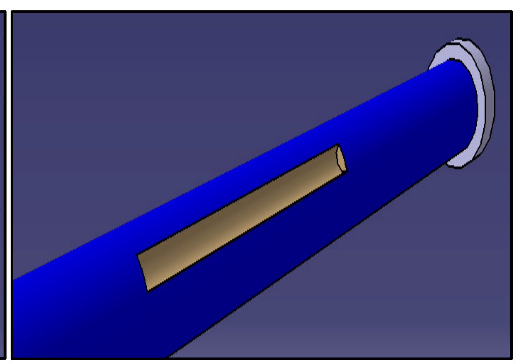

Figure 10: Modified shaft with keyway

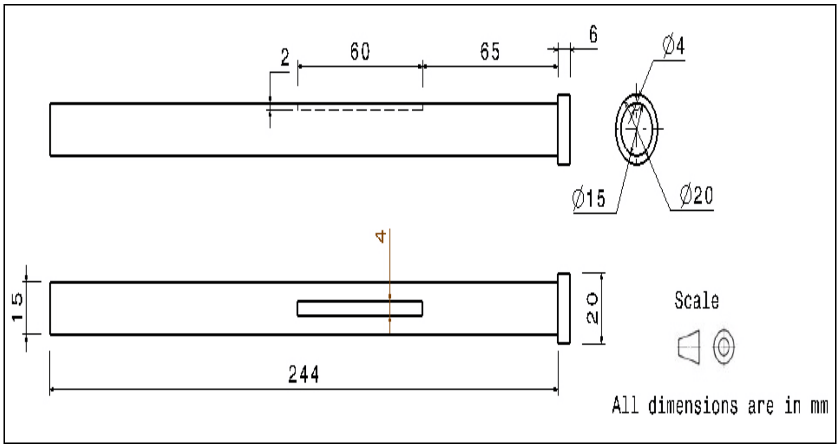

Figure 11: Orthographic view of the modidied shaft

2.5. Speed Ratio

i = (c × t)/a... (2)

i = No. of cups, 8

c = circumference of drive wheel, 116.18 cm

t = speed ratio (Drive wheel shaft to metering shaft)

a = bulb to bulb spacing = 10 cm (Brewster, 1999)

Therefore speed ratio t = (a × i) /c

= (10 × 8) / 116.18

= 0.68

Therefore, speed ratio was taken as 0.7

Circumference of rotor = π × d

= 3.14 × 25.6

= 80.42 cm

Peripheral distance between cups = circumference of rotor / No. of cups

= 80.42 / 8 = 10 cm (Approx.)

Therefore, peripheral distance between cups was taken as 10 cm.

2.6. Power Transmission

Positive drive with multi-stage transmission was provided to the seed metering device to ensure minimum power loss and to maintain metering accuracy as shown in table 1.

S. No.	No. of teeth on metering shaft (T_M)	No. of teeth on drive wheel shaft (T_D)	Speed ratio ($N_D/N_M = T_M/T_D$)
1.	28	24	1.16
2.	28	20	1.4
3.	28	17	1.64
4.	28	14	2
5.	24	24	1
6.	24	20	1.2
7.	24	17	1.4
8.	24	14	1.71
9.	20	24	0.8
10.	20	20	1
11.	20	17	1.17
12.	20	14	1.42
13.	17	24	0.7
14.	17	20	0.85
15.	17	17	1
16.	17	14	1.21
17.	14	14	1
18.	14	17	0.8
19.	14	20	0.7
20.	14	24	0.58

Table 1: Speed ratios obtained by using long chain with idler

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