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Development and Evaluation of a Bullock Drawn Vegetable Transplanter

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A B S T R A C T

Vegetables are the cheapest source of natural nutrients. To achieve true nutritional self-sufficiency, the production of vegetables in India must be doubled by 2050. This can be achieved through better cultivation practices. In India most of the vegetable crops are transplanted by traditional manual method; which is a tiresome and labour consuming process. Thus mechanization of vegetable transplanting is an immediate need. On the way of mechanization lies the marginal land holdings and poor socio- economic status of farmers. However the substantial bullock population paved way for developing a one row semi-automatic bullock drawn vegetable transplanter. The developed transplanter consisted of a furrow opener, a seedling drop tube, a pair of press wheels and a tray type seed metering mechanism. The metering mechanism of the developed transplanter was powered by the ground wheel. The machine was evaluated in the field condition with a pair of bullocks using bare root seedlings of brinjal and chilli of 10- 12% moisture content. From the field studies the average depth of planting brinjal and chilli was found to be 58-60 cm. The plant stand and plant mortality after 21 days of transplanting was found to be 70.78-72.76 % and 21.66- 25.66 % respectively. The tray type metering mechanism maintained a plant to plant spacing of 525 mm. Draft developed by the vegetable transplanter was 21 kgf. The field capacity and field efficiency of the developed transplanter was 0.052 ha/h and 72.20% respectively.

Introduction

Vegetables are important constituents of Indian agriculture and nutritional security. Vegetable production in India is 146.55Mt from an area of 8.5 Mha with a productivity of 17.3 t/ha in 2010-11 (IIVR, 2013). However with the increasing trends in processing, export and population the production of vegetables needed to be doubled by 2050. This can be possible through better cultivation practices, high yielding seeds and appropriate mechanization. Presently around sixty varieties of vegetables are grown in India and most of vegetable crops are transplanted. Whereas most of the farm operation for transplanting except seedbed preparation are carried out manually; but manual transplanting of vegetables is a tiresome and labour consuming process and requires about 20 % of total labour required for vegetable cultivation (Choudhuri *et al.,* 2001). Thus Mechanization

of vegetable transplanting is an immediate need. A lot of developments have been made for transplanting vegetable seedling with automatic and semiautomatic transplanter in India. But the socio economic status with marginal and fragmented land holding of Odisha farmers did not gave acceptance for higher form of non-renewable power source. Thus (Naya, 2008) developed a manually operated vegetable transplanter at CAET, Bhubaneswar. But the draft developed by the manually operated vegetable transplanter was quite higher for a human. However the substantial bullock population in Odisha i.e. 4 million (19th Livestock census) as a source of green energy paved way for developing a single row semi- automatic bullock drawn vegetable transplanter.

Materials and Methods

Development of the transplanter

The functional component of vegetable transplanter consisted of a furrow opener, a pair of inclined press wheels, a funnel with seedling drop tube, a pair of transport wheels and a tray type seedling metering mechanism. The functional components were attached to the main frame. All the necessary parts of the transplanter were made of MS angles, MS rod, MS flat bar, MS pipe and square bar. A plastic tray was being placed on the main frame to keep the freshly uprooted bare root seedlings. The frame of the transplanter was made with hollow square bar with an arrangement of hitching attachment. Two transport wheels of 300 mm diameter were attached to the main frame, with provision for lifting or lowering the main frame to control the depth of operation.

Furrow opener

The furrow opener of the vegetable transplanter was designed in such a way that it only opens the soil and facilitates backward flow of soil for self-filling of furrow. The wedge angle was calculated as per the following equation considering the mechanics of a vertical tillage tool to suit the types of soil condition (Mahapatra, 2006).

$$\tan\lambda = \frac{\tan\left[\frac{\pi}{4} - \frac{\emptyset}{2}\right]}{\cos\delta} \ldots\ldots (1)$$

Where,

λ = Angle between the direction of travel and sides of the wedge in a horizontal plan.

$\emptyset$ = Angle of internal soil friction

δ = Angle of soil metal friction

tan δ = 0.4^{-} 0.5 for heavy soil and steel at 16-20% m.c (db); So assuming $\delta = 21.8^0$

$\emptyset = 27.9^0 - 47.73^0$ and assuming $\emptyset = 30^0$, we have wedge angle = $2\lambda = 42^0$

A furrow opener was fabricated with MS flat bar, keeping the wedge angle 42^0; such that the seedlings can be dropped without any injury to the root system. Figure 1 illustrates the developed furrow opener.

Funnel and seedling drop tube

A funnel was made up of GI sheet for smooth dropping of seedlings. A PVC pipe of diameter 75 mm and length of 255 mm was attached with the funnel to guide the seedlings into the furrow. The diameter was selected so as to accommodate the foliage area of the seedlings with minimal injury to the plants.

There was a cut at the rear side of the seedling drop tube at the bottom end. It helps the seedlings to be placed into the furrow without injury when the machine moves forward. The side angle of the funnel with horizontal was kept as 75^0 to confirm proper dropping of seedlings.

Furrow covering-cum-press wheels

A pair of press wheels of diameters 300 mm and 65 mm width was used to close and compact the soil at the root zone of the seedling, such that the seedlings can stand erect. The inner sides (at the soil engaging end) of the press wheels were tilted for better compaction. Considering the agronomical requirement of the plants and to accommodate the seedlings in between these two press wheels a clearance of 75 mm was kept.

Seedling metering mechanism

Seedling metering mechanism consisted of a feeding chain of length 1230 mm; nine finger trays were attached to the chain with L-shaped riveted clamps. Power was transmitted to metering mechanism from ground wheel of 500 mm diameter with a set of bevel gear, chain and sprockets. The full assembly of the developed vegetable transplanter with different components and the metering mechanism is shown in Figure 2.

Field test and performance evaluation of the developed transplanter

Field evaluation for bare root seedlings of brinjal and chilli crops was done considering 2 factors (height of seedlings and type of crop) with three replications. Size of each plot was chosen as 15m x 10 m. Two different type of crop and three different sizes of seedlings were selected for transplanting in each plot.
The machine performance variables plant stand, plant mortality after 21 days, draft of the implement, planting depth and plant to plant spacing were measured and recorded.

Plant stand

The number of plants stand were calculated by counting the no of plants inclined at less than 30^0 to the vertical, for a fixed distance of 10 m in a row. The improperly transplanted seedlings, which are slanted more than 30^0 to the vertical, were considered as lying down seedlings. This percentage was calculated by using the following formula.

$$\text{plant stand}(\%) = \frac{N_1}{N_2} \times 100 \quad \text{..... (2)}$$

Where,

N_1 = number of seedlings inclined at less than 30^0 to the vertical

N_2 = Total number of seedlings transplanted in 10 m distance

Plant mortality

For measuring plant mortality, 10 m (one complete row) length was marked randomly at 5 different places. The numbers of transplanted plants after transplanting and the numbers of surviving plants after 21 days of transplanting were counted. The plant mortality was calculated as follows.

$$\text{plant mortality } \% = \frac{N_3 - N_4}{N_3} \quad \text{..... (3)}$$

Where,

N_3= Number of plants in 10 m length excluding lying down seedlings and

Table.1 Test conditions of the field and crops during transplanting

Sl. No.	Variables	Experiment No.	
		1	2
1	Date of experiment	24.04.2015	24.04.2015
2	Crop and Varity	Brinjal 'hybrid F1-132'	Chilli 'VNR-305'
3	Type of seedlings	Bare root seedling of brinjal	Bare root seedling of chilli
4	Seedling Size, mm	100-150,150-200,200-250	100-150,150-200,200-250
5	Average soil moisture content, % (db)	11.80%	11.80%
6	Mean diameter of soil clod, mm	2.4 mm	2.4 mm

Table.2 Field observation data

Items	Transplanting using BDVT	
	brinjal	chilli
Depth of transplanting, mm	60	60
Plant to plant spacing in a row, mm	525	525
Speed of operation, km/h	1	1
Draft of BDVT, kgf	21	21
Plant stand,%	70.78	72.76
Plant mortality after 21 days of transplanting, %	21.66	25.66

Fig.1 Furrow opener

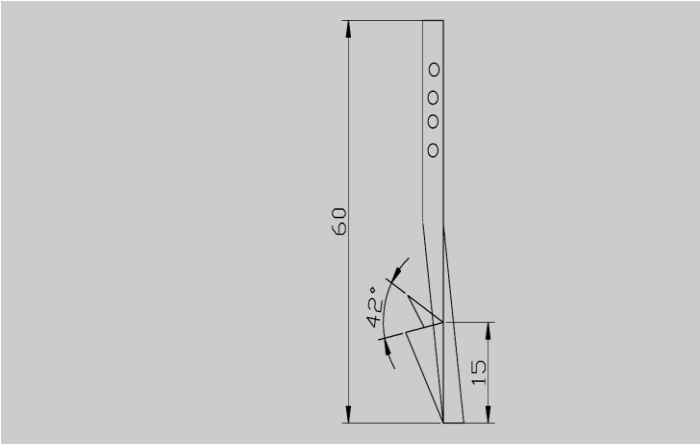
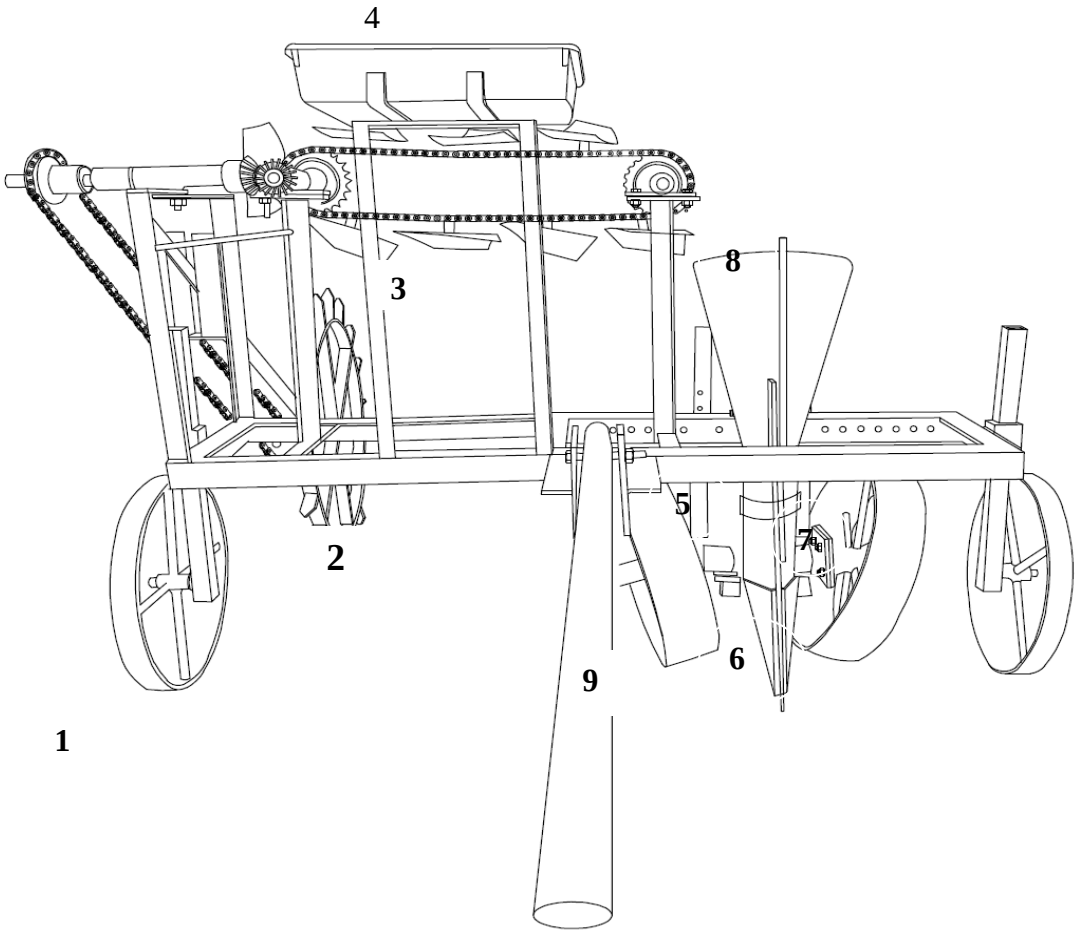


Fig.2 Front view of the developed bullock drawn vegetable transplanter



1.	Transport wheels	2.	Ground Wheel
3.	Finger Tray	4.	Seedling placing Tray
5.	Seedling drop tube	6.	Furrow Opener
7.	Press wheel	8.	Funnel
9.	Hitching pipe		

Fig.3 Draft measurement of developed BDVT using dynamometer in field condition

N_4= number of surviving seedlings in the same transplanted length after 21days

Draft

The draft of the developed machine was measured in the field. The draft is measure as per BIS standard using spring dynamometer. The draft measurement in the field condition is shown in Figure 3.

Field capacity

It is the ratio of actual area covered by the machine per unit time. Field capacity was calculated using the formula.

Field capacity, C = A/T

Where,

C = field capacity (ha/h)
A = area covered (ha)
T = total time for transplanting (h)

Results and Discussion

The performance evaluation of the vegetable transplanter was done in OUAT farm, Bhubaneswar, India. The condition of field and crop parameters taken during field test is presented in Table 1.

Table 2 presents the machine parameter data taken during field observation.

The overall performance of the developed bullock drawn vegetable transplanter is fairly satisfactory.

Recommendation

Bullocks could not provide constant motion (or forward speed) which affected the transplanting process negatively. So requirement for proper training of bullocks was felt during transplanting.

Single bullock is sufficient to pull the developed transplanter.

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