

# Development and evaluation of tractor operated inclined plate metering device for onion seed planting

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**Abstract:** Onion (*Allium cepa* L.) is one of the major vegetable crops grown throughout India. A six row tractor operated planter for direct sowing of onion was developed using inclined plate seed metering mechanism. Experiments were conducted for seed metering unit in the laboratory. Inclined plates having 18, 24 and 30 grooves were evaluated in the laboratory. Performance was evaluated on the basis of missing index, multiple index and quality of feed index. Missing index was highest in case of 18 groove plate at speed of 2 km/h. It decreased with the decrease in forward speed and also with the increase in the number of grooves of the metering plate. Minimum missing index was for 30 groove plate at the speed of 1 km/h. Multiple index was highest at speed of 2 km/h for 30 groove plate. Minimum value of multiple index was 13.67% at speed of 2 km/h for 18 groove plate. As the forward speed was increased from 1 km/h up to 2 km/h, multiple index was decreased. Quality of feed index was best for 30 groove plate at the forward speed of 1.5 km/h. Based on the results of the laboratory evaluation, 30 groove seed metering plate and a forward speed of 1.5 km/h was selected for the field evaluation. Average field capacity of the machine was found to be 0.11 ha/h and average fuel consumption of the tractor was 3.2 L/h. The average germination count after 28 d of planting was found to be 14.66 plants/m row length. The average onion bulb size was found to be 4.94 cm, average bulb weight was 56.68 g and the average yield of onion bulbs was found to be 334 q/ha which was comparable with that of transplanted onion.

**Keywords:** direct sowing, inclined plate, onion planter, small seed planter

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## 1 Introduction

In India, area under vegetable cultivation was around 8.49 million ha and production was 146.55 Mt during 2010-11. The main constraint to enhance the productivity and quality of vegetable crops in India could be attributed to the inadequacies in variety and quality of seeds and nutrients, inefficient methods of applying critical inputs like fertilizers, pesticides and seeds as well as not accomplishing the critical operation in time (Rajan and Sirohi, 2006). Introduction of precision methods, devices and techniques to enhance application efficiency of critical agro-inputs with minimum labour and drudgery

have brought out sea change in agricultural production system of developed nations.

Onion (*Allium cepa* L.) is one of the major vegetable crop grown throughout the country. It is widely grown in different parts of the country mainly by small and marginal farmers. In Maharashtra and Gujarat, this crop has gained the importance of cash crop rather than as a vegetable crop because of its very high export potential. In India, Maharashtra is a leading onion growing state followed by Gujarat, Uttar Pradesh, Orissa, and Rajasthan. In Punjab state, onion is sown over an area of about  $7.61 \times 10^3$  ha having production of  $164.02 \times 10^3$  t. Generally, the onion seeds are sown in nursery and transplanted with Row to row spacing of 15 cm and plant to plant spacing of 7.5 cm to get optimum yield. During onion cultivation, transplanting of seedlings, weeding and harvesting are the most labour intensive operations that

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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). Because of high requirement and shortage of labour, the area under onion cultivation is low and can be increased by mechanization of this crop. 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. Onion can also be grown by direct seeding method which is an evolving technology and this can also help in saving labour. A two row manually operated direct seeder for onion crop using inclined plate metering mechanism was developed and evaluated by Chhina (2010) but its field capacity was low. So need was felt to develop a tractor drawn, high capacity machine for timely sowing of onion and to cover large area under the crop. Keeping this in view, a study was conducted to develop a tractor operated mechanical planting mechanism for direct sowing of onion seed.

## 2 Material and methods

### Development of the tractor operated onion planter

The functional requirements of the prototype for planting six rows onion crop were identified and were kept in mind while its development. In Punjab onion is generally grown in *rabi* season. The best time to sow nursery is mid-October to mid-November and first week of January is being the best time to transplant the crop (Anon., 2011). Onion can be grown on beds as well as flat fields. Ten to twelve kilograms of seed is required for raising nursery for one hectare. The recommended row to row spacing for onion crop is 15 cm and plant to plant spacing is 7.5 cm. So the row to row spacing was fixed at 15 cm and plant to plant spacing would be maintained by changing the speed ratio of the gear sprocket of the metering system. In order to arrive at the width of the machine, it was decided that width of the machine would be such that it could plant six rows on a raised bed that is 100 cm in width. This will make it

easier to use a vegetable digger, with working width of 100 cm, for digging out the onion crop. The raised bed 100 cm in width would be made using a bed maker. The planting depth was to be maintained at 1.5-2.5 cm as per agronomic practice.

### Main frame

The main frame of the machine was fabricated by using a mild steel square section. It was provided with the arrangement to fix the seed hopper, power transmission mechanism and seed placement furrow openers. Two height adjustable wheels are attached, one on either side for balancing of the machine and for maintaining the proper depth during the sowing operation.

### Seed metering mechanism

As per literature review, the inclined plate metering mechanism gave the best results. So, inclined plate metering mechanism was selected for the proposed prototype. An inclined plate was developed based on the design procedure adopted by Ryu and Kim (1998) and Chhina (2010). Seed metering unit was kept as close as possible to the ground level so that there is minimum obstruction to seed fall through the tube and the seed has to travel minimum distance. The side view, top view and developed prototype of the machine are shown in Figure 1, Figure 2 and Figure 3 respectively.

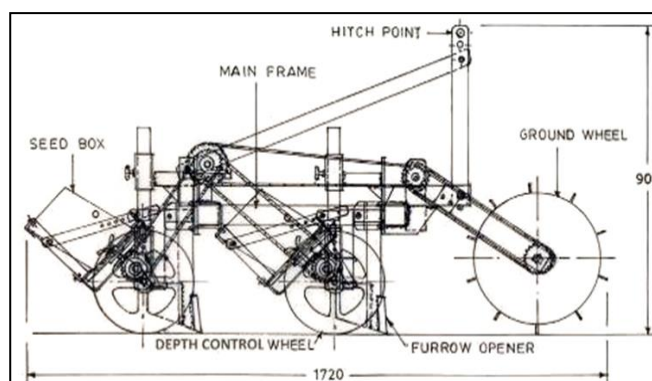


Figure 1 Side view of the tractor operated onion planter

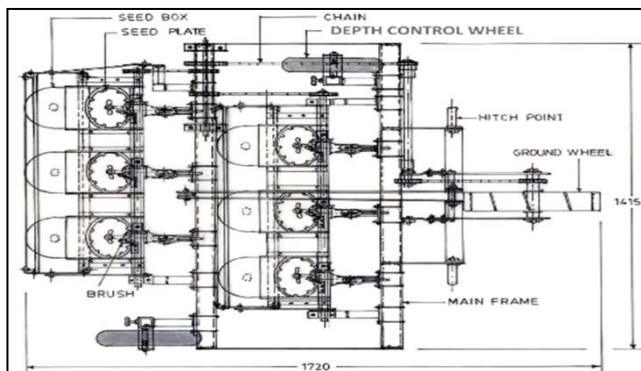


Figure 2 Top view of the tractor operated onion planter



Figure 3 A view of tractor operated onion planter

### Ground wheel

A lugged ground wheel was provided for giving drive to seed metering mechanism. The ground wheel of 380 mm diameter and 90 mm width was fitted with ten trapezoidal shaped lugs on the periphery for the positive rotation under the stubble field conditions. A spring was provided between the main frame and the wheel arm to keep the wheel pressed on ground surface during the sowing operation for reducing wheel slip and missing of seed metering mechanism.

### Power transmission for metering mechanism

The power transmission was provided from ground wheel through sprockets and chain for seed metering. A nineteen teeth chain sprocket was used at ground wheels to transmit power to fourteen teeth sprocket on the main shaft. The power from the main shaft with fourteen teeth sprocket was transmitted to secondary shaft with thirty teeth sprocket. Two sprockets with twenty four teeth each were provided on the secondary shaft to

transmit power to the inclined plate seed metering units with nineteen teeth each. Power transmission is shown in the Figure 4.



Figure 4 Power transmission system of the machine

### Seed box

Seed box was developed for each inclined plate type seed metering mechanism of the six rows (Figure 5). Six independent units were used for six inclined plates for sowing six rows of onion crop. In order to avoid frequent filling of the seed in the seed box, the seed capacity of each seed box was kept one kg. The seed boxes were provided with baffle plates to maintain constant flow of the seed.

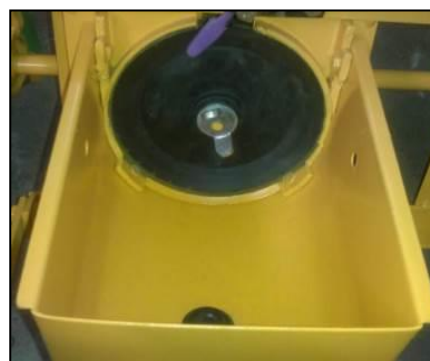


Figure 5 Seed box of the machine

### Depth control wheels

Two depth control wheels (Figure 6), one on each side of the machine were used. The wheels provide balance to the machine and helps in maintaining proper depth of sowing. The diameter of the wheel is 280 mm and width is 50 mm. The height of the wheels from the ground level could be adjusted to maintain the balance and appropriate depth of sowing.



Figure 6 Depth control wheel

### Furrow opener

Six shoe type furrow openers, one for each row were used to open the soil for placement of seeds. The seeds were conveyed through plastic tubes from metering mechanism to the furrow opener.

### Laboratory evaluation of the onion planter

The metering mechanism of the onion planter was evaluated in the laboratory for the seed distribution pattern at different forward speeds and using different seed metering plates.

### Experimental setup

The setup being used for testing of seed cum fertilizer drills by the Farm Machinery Testing Centre of the Department of the Farm Machinery and Power Engineering, PAU Ludhiana was used to evaluate the seed metering mechanism of onion planter. The speed of the moving canvas belt of test rig simulated ground speed of onion planter with the provision to vary the speed of operation. The planter was mounted on the universal mounting frame of the test rig. The power to operate the onion planter was given through gear box, variable drive and set of pulleys.

### Independent and dependent variables

Three levels of seed metering plate holes (18, 24 & 30 holes) and three levels of forward speeds (1.0, 1.5 & 2.0 km/h) were taken as independent variables in the lab experiments. The performance of the onion planter was evaluated in the terms of missing index, multiple index, quality of feed index and degree of seed spacing.

$$\text{Missing index (M)} = n_1/N$$

Where,  $n_1$  = Number of spacing greater than 1.5 times the theoretical spacing in given observations

$$N = \text{Total number of observations}$$

$$\text{Multiple index (D)} = n_2/N$$

Where,  $n_2$  = Number of spacing that are less than or equal to half of the theoretical spacing in the given observations

$$N = \text{Total number of observations}$$

$$\text{Quality of feed index (A)} = n_3/N$$

Where,  $n_3$  = Number of spacing between 0.5 times the theoretical spacing and 1.5 times of the theoretical spacing in the given observations

$$N = \text{Total number of observations}$$

$$\text{Degree of variation (C)} = S/X_{ref}$$

Where,  $S$  = Sample standard deviation of the  $n_3$  observations

$$X_{ref} = \text{theoretical spacing}$$

### Statistical analysis

The observed data was statistically analyzed by using software CPCS1.

### Field evaluation of the machine

Based on the results of the laboratory evaluation, 30 groove seed metering plate and a forward speed of 1.5 km/h was selected for the field evaluation. The onion crop was sown on 2.11.2012. The machine was operated with a 45 hp tractor. The field parameters such as forward speed and field capacity were measured as per standard procedure mentioned in Indian Standard: IS: 7640-1975 (Reaffirmed, 1999). The fuel consumption was measured for 50 m run of the tractor using fuel flow meter installed in the fuel line of the tractor having least count of 1 ml. Time was noted separately with the help of stop watch for 50 m run. The average germination count after 28 d of planting was recorded. The average onion bulb size was measured using a vernier caliper upto accuracy level of 0.1 mm. The average weight of onion bulb was measured with a weighing scale having least count of 0.01 g. The yield of onion bulbs was also recorded in an area of 1 m<sup>2</sup> at ten different locations in the

field and thereafter the average crop yield was calculated in terms of q/ha.

### 3 Results and discussion

#### Laboratory evaluation of tractor operated onion planter

Laboratory studies were conducted to determine the effect of the selected parameters on the performance of the seed metering unit. The performance of the seed metering unit was evaluated for missing index, multiple index, quality of feed index and degree of variation.

#### Effect of forward speed and type of seed metering plate on missing index

Missing index increased with the increase in forward speed as shown in Figure 7. The average miss index observed were 12.00, 18.33, 30.00 for 18 groove plate; 9.33, 15.00, 24.67 for 24 groove plate; 6.67, 9.67, 18.33 for 30 groove plate at forward speed of 1.0, 1.5 and 2.0 km/h respectively. Analysis of variance also indicated that the forward speed had significant effect on missing index. The increase in missing index with the increase in forward speed might be due to decrease in exposure time of cell to seed in the hopper and also the higher centrifugal force at higher speeds may be the reason which throws the seed out of cell prematurely.

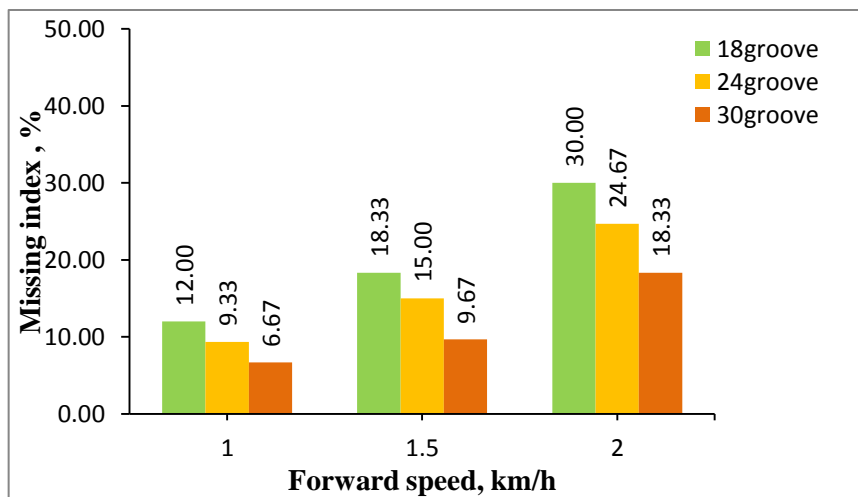


Figure 7 Effect of forward speed and type of seed metering plate on missing index

Missing index decreased with the increase in the number of grooves of the plate. The average miss index observed was 12.00, 9.33, 6.67 at 1.0 km/h, 18.33, 15.00, 9.67 at 1.5 km/h, 30.00, 24.67, 18.33 at 2.0 km/h for 18, 24 and 30 groove plate respectively. Analysis of variance also indicated that the type of seed metering plate had significant effect on missing index.

#### Effect of forward speed and type of seed metering plate on multiple index

Multiple index decreased with the increase in forward speed. It is evident from Figure 8 also that the multiple index decreased with the increase in forward speed. Analysis of variance also indicates that the forward speed had significant effect on multiple index. The average multiple index observed were 27.33, 16.67, 13.67 for 18 groove plate, 33.33, 19.00, 16.00 for 24 groove plate, 39.33, 21.67, 19.00 for 30 groove plate at forward speed of 1.0, 1.5 and 2.0 km/h respectively.



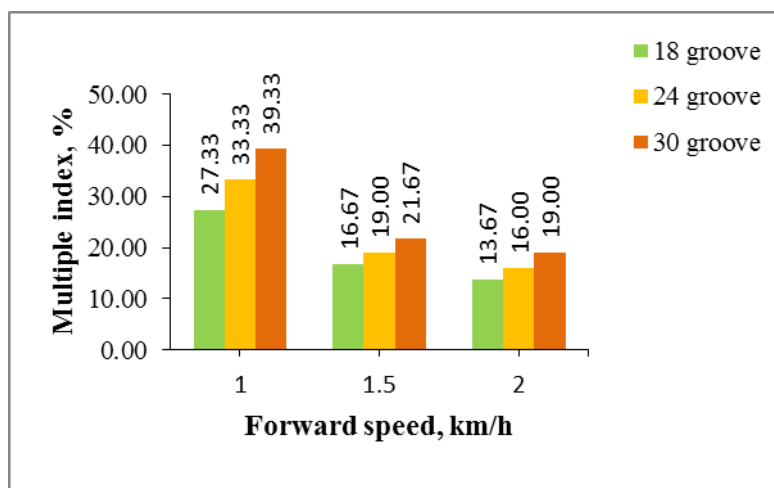


Figure 8 Effect of forward speed and type of seed metering plate on multiple index

Type of seed metering plate had significant effect on multiple index. Multiple index increased with the increase in the number of grooves of the plate. The average multiple index observed were 27.33, 33.33, 39.33 at 1.0 km/h, 16.67, 19.00, 21.67 at 1.5 km/h, 13.67, 16.00, 19.00 at 2.0 km/h for 18, 24 and 30 groove plate respectively.

#### Effect of forward speed and type of seed metering plate on quality of feed index

Variation of quality of feed index with respect to the forward speed is shown in Figure 9. Quality of feed

index first increased when the forward speed was increased from 1.0 km/h to 1.5 km/h and when the forward speed was increased from 1.5 km/h to 2.0 km/h the quality of feed index also decreased. Analysis of variance indicated that the forward speed had significant effect on quality of feed index. The average quality of feed index observed were 60.67, 65.00, 56.33 for 18 groove plate, 57.33, 66.00, 59.33 for 24 groove plate, 54.00, 68.67, 62.67 for 30 groove plate at forward speed of 1.0, 1.5 and 2.0 km/h respectively.

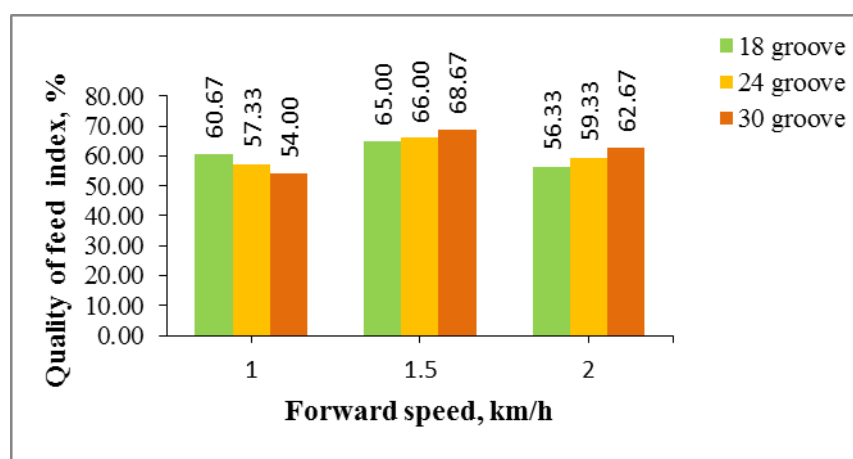


Figure 9 Effect of forward speed and type of seed metering plate on quality of feed index

The quality of feed index varied slightly with the change in type of seed metering plate. The quality of feed index decreased with the increase in the number of grooves of the seed metering plate at forward speed of 1 km/h, whereas at forward speed of 1.5 km/h and 2.0 km/h

the quality of feed index increased slightly with the increase in number of grooves of the seed metering plate. At forward speed of 1.5 km/h, the quality of feed index was observed to be 65.00, 66.00, 68.67 for 18, 24 and 30 groove plate respectively. Type of seed metering plate

had non-significant effect on quality of feed index.

### Effect of forward speed and type of seed metering plate on degree of variation

The effect of type of seed metering plate on degree of variation at different forward speeds is shown in Figure 10. Degree of variation increases with the increase in speed for all types of seed metering plates. Analysis of variance

indicated that the forward speed had significant effect on degree of variation. The average values of degree of variation observed were 15.67, 17.63, 21.73 for 18 groove plate, 14.30, 15.40, 19.53 for 24 groove plate, 12.17, 14.60, 18.03 for 30 groove plate at forward speed of 1.0, 1.5 and 2.0 km/h respectively.

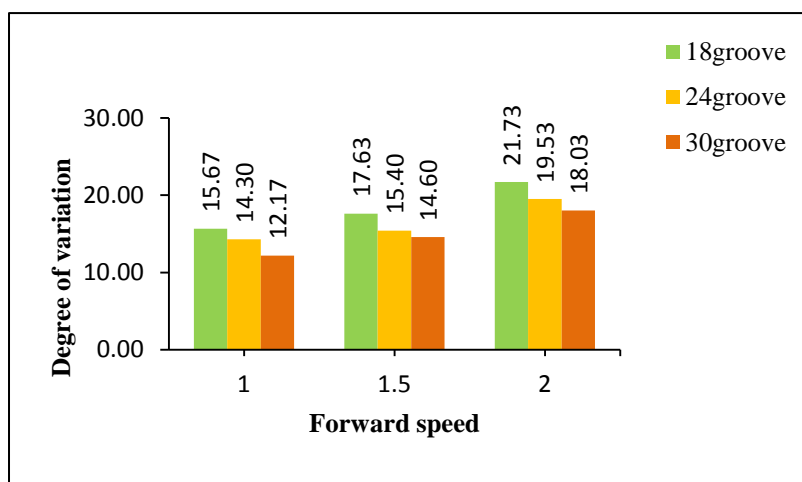


Figure 10 Effect of forward speed and type of seed metering plate on degree of variation

Degree of variation decreased with the increase in the number of grooves of the plate. Analysis of variance also indicated that the type of seed metering plate had significant effect on quality of feed index. The average values of degree of variation observed were 15.67, 14.30, 12.17 at forward speed of 1 km/h, 17.63, 15.40, 14.60 at forward speed of 1.5 km/h, 21.73, 19.53, 18.03 at forward speed of 2.0 km/h for 18, 24 and 30 groove plate respectively.

### Field performance evaluation

The average field capacity of the machine was found to be 0.11 ha/h and average fuel consumption of the tractor was 3.2 L/h. The average germination count after 28 d of planting was found to be 14.66 plants/m row length. The average onion bulb size was found to be 4.94 cm, average bulb weight was 56.68 g and average yield of onion bulbs was 334 q/ac which was comparable with that of transplanted onion.

## 4 Conclusions

A prototype of tractor operated onion planter, which can sow six rows of onion in one go on a 100 cm wide raised bed, was developed and fabricated. Inclined plate with grooves was used as a metering mechanism. Performance of the planter was evaluated in the laboratory at three different forward speed levels (1.0, 1.5 and 2.0 km/h) and with three different levels of seed metering plate holes (18, 24 and 30 groove plates). The selected dependent variables were missing index, multiple index, quality of feed index and average seed spacing. The observed data were statistically analyzed by using software CPCS1. Laboratory experiments with the seed metering unit revealed that the forward speed and type of seed metering plate significantly affect the missing index, multiple index and average seed spacing. Missing index was highest in case of 18 groove plate at speed of 2.0 km/h. Missing index decreased with the decrease in speed and also with the increase in the number of grooves of the metering plate. Minimum missing index was for 30 groove plate at a forward speed of 1 km/h.

Multiple index was highest at a forward speed of 3 km/h for 30 groove plate. Minimum value of multiple index was 13.67% at forward speed of 2 km/h for 18 groove plate. As the forward speed was increased from 1 km/h up to 2 km/h, multiple index decreased. Quality of feed index was maximum for 30 groove plate at the forward speed of 1.5 km/h. Based on the results of the laboratory evaluation, 30 groove seed metering plate and a forward speed of 1.5 km/h was selected for the field evaluation. Average field capacity of the machine was found to be 0.11 ha/h and average fuel consumption of the tractor was 3.2 L/h. The average germination count after 28 d of planting was found to be 14.66 plants/m row length. The average onion bulb size was found to be 4.94 cm, average bulb weight was 56.68 g and the average yield of onion bulbs was found to be 334 q/ha which was comparable with that of transplanted onion.

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