J Krishi Vigyan 2021, 9 (2) : 40-45 DOI : 10.5958/2349-4433.2021.00007.6

Design and Development of Onion Drum Seeder for Direct Sowing of Onion (*Allium cepa L*) Seeds

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ABSTRACT

In India the area under onion cultivation is about 1.064 ha with 15.1 Mt of bulb production. The average yield of onion in India is about 14.2 t/ha which is very low as compared to the world average yield of 19.1 t/ha. The labour requirement in manual transplanting of onion seedlings is as high as 100-120 man-day/ha as 8.9 lakh seedlings per hectare are to be transplanted. Efficient machinery helps in timely farm operation, input use efficiency, increasing productivity. Onion can also be grown by direct seeding method which is an evolving technology and this can also help in saving labour therefore, the design and development of onion drum seeder was done in the department of Farm Machinery and Power Engineering of PAU, Ludhiana, Punjab. The forwarding speed of onion drum seeder was 1 to 1.5 km/hr. The field capacity observed was 0.05 ha/hr and field efficiency was 83 per cent. The draft calculated was 10.61 kgf. Onion drum seeder was capable of sowing six row at once with row to row spacing of 10 cm and seed to seed spacing of 7.5 cm.

Key Words: Drum seeder, Onion, Direct seeding, Timely sowing, labour saving.

INTRODUCTION

Onion (*Allium cepa L.*) belongs to family *Amaryllidaceae* is one of the most important commercial vegetables and is an integral component of Indian culinary. The average yield of onion in India is about 16.97 t/ ha which is very low as compared to the world average yield of 20.1 t/ha (Anon, 2019). Generally, the onion seeds are sown in nursery and transplanted in the field with Row to row spacing of 15 cm and plant to plant spacing of 7.5 cm to get optimum yield. The labour requirement in manual transplanting of onion seedlings is as high as 100-120 man-day/ha as 8.9 lakh seedlings per hectare are to be transplanted (Kumar *et al*, 2016). Due to high requirement and shortage of labour, the area under onion cultivation is low and can be increased by mechanization of this crop.

Efficient machinery helps in timely farm operation, input use efficiency, increasing productivity by 30 per cent, enabling the farmer to raise a second crop or multi crops making the Indian agriculture attractive. Thus, development and introduction of high capacity, precision, reliable and energy efficient equipment and their judicious use can bring in the precision and timeliness in field. To meet up the demand of increased population, onion production should be increased with lower production cost. work on semi-automatic transplanters have been done in India for sowing of wide row vegetable crops, whereas very little work has been done regarding transplanting of onion. A tractor drawn, high capacity machine is also developed for timely sowing of onion and to cover large area under the crop. But sowing by these tractor operated machines become costlier for the small and marginal farmer as the rate of fuel is increasing day by day and also the machinery cost is high.

Onion can also be grown by direct seeding method which is an evolving technology and this

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Table 1. Physical properties of onion seeds.

Dimensions of seeds	Punjab Naroya	PRO-6	Average Value
Major dimension (mm)	2.73	2.82	2.76
Intermediate dimension (mm)	1.93	2.04	1.97
Minimum dimension (mm)	1.53	1.53	1.47
Geometric mean diameter (mm)	2.18	2.21	2.19
Sphericity	0.70	0.71	0.71
Roundness	0.64	0.65	0.65
1000 seed weight (g)	2.70	2.70	2.70
Angle of repose (degree)	31.62	31.54	31.61
Bulk density (kgm^{-3})	476.19	447.42	469.0
Coefficient of static friction	0.39	0.41	0.40

can also help in saving labour. Keeping this in view, a need of inexpensive technology is arises that results in timely sowing, increasing production and reducing labour (Rathinakumari *et al*, 2003). Therefore, the idea of design and development of drum seeder for onion is came into existence which may help the farmers in low-cost production, timely sowing, increasing area under production and better economy for the marginal and small farmers.

MATERIALS AND METHODS

Physical properties of seeds

Physical properties of seeds influence the design of various components of the sowing equipment. Therefore, the average value of data related to the physical properties of onion seeds for PRO 6 and Punjab Naroya cultivars were collected from the research work done earlier in the department of Farm Machinery and Power Engineering of PAU, Ludhiana (Chinna, 2016; Gautam, 2016). The average values of physical properties of onion seeds are given in Table 1.

Design calculation for onion drum seeder

Calculation of the different machine parameters like drum size, section of drum, number of holes on each section of drum, surface area of each section of drum, size of ground wheel, handle size, and furrow opener etc were done on the basis of the design procedure followed in the reviews of the research already had been done in this field (Wohob and Hoque, 2013; Girish *et al*, 2017). The design calculation was done for drum, shaft,ground wheel,furrow opener and handle.

Design of drum

The design calculations of drum include calculation for the surface area of the drum section, seed section of the drum, number of holes size of holes and distance between holes on each section. Both of which were calculated by following the design procedure as given below

Design of seed dropping hole

Shape of the seed dropping hole

The sphericity of the onion seed is ≥ 0.7 and sphericity is the measure of roundness of a shape. A sphere is most compact solid, so more compact an object is, the more closely it resembles to sphere. The shape of object with sphericity equal to 1 is perfectly round. Here the sphericity of onion seed is near to 1 and also in research done earlier round shape was selected for dropping onion seeds. Therefore, the round shape for the seed dropping hole is selected.

Diameter of seed dropping hole

The average major dimension of seed was 2.76 mm as mentioned in Table 1. Therefore, for sowing single seed and to avoid the missing due to the brazing effect the minimum hole size of 3.0mm will

selected. With variation of 0.5mm, the hole size with three diameters 3.0mm, 3.5mm and 4mm for drum D1, D2 and D3 respectively were selected.

Number of holes on periphery of seed box

Required number of holes on the seed section will be calculated by the formula

Number of holes on seed section $= \frac{\pi D}{xi}$

Where,

D = Diameter of the ground wheel, cm

x = required seed to seed spacing, cm

i = Gear Ratio

Here, the diameter of the ground wheel is 30 cm and the recommended seed to seed spacing for onion seed is 7.5 cm. The drum and ground wheel is driven by the same shaft so that in one rotation of ground wheel the drum also complete its one rotation. Therefore, the gear ratio is 1:1. From above formula the number of holes on periphery of seed section calculated is 12 holes per seed section.

Length of the drum of onion drum seeder

Onion drum seeder was designed for direct sowing of onion seeds on 1 meter of seed bed at row to row spacing of 10 cm. The effective width of the bed is 60 cm, while keeping 20 cm free space both side of the drum for movement of the ground wheels.

The number of rows at 10 cm of row spacing on 60 cm wide seed bed is

Number of seed box $= \frac{\text{effective width of seed bed}}{\text{Row to row spacing}} = \frac{60}{10} = 6\,(Nos.)$

Now the length of each seed box

Length of seed box $= \frac{\text{effective width of seed bed}}{\text{number of seed section}} = \frac{60}{6} = 10$ cm

Therefore, the length of cylindrical seed box is 10 cm and total length of the drum is 60 cm.

Diameter of drum of onion drum seeder

The recommended seed rate for the onion crop was 10 kg/ ha. Design consideration was taken for sowing continuously in .04 ha. Therefore, 4 kg of seed was required.

Now, Amount of seed require in one row = 4/6 = 0.667 kg0.7 kg

Bulk density of onion seeds was = 469 kg m^{-3}

Volume of onion seeds in one seed box $= \frac{\text{weight of seeds (kg)}}{\text{bulk density}(kgm^{-3})} = 0.7 / 469 = 0.0015\ m^3$

For 0.0015 m^3 volume of onion seeds required volume of seed box = 1.1 x Volume of seeds

= 1.1 x 0.0015 = 0.0016 m^3

Also, the volume of cylindrical section $= \frac{\pi}{4} d^2 L$

Where,

d = diameter of section

L= length of section (10 cm)

Therefore,

$$0.0016 = \frac{\pi}{4} d^2 \times 10$$

Where,

$d^2 = (0.0016 \times 4) / (3.14 \times 0.1) = 0.021$ m

$d = \sqrt{0.021} = 0.144$ m = 14.4cm = 144 mm

Calculated diameter of pipe for drum of the onion drum seeder was 144 mm. But, the available pipe in the market is of 149 mm diameter. Therefore, the pipe of 149 mm diameter was selected for making drum.

Spacing of seed dropping hole on periphery of seed section

As calculated above the number of holes on seed box is 12 and diameter of pipe for seed box is 14.9 cm. To calculate the spacing between seed dropping holes circumference of pipe used for seed box is required.

So,

Circumference of seed box = 2r and r = radius of seed box

Therefore,

Circumference of seed box = 2 x 3.14 x 7.45 = 46.78 cm

Hole to hole spacing on periphery of seed box $= \frac{\text{circumference of seed box}}{\text{calculated number of holes}}$

Spacing between seed dropping holes = 46.78/12 = 3.89 cm

Design of shaft

As the shaft is use to transmit the torque and rpm from ground wheel, it subjects to torsion therefore the shaft is designed for diameter of shaft is calculated as follow,

Power developed by an average man = 0.1hp= 74.57 watt

Ground wheel rpm for 2km/hr = 35rpm

We know,

$$P = \frac{2\pi NT}{60}$$

Where,

P = power in watt = 74.57 watt

N = speed in rpm = 35 rpm

T = torque, N-m

Torque calculated from above formula is = 20.35 N-m = 20.35 x 10^3 N-mm

Also,

$$\text{Torque} = \tau \times \frac{\pi}{16} \times D^3$$

Where,

= twisting moment (42 Mpa, maximum permissible shear stress as per ASME code)

D = diameter of shaft

Therefore,

20.35 x 10^3 N-mm = 42 x 0.19 x D^3

D = 14.08 mm (But in local market 20 mm diameter shaft was available). So, we used shaft of 2 cm diameter made of MS steel and of 88.5 cm required length.

Design of ground wheel

The diameter of the ground wheel is selected on trial and error method and mainly based on the height of the machine.

Peripheral distance = π D

Where,

D = diameter of wheel (30 cm)

Peripheral distance = 3.14 x 30 = 94.24 cm

Therefore,

Revolution of wheel per hour $= \frac{\text{Forward Speed (m hr}^{-1})}{\text{Peripheral distance(m)}}$ = 2000/ 0.942 = 2123

Revolution of wheel per hectare $= \frac{\text{revolution of wheel per hour}}{\text{Area coverd (ha hr}^{-1})}$ = 2123/ 0.17= 12488

Design of furrow opener

The furrow opener of inverted T type was selected for onion drum seeder. Six adjustable furrow openers were mounted at inner front side of the frame in such a manner that center of the hole and center of the bottom of furrow opener lies on straight line in working condition to maintain the in-line sowing of seeds. The furrow openers were made up of MS bar of 7.5 mm thickness and 25 mm width. The bottom of furrow opener was with 50 mm width, 25 mm height and 75 mm thickness. The total length of the furrow opener was 225 mm to provide the furrow depth of 5 to 20 mm.

Design of handle

The handle of the onion drum seeder was made up of the MS conduit pipe each of 1mm diameter and 0.5 mm thickness. The length of the handle was 600 mm for easy holding. The beam of handle was made of two pipes joint adjacently up to length of 900 mm and remaining portion of 350 mm for both pipes were bend in opposite directions to form L shape to attach it on frame. The length of beam was taken on the basis of average standing elbow height (1000 mm to 1150 mm) for the male or female workers of India and distance of ground wheel center form the operator in operation condition *i.e.,* 1150 mm for pulling and pushing type of manual machine. A handle of 600 mm length was attached horizontally from center at the top end of the beam in a manner that 900 mm length pipes were perpendicular on it. The moment of handle was free so that it will move up and down freely as suitability of the operator.

CAD design of onion drums seeder

With the help of above calculations, 3 dimensional model of onion drum seeder was designed in CAD Laboratory of Farm Machinery and Power Engineering department of Punjab Agricultural University situated at Ludhiana, Punjab by using the design software Creo 2.0 as feel ease in handling. The design was done on the bases of physical properties of seeds and the recommended sowing parameters. The conceptual design of onion drum seeder is shown in Fig.1 and the 2D design of the conceptual model is shown in Fig.2.

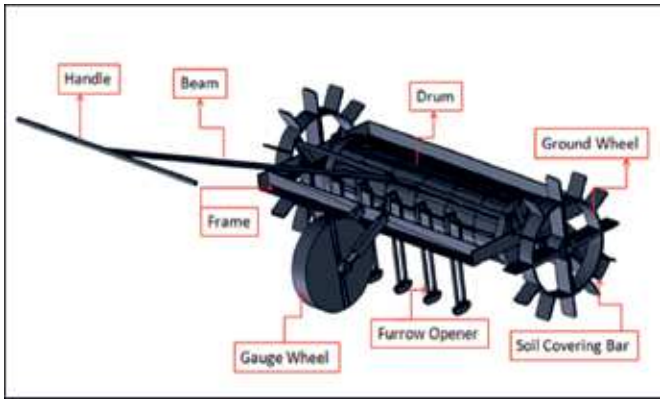

Fig.1 Conceptual CAD design of onion drum seeder

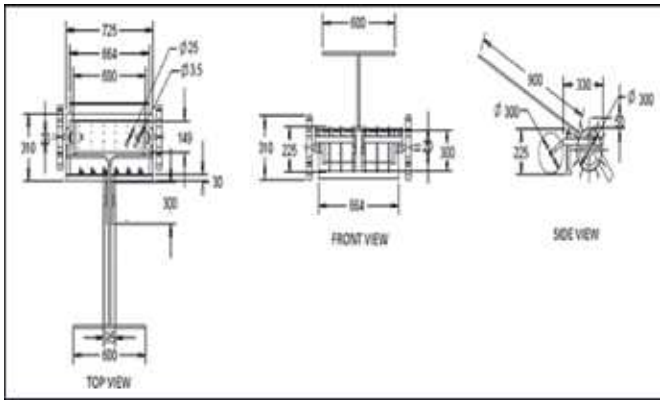

Fig.2 2D design of conceptual CAD model

Development and fabrication of onion drum seeder

The six row onion drum seeder was developed by fabricating the different parts in the workshop with the help of the different machine. First the required material for fabrication of onion drum was purchased from the local market on the basis of knowledge gathered from the cited reviews of earlier researches which had been done in this field of drum seeding technology. After purchasing the material, single-2 parts of machine were fabricated according to the developed conceptual CAD design and 2D drawings generated on base of CAD design of different parts of the onion drum seeder. The machine was developed and fabricated with the help of the local manufacturer Rajar Agriculture works at Mallahpur, Ludhiana. Each part of onion drum seeder was fabricated separately than fastened with nuts and bolts to develop the prototype model of onion drum seeder. Table 2 will show the specification of machine. Fig.3 shows the developed onion drum seeder.

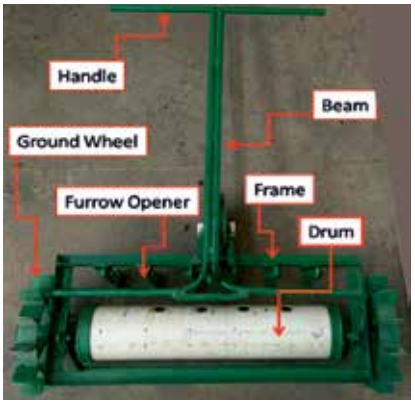

Fig.3 Onion drum seeder

RESULTS AND DISCUSSION

The developed onion seeder was evaluated in the field. It was found that forwarding speed of onion drum seeder was 1 to 1.5 km/hr. The field capacity observed was 0.05 ha/hr and field efficiency was 83 per cent. The draft calculated was 10.61 kgf. The onion drum seeder with 3.5mm seed dropping hole size drum was capable of maintaining seed to seed spacing of 7.5 cm. it was observed that an average man can take approximately 20 men hours for sowing one hectare. The yield of the onion sown by onion drum seeder was little less than the yield by manual sowing due to missing of seed dropping by machine. Sowing by machine save time of sowing nursery and reduce the labour cost.

Table 2. Specification of onion drum seeder.

Sr. No.	Particulars	Specifications
1	Frame (MS angle bar of size 3cm x 3cm x 2mm)	730mm width and 330mm length
2	Ground wheel (MS flat bar of size 5cm x 3mm)	300mm dia.
3	Handle (0.5mm MS conduit pipe of 1.7cm dia.)	900mm
4	Furrow opener (MS flat bar of 3cm x 5mm)	225mm
5	Drum(1mm PVC plastic pipe of 14.9 cm dia.)	600mm width (6 section from inside each of 100mm width)
6	Soil covering bar (MS flat bar of size 3cm x 2mm)	660mm
7	No. of holes in row	13
8	Holes dia.(3 replaceable drums with different holes dia. were used, single drum at once)	3.0mm, 3.5mm, 4.0mm
9	No. or rows per drum	6
10	Depth guiding wheel (PVC plastic of 4cm width)	300mm dia.
11	Working width of machine	600mm
12	Row to row distance	100mm
13	Source of power	Manual
14	Power transmission	Ground wheel

CONCLUSION

It was concluded that machine was capable of maintaining the row to row and seed to seed spacing. The depth control option of furrow openers will help in dropping the seeds at proper depth. The machine will save the time of farmer for raising nursery and reduce the labour cost as the nursery preparation operation is exempted. The transplanting cost of seedlings is also saved because seed is directly sown by single person. As engineers we appreciate this direct seeding technology it will results in raising the area under onion cultivation and raise the income of the farmers. This technology is a cheaper than other developed machine and can be affordable for the farmers.

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Received on 06/05/2021 Accepted on 20/05/2021