International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 9 [2] June2018 : 45-50
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www.soeagra.com/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA ORIGINAL ARTICLE

DOI: .10.15515/iaast.0976-4828.9.2.4550

Design and Development of Manually Operated Ridge Vegetable Planter

Vinod Kumar*, Vijaya Rani, Mukesh Jain, Anil Kumar, Sushil Kumar and Naresh
Department of Farm Machinery and Power Engineering,
CCS Haryana Agricultural University, Hisar-125004, Haryana, India
*Corresponding author, Email: vinodghorla@yahoo.co.in

ABSTRACT
A manual ridge vegetable planter was developed for planting seeds on ridges. The planter consisted of seed metering mechanism–a plastic (ABS) seed metering roller having cells on its periphery, main frame, speed reduction unit, handle, seed tube and tyne. The cell effectively holds one or multiple seed at a time depending upon its size, without causing any damage to the seed. The cleaning brush mounted over seed metering roller wipes any extra seed in cell.Roller tyres were mounted on two forks, which were attached to the main frame. Seed metering mechanism received power from rear roller tyre. Seed tube with conical seed capturing funnel were provided to guide seed to the boot of tyne. Tyne was mounted on tyne bolt for intra-row spacing adjustment.The height of handle from ground at cross bar was 1118 mm. Lower height is obtained with the help of handle tilt adjustment pin.The developed ridge vegetable planter was able to effectively place seeds at acceptable pattern.
Keywords*: Ridge Vegetable Planter, seed metering mechanism*

Received 22/02/2018 Revised 20/03/2018 Accepted 09/05/2018

Citation of this article
Vinod Kumar, Vijaya Rani, Mukesh Jain, Sushil Kumar, Anil Kumar, Sushil Kumar, Naresh. Design and Development of Manually Operated Ridge Vegetable Planter. Int. Arch. App. Sci. Technol; Vol 9 [2] June 2018.45-50.

INTRODUCTION

India occupies second position in vegetable production in the world next only to China. It had 121.02 million tonne vegetable production in 2013 contributing 10.65% of world's total vegetable production. It occupies first position in okra production. At this level of vegetable production, planting operations are one of the least mechanized operations in farm operations owing 29% mechanization only [14]. Manual method of seed planting results in non-uniform seed to seed spacing and poor depth control of seed placement. There is increased probability of planting two or more seeds per hill, which result in financial burden to the farmers. The labor needs to be in continuous bending position while planting of seeds on ridges, which in turn may results in serious backache and other health problems(Hagen *et al.,* 1993). This also limits the size of field that can be planted manually.
The average size of land holding in India was 0.592 ha per household in 2013 [1]. Land holdings in the marginal category (less than 1 ha.) comprise 75.42% of the operational holdings in the country. Small and marginal holdings collectively make up 85.42% in terms of number of operational holdings. Small size and scattered holdings of the farmers leads to under-utilization of the available farm machinery. This results into economic losses for farmers. Most of small farmers are poor who are not in a position to purchase the costly machinery like seeders with tractors, self-operated planters, etc. The need for agricultural mechanization in India must therefore be assessed with a focus on the small land holder farmer's activities [9]. It is also very important for peasant farmers to use their time for

multiplying their productivity in farm jobs, which does not require much human power, to squeeze out every drop of their financial investments.

In recent years, efforts have been made to develop manual planters. A two row okra planter developed from locally available materials was able to effectively place maximum of two seeds per hill [5].For digging and seeding for sowing on flat seed bed, a plunger flapper mechanism was used [12]. It has different sizes of cylindrical hole perpendicular to axis of seed plate, based on suitability for different crops such as okra, beet, pea, carrot, etc. Adisa & Braide [3] developed a manually operated template row planter, which was able to plant on both ridged seedbed and flat seedbed. Adekanye *et al.* [2] developed and evaluated a manual multi-crop hand push planter. The seed metering mechanism of the planter consisted of plastic roller with cells on its periphery. The planter was used for three crops-cowpea, maize and soybean on flat seedbed. The present study on was undertaken to design and develop a manually operated ridge vegetable planter.

MATERIAL AND METHODS

The basic objective of planter was to meter the seed without causing any damage to them and put it on ridges at desired depth and spacing. It should cause minimum drudgery to the labor. The design of the planter was made as simple as possible which can readily be manufactured at reasonable price for the peasant farmers. The ridge vegetable planter consisted of following basic units-

Main Frame

It is the main supporting unit of the designed vegetable planter (Fig. 1). It was fabricated for mounting the handle, seed metering mechanism, power transmission mechanism, forks, tyne and seed tube.

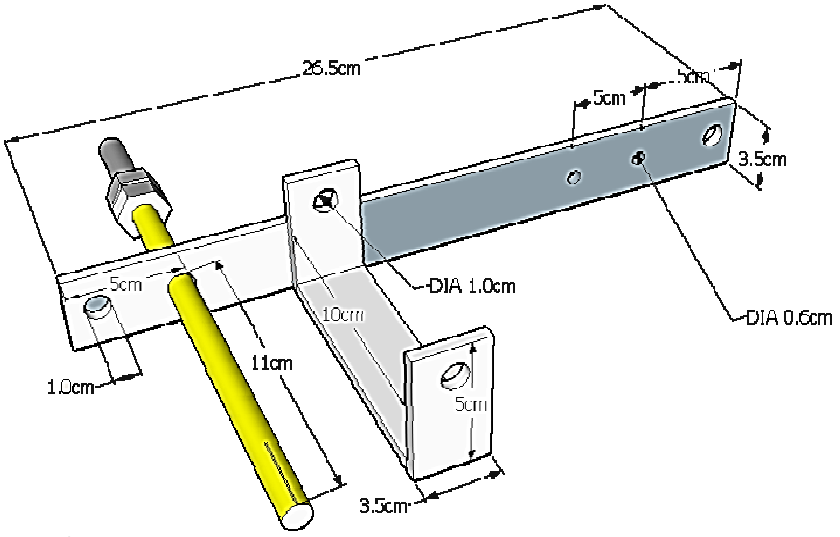

Fig. 1: Main frame dimension

Two forks (Fig. 2) at an angle 30°measured from vertical to the frame for mounting roller tyre were also provided. A mild steel plate having width 35 mm and thickness 5 mm were used for fabrication of main frame. The roller tyre were made from mild steel plate. The diameter and length of the tyre was 150 mm and 250 mm, respectively. The diameter of sidewall disc of tyre was 80 mm. A shaft having diameter 10 mm was used to attach tyres to the main frame.

Design of the seed metering mechanism

The seed metering mechanism consists of a thermoplastic polymer- ABS (acrylonitrile butadiene styrene)seed roller having cells on its periphery. The shape of the cell was an ellipsoid with two axis viz. major and minor. It was a hemisphere at bottom to hold the seed and a trowel at top to guide seed to the hemispherical part. Due to this shape, the cell was termed as '*Anjul*' [8]. The trowel of cell provides enough time to capture one seed from feeding chute and the same helps in releasing of seed easily.The size of the cell was kept 7 mm for okra seed. The cleaning brush with nylon bristles wipes any extra seed in cell. Kumar [11] used seed plates divided into two halves so that they could easily be replaced.

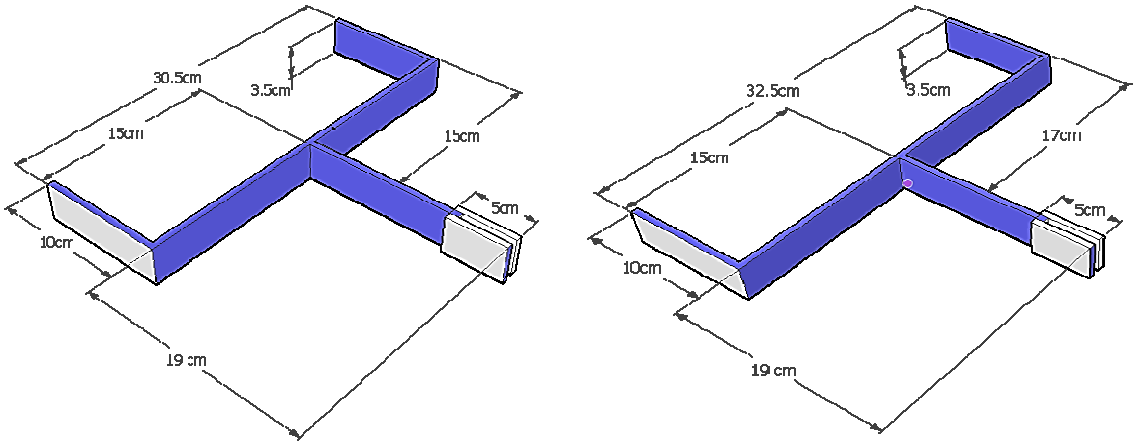

Fig. 2: Fork dimension (Left: Front fork, Right: Back Fork)

Similar split roller design was chosen for easy replacement of seed metering roller in the field. The internal diameter and thickness of seed roller were 40 mm and 15 mm, respectively. Its external diameter was 60 mm. The circular metal plate was attached on one side of the shaft that receive power from power transmission unit through driven sprocket. The number of cells on each seed metering roller was eight which were located equidistant from each other.

Seed box design

A seed box with feeding chute was designed (Fig. 3). A cleaning brush was attached to feeding chute at top of the seed roller to wipe any extra seed in cells. A flow control plate was mounted on seed box to avoid the expected overflow of seed in feeding chute. The seed box was made from mild steel plate having thickness 1.5 mm. A feeding chute was attached to the bottom of the seed box to feed seed to the seed roller. The slop of bottom surface of feeding chute was 35° to the horizontal.

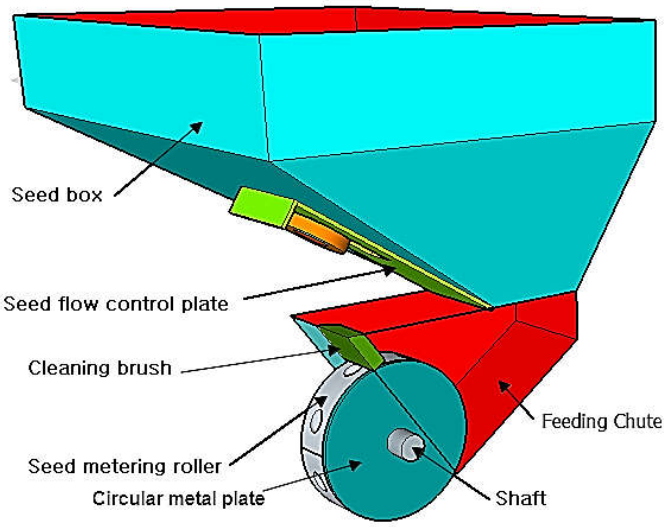

Fig. 3. Seed metering mechanism

Power Transmission Unit

The power for seed metering mechanism is transferred from rear roller tyre through chain sprocket system. The power is transmitted from smaller driving sprocket mounted on shaft of rear roller tyre, to a larger driven sprocket mounted on shaft of seed metering mechanism. The shaft is supported by two ball bearings to reduce friction.

Chain length was calculated by formula [10]:

$$\text{Chain Length (in number of picthes)} = \frac{Z_1 + Z_2}{2} + \frac{2C}{P} + \frac{\left(\frac{Z_2 - Z_1}{2\pi}\right)^2 \times P}{C}$$

Where, Z_1 = Number of teeth in drive sprocket,

Z_2 = Number of teeth in driven sprocket,

C = Centre to centre distance in mm,
P = Chain pitch in mm,

Speed reduction is done by sprockets having different number of teeth given in Table-1.

Table 1.Specificationsof power transmission unit

Sr. No.	Name of component	Specification
1.	Driving sprockets: No. of teeth	 54,44, 40
2.	Driven sprockets: No. of teeth	 20
3.	Chain: Centre to centre length, mm Pitch, mm	 405 12.5
4.	Material of chain	Mild Steel

Handle

Handle was mounted on main frame on rear side of seed box. Handle was made from a hollow pipe having external diameter 22 mm and thickness 1.5 mm.Total length of handle was 910 mm having a cross bar at one end for hand gripping. The height of handle from ground at cross bar was 1118 mm (Male elbow height for 95 percentile [13]. Lower height can be obtained with the help of handle tilt adjustment pin.

Tyne and seed tube

Tyne was made of a mild steel plate having width of 25 mm and thickness of 5 mm. The total length of tyne was 300 mm. Depth of tyne can be adjusted by sliding it through a rectangular hub. A bolt was attached to the rectangular hub to lock position of the tyne. A hoe type furrow opener [4] was attached at the bottom end of the tyne. Narrow seed tube, having diameter approximately two times of geometrical mean diameter of the seed, with conical seed capturing funnel was used to reduce time spend by seed in seed tube which is a source of variation in seed spacing. A transparent nylon seed tube having internal diameter 12.7 mm was provided to guide seed from seed capturing funnel to the tyne boot.

The total length, width and height of the developed planter was 1150 mm, 355 mm and 1120 mm, respectively. The total weight of the planter was 11.5 kg.

A design of the manual ridge vegetable planter(Fig. 4) was prepared in 3D design software-SketchUp.

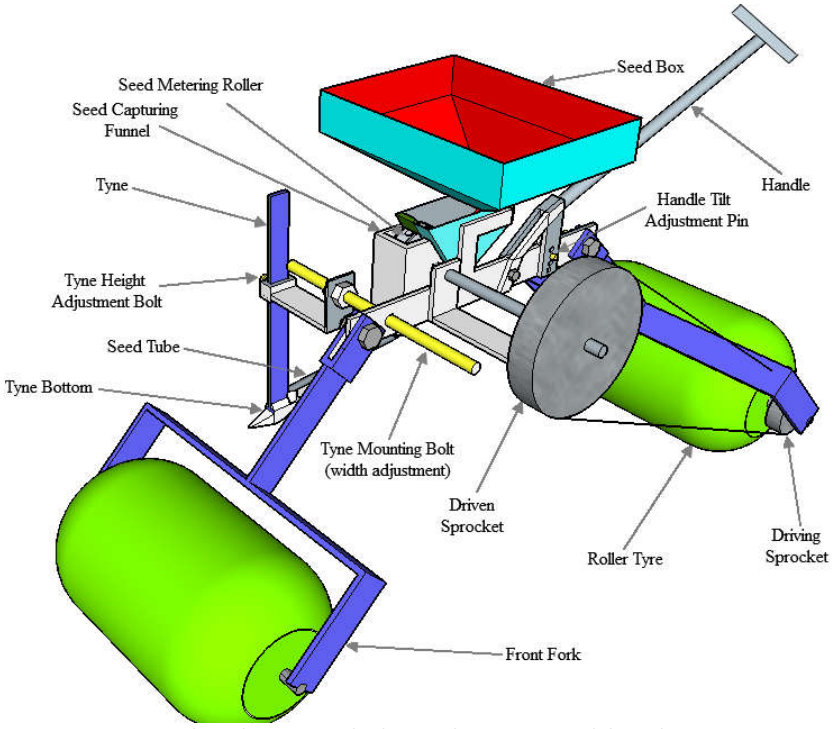

Fig. 4. The design of the ridge vegetable planter.

Handle adjustments

Height of handle from ground can be adjusted upto following 4 levels by handle tilt adjustment pin-Level-1: 720 mm (Minimum), Level-2: 850 mm, Level-3: 980 mm andLevel-4: 1118 mm (Maximum)

Fabrication of the Planter

A prototype of the planter (Fig. 5) was fabricated at Workshop, FMPE, COAE&T, CCSHAU. The seed metering roller was 3D printed.

Fig. 5: The developed ridge vegetable planter

RESULTS AND DISCUSSION

The ridge vegetable planter is designed and fabricated to mechanize the manual dibbling process of seeds on the ridges. The design of components of planter- seed metering mechanism, power transmission unit, handle, seed box, main frame were calculated keeping in mind the functional and ergonomic requirement of the job. The planter was developed to meter the seed and placement of seed at desired depth and spacing on ridges. Roller tyres were provided aimed to reduce variation in depth of seed placement and to stabilize the planter while operating. These tyres were also integral parts of the seed metering mechanism. The rear roller tyre was coupled with the driven sprocket of the power transmission unit. No special drive wheel was provided aiming to reduce the planter weight.

Narrow seed tube, having diameter approximately four times of geometrical mean diameter of the seed, with conical seed capturing funnel was used to reduce time spend by seed in seed tube which is a source of variation in seed spacing. Seed capturing funnel was made of aluminum.

Narrow tyne was used which not only resulted into no need of seed or furrow covering mechanism, but also in reduction of soil resistance to the tyne in moving forward. Bamgboye and Mofolasayo [5] developed a manual two row okra planter with a mild steel furrow-covering device. Dineshkumar and Jaimin [6] used a pull type manual cotton planter with two drive wheels mounted side by side of the planter. Molin *et al.* [15] developed punch planter with adjustable seed spacing and pneumatic seed metering mechanism. Kumar [8] designed and fabricated a manually operated single row planter using different seed plates having differences in size of cells. Adisa and Braide [3] developed a template row planter. Planter was made of light durable galvanized metal sheet. Khan *et al.* [9] also designed a manually operated single row multi-crops planter.

CONCLUSION

The need of a small land holder has fulfilled by the ridge vegetable planter. It can effectively place seeds at acceptable pattern. As seed of different crops vary in size and shape, the size of the cell of seed metering roller need to be changed. It can be easily done by replacing the seed roller of appropriate size. The developed manual ridge vegetable planter consisted of the seed metering unit, seed box, speed reduction unit, handle, seed tube and tyne. The planter will effectively solve the problem of manually dibbling precious seeds of vegetable crops on ridges and increase the productivity of the farmer.

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