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Research Paper

Development and performance evaluation of power tiller operated multi-crop planter for hill agriculture

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ABSTRACT

A multi-crop planter was developed at Agricultural Engineering Workshop during the year 2021-22 and its field performance was conducted at the vegetable research farm of SKUAST-K Shalimar campus. To determine the uniformity of seed spacing in the rows, missing Index, multiple Index and quality of feed Index (QFI) the developed planter was evaluated at three levels of hopper fillings (H_1, H_2 and H_3) and three level of forward speeds (S_1, S_2 and S_3). During the experiment the optimum value 20.86 cm of seed spacing was found at H_2S_2, missing index 7.71 % at S_3H_2, multiple index 8.5 % at S_1H_3 and highest percentage 83.6 % of quality of feed index was found at S_1H_1, respectively. The effective field capacity and field efficiency of developed planter was found to be 0.18 ha/h and 85.73% respectively.

Key words: Hopper level, missing index, pea-planter, power tiller, seed metering device, seed spacing

Jammu and Kashmir, being a hilly region, is blessed with naturally occurring micro agro-climatic regions suitable for cultivation of a wide range of agri-horticultural crops with a great potential for development. Pea (*Pisum sativum* L.) is a *commonly grown leguminous vegetable in* the India, while often eaten as a vegetable. Jammu & Kashmir is 9th largest producer of pea in India. The area and production under pea in Jammu and Kashmir (UT) is 4000 hectare & 51930 metric ton respectively (FAE-2021-22).

The level of farm mechanization in J&K (UT) is low due to undulating topography, small and irregular sized of fields, fragmented land, lack of skilled manpower, poor facilities of repair and maintenance, lack of agricultural machinery manufacturers, poor purchasing capacity of farmers and non-availability of improved farm implements and machines in the region. Farmers cannot purchase & transport big machines in these difficult terrains. Despite various constraints, there is a great scope for increasing productivity of land and labour in hills with proper mechanization by means of introduction of suitable mechanical power source with matching equipment, efficient gender friendly tools. Power tiller operated matching implements and machinery is the best option for hilly areas in performing unit operations like ploughing, sowing, spraying, weeding, harvesting, threshing and transportation of produce.

The introduction of agricultural innovations in developing countries attracts considerable attention as they can provide the basis for increasing output and income of farmers. In the Kashmir region, majority of farmers use traditional methods to sow the seeds. The traditional planting method is tedious and causes fatigue and back pain due to the longer hours required to carefully plant the seeds by hand if crowding or bunching is to be avoided. In order to solve this problem, the machine/device should be designed to be operated with a walking tractor. The proposed multi-crop planter will have many advantages: time saving, lower seed rate, adjustable and easy to change seed metering disc, easy dismantling, transport in hilly terrain by a single person. The cost of developed planters will be less and affordable for marginal and small farmers of the valley.

MATERIALS AND METHODS

Development of the power tiller operated multi-crop planter: The power tiller operated multi-crop was developed in Engineering Workshop of CoAE&T, SKUAST-K Shalimar Srinagar. The developed planter consists of a main frame, seed hopper, metering disc, furrow opener, seed tube, ground wheel and seed covering device. The metering disc was ingrained in the seed hopper primarily to pick the seeds from the hopper and deliver in the seed tube for placement in the opened furrow. The physical and engineering properties of pea seeds were considered for the development of seed hopper and seed metering disc.

Main frame: The main frame provided a base to support other components of the planter. The length, width and thickness of frame were 1000×500×50.8 mm respectively. Ten holes each having 10.5 mm diameter spaced at 24.5 mm were made for adjustment of different crop row spacing.

Metering disc: Seed metering mechanism is the heart of the planter. The main work of seed metering disc is to take the seed from seed hopper and deliver into the seed tubes. Mild steel was used for the fabrication of the metering discs. Total three discs were used for development of power tiller operated multi crop planter (Figure 1a and 1b). The selected diameter of each disc was 152.4 mm. The cups were welded on the side of circular disc having 10 mm diameter.

(a) (b)

Fig. 1: Fabricated views of seed discs (a) & hopper (b)

Seed hopper: The seed box was made from 18-gauge M.S sheet metal. Three sets of hoppers were made in a trapezoidal shape of 203.2 mm height, 127mm bottom width and 152 mm top width. The seed hopper was mounted on the main shaft and welded to the main frame to provide stability to the hopper (Fig. 1b).

Furrow opener: The major function of the furrow opener is to create a well-defined groove in the soil where the seed can be placed at the proper depth. The shovel type furrow opener was fabricated with rake angle of 62.5°. The curved length and width of furrow opener were 150 mm and 32 mm respectively.

Furrow closer: Furrow closer puts the warmer, moist surface soil on top of the seed, where it can enhance germination, speed sprouting time, and speed emergence. Drag type furrow opener was used for development of planter.

Driving wheels: Both drive wheels were mounted on the side of the frame with diameter of 457.2 mm. The function of drive wheel is to provide drive to the seed and fertilizer metering systems. Twelve lugs were bolted on the periphery of both drive wheels to avoid or minimize the slippage during the field operation (Fig. 2a and 2b).

Main shaft: The main shaft was driven by the two drive wheels. It was made of GI pipe with 25.4 mm diameter. The length of the main shaft was 1143 mm. It was used to transfer power to metering discs in order to carry the seed from hopper to seed tubes.

Design of seed metering disc for pea seed: The diameter of the seed metering disc was calculated by following equation (Sharma and Mukesh, 2010)

$$D_m = \frac{Vr}{\pi Nr} \qquad \text{(i)}$$

Where,

D_m = diameter of seed metering disc, cm

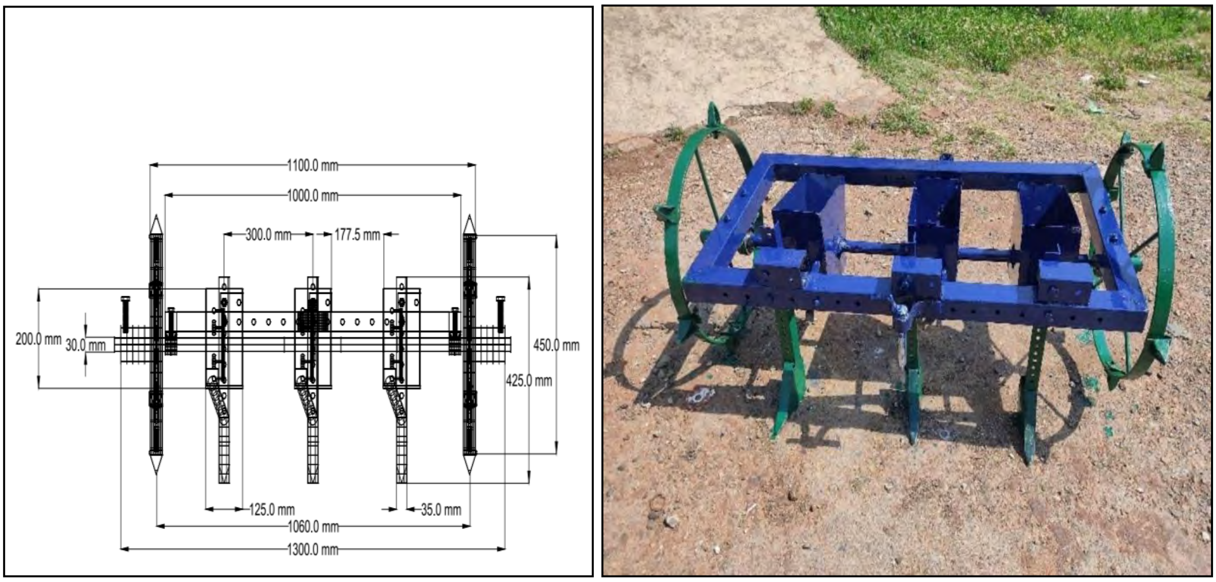
$V_r =$ Peripheral velocity of seed metering wheel, m/min
$N_r =$ rpm of seed metering disc

$$\text{Diameter of seed metering disc} = \frac{V_r}{\pi N_r} = \frac{16.50}{\pi \times 50} = 105 \text{ mm i.e., } 10.5 \text{ cm}$$

Number of cells required in seed metering disc: The numbers of cells on seed metering disc were calculated by following equation (Ikechukwu *et al.,* (2014).

$$\text{No. of cells in seed metering disc} = \frac{\pi \times \text{diameter of drive wheel (cm)}}{\text{drive ratio} \times \text{plant spacing (cm)}} \qquad \text{(ii)}$$

$$\text{No. of cells in seed metering disc} = \frac{\pi \times 48}{1 \times 25} = 06$$



(a) (b)

Fig. 2 (a) 2D front view of developed planter (b) Stationery view of developed planter

Measurement of Parameters: The developed power operated multi crop planter was evaluated for its performance at Research Experimental Farm, CoAE&T, SKUAST-K, Shalimar. The developed planter was evaluated based on three operational speed (S_1=1.5, S_2 = 2.5 & S_3= 3.10 km/h) and three hopper levels (F_1= full, F_2 = half, F_3 = quarter), as shown in Table 1. Since hopper filling level and forward speed has significant effect on responses parameters (Kumar *et al.,* 2021) like seed spacing (cm), missing index (%), multiple index (%), and quality of feed index (%)

Table 1. Description of different forward speed and filling level of hopper of planter during field test

Treatment Combination	Description of forward speed and hopper filling level
H_1S_1	Full hopper level + Planter speed at 1.5 km/h
H_1S_2	Full hopper level + Planter speed at 2.5 km/h
H_1S_3	Full hopper level + Planter speed at 3.1 km/h
H_2S_1	Half hopper level + Planter speed at 1.5 km/h
H_2S_2	Half hopper level + Planter speed at 2.5 km/h
H_2S_3	Half hopper level + Planter speed at 3.1 km/h
H_3S_1	Quarter hopper level + Planter speed at 1.5 km/h
H_3S_2	Quarter hopper level + Planter speed at 2.5 km/h
H_3S_3	Quarter hopper level + Planter speed at 3.1 km/h

Average seed spacing: To determine the uniformity of seed spacing (seed to seed spacing in row) of developed planter, the planter was fully, half and quarter loaded with pea seeds. Planter was allowed to run at different forward speedforward speed (S_1=1.5, S_2=2.5 & S_3=3.10 km/h).

A measuring steel tape was used to measure the distance between seed to seed in the row. This process was repeated three times to record the observation during the operation (Oduma *et al.,* 2014).

Missing Index (I_{miss}): The missing index defines the empty slots that should have been occupied by seeds. Missing index was determined by the following equation

$$\text{Imiss} = n_1/N \qquad \text{(iii)}$$

where,

n_1 = number of spacing >1.5 S
N = total number of measured spacing.
S = plant to plant spacing, cm

Multiple Index (I_{mult}): Multiple Index defines the multiple droppings of the seed at a particular spot. It was calculated as the Percentage of spacing's that are less than or equal to half of the set plant spacing in cm (Figure 3a and 3b). Following equation is used to determine the multiple index (I_{mult}) **(**Staggenborg *et al.*, 2004)

$$I_{multi}= n_2/N \qquad \text{(iv)}$$

where,

n_2 = number of spacing ≤ 0.5 S
S = plant to plant spacing, cm

Quality of feed index (QFI): The quality of feed index is a function of both missing as well as multiple Index (Fig.3a and 3b). Following equation was used to determine the quality feed index (QFI).

$$\text{QFI, \%} = 100 – (\text{Missing index} + \text{Multiple index}) \qquad \text{(v)}$$

Actual Field Capacity(ha/h) : For calculating actual field capacity, the time taken for actual work and that lost for other activities such as turning, filling of tank was taken into consideration. The time required for actual operation and time lost were measured by stopwatch. Actual field capacity was calculated by following equation (Hunt, 2008).

$$\text{Actual Field Capacity (ha/h)} = \frac{A\times 36}{T\times 100} \qquad \text{(vi)}$$

where,

A= Area covered by multi-crop planter, m^2
T=Total time taken, s
Total Time Taken = Time taking in turning + Time taking in filling +Time taken for actual work

Field efficiency: The field efficiency relates the theoretical and actual field capacity of the power tiller operated multi crop planter. It was calculated by the ratio of the effective field capacity to the theoretical field capacity. (Khan & Moses, 2017).

$$\text{Field efficiency (\%)} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}}\times 100 \qquad \text{(vii)}$$

RESULTS AND DISCUSSION

The performance evaluation of developed planter was carried out in terms of three level of forward speeds and three filling hopper levels. Various response parameters were measured to check the efficiency of power tiller operated multi crop planter. The area of experimental plot was178 m^2.

(a) (b)

Fig.3 (a) Performance evaluation of developed planter (b) Measurement of various indices

Effect of forward speed and hopper level on seed spacing, missing index & multiple index: Seed spacing (cm) was measured with the help of measuring tape. A total of 3 readings were recorded for each treatment combination. The optimum value of seed spacing of 20.86 cm was observed at H_2S_2 treatment combination. It was similar to standard spacing of pea seed in the row (Seed and Sowing in Vegetable Pea, 2009). It was observed that, seed spacing was significantly affected by forward speed and filling hopper level, the seed spacing increased with increase in forward speed and decreased at H_3 hopper level. The higher value 27.60 cm of seed spacing was observed at H_3S_3 treatment combination. The decrease in hopper level resulted in increase in seed spacing due to the fact that when the hopper level decreased there was less chance for each seed cup to be filled with seed (Fig 4).

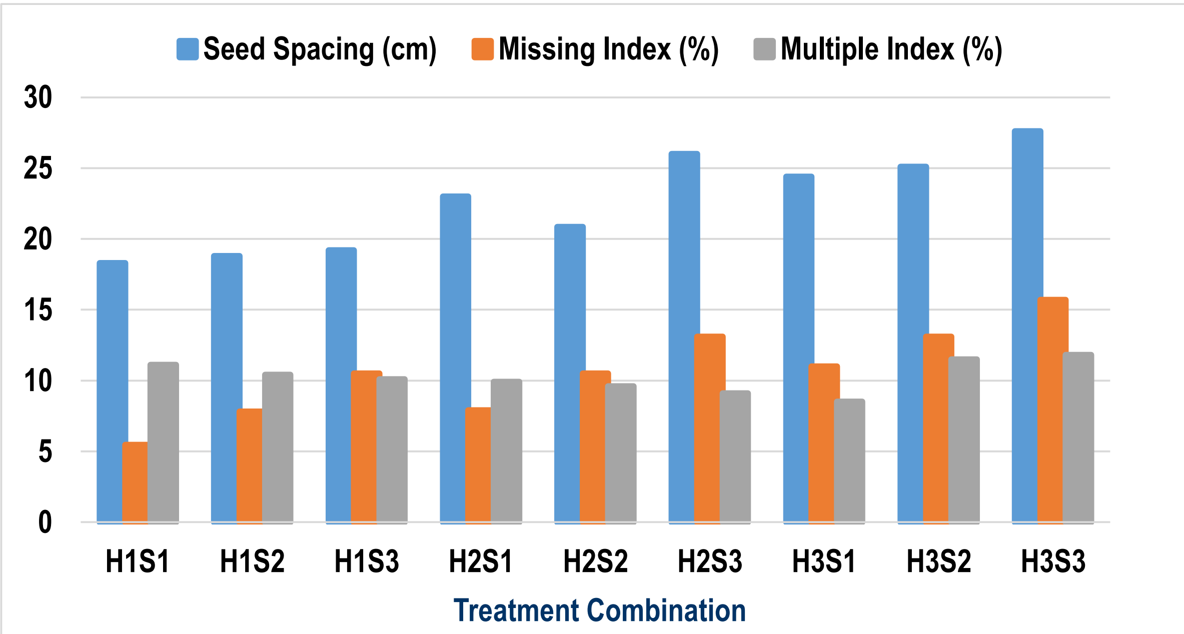


Fig. 4. Effect of forward speed and hopper level on seed spacing, missing index& multiple index

It was also observed that maximum value 15.7% of missing index was found at H_3S_3 treatment combinations and minimum 5.46 % at H_1S_1 which is presented in figure 4. It was found that when speed is increased the cups were not filled properly with seed due to this reason there is an increase in missing index, similar result was reported by Staggenborg *et al*, 2004. The multiple index is the representative of seed dropping in more than acceptable limit. The value of multiple index was observed to increase with increased forward speed and the effect of hopper level on multiple index was significant. The maximum 11.1 % and minimum 8.5% value of multiple index was observed at H_1S_1 and H_3S_1 respectively. Similar study done by Satyanaryan *et al*, 2016.

Effect of forward speed and hopper level on quality of feed index (QFI): The quality of the feed index was measured with respect to forward speed and hopper level. The highest percentage of quality of feed index was found to be 83.6 % at H_1S_1 and low at H_3S_3 treatment combination as presented in figure 5. Same range was found by Badgujar *et al.,* (2017), and reported that percentage of quality feed index was 62.1 % at forward speed of 2 km/h.

Field Capacity and Field efficiency: It was observed that by increasing the forward speed of the planter, field capacity increased. In addition to that hopper filling level was not affected by field capacity. Effective field capacity (ha/h) & field efficiency (%) of developed planter was observed to be 0.18 and 85.13 respectively.

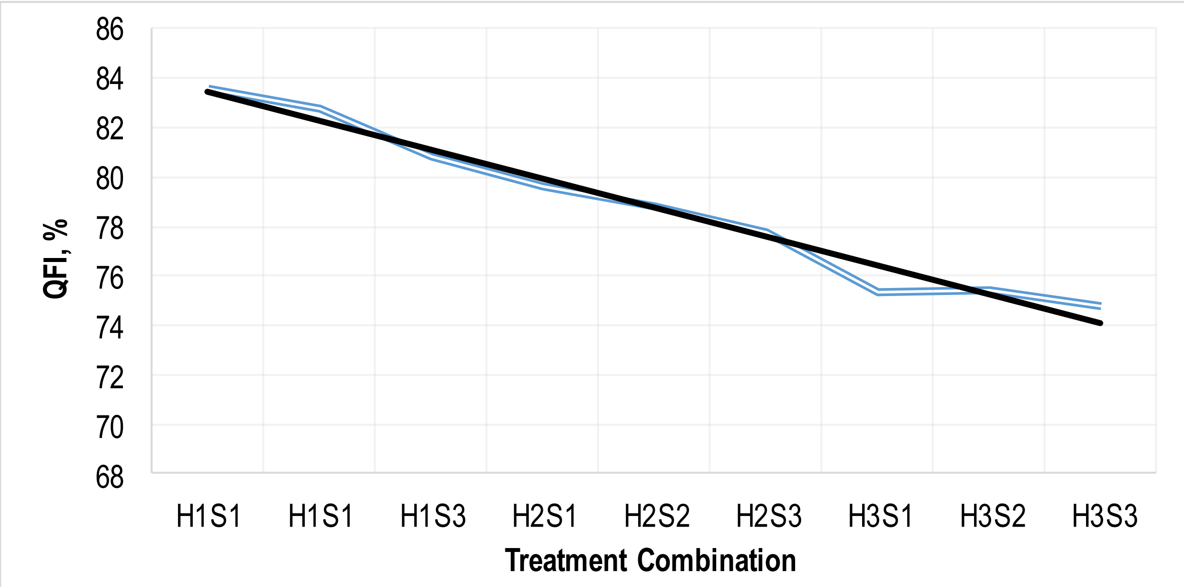


Fig. 5. Effect of forward speed and hopper level on quality feed index (%)

CONCLUSION

The developed power tiller operated multi-crop planter will reduce the mechanization gap for planting crops in hill areas of Jammu and Kashmir (UT) and will also result in improving farm and labor productivity in the region.

REFERENCES

Badgujar C.M., Dhingra H.S., Mannes G.S. and Khurana R. 2017. Development and Evaluation of Inclined Plate Metering Mechanism for Soaked Okra (*Abelmoschus esculentus*) Seeds" *International Journal of Current Microbiology and Applied Sciences,* **6**: 3948-3961.

First Advance Estimates of *All India* Area *and* Production *of Horticulture Crops*. Category-wise: 2021-22

Hunt, D. 2008. A text book of Farm Power and Machinery Management. Waveland Press.

Ikechukwu, I. B., Gbabo, A., & Ugwuoke, I. C. 2014. Design and Fabrication of a single row maize planter for garden use. *Journal of Advancement in Engineering and Technology*, **1**:1-7.

Jammu & Kashmir farmers Guide, 2022, Government of India, Ministry of Agriculture, Department of Agriculture & Cooperation Mechanization &Technology Division.

Khan and Moses. 2017. Performance Evaluation of Manually Operated Multi-Crop Planter for Okra". *Journal of Pharmacognosy and Phytochemistry,* **6**: 264-269.

Kumar, Devesh., Tripathi, Ashok., Prakash, Om., Joshi, Pratibha., Khan, Kalay., and Kumar, Manish. 2021. Seed metering device evaluation by Grease Belt Method. *Indian Journal of Agricultural Sciences,* **10**: 1443-1446.

Oduma, O. Edhe John, Johnson Igwe. 2014. Development and Performance Evaluation of a manually operated Cowpea Precision Planter. *International Journal of Engineering and Technology*, **4**: 693-699.

Satyanarayan, Anantacha M., Reddy B. Sanjeeva, Nagesh Kumar T., and Mareppa N. B. 2016. Development and evaluation of horizontal plate planter for rain-fed conditions" Eco. Env. & Cons. **2**: 589-594.

Seed and sowing in Vegetable Pea 2009. (*http://agropedia.iitk.ac.in/content/seed-and-sowing-egetablepea#:~:text=The%20recommended%20rate%20is%20100,20%20cm%20row%20to%20row*).

Sharma D N and Mukesh S. 2013. Farm Machinery Design, 3rd edition. Jain Brothers, New Delhi, India

Staggenborg S. A., Taylor R. K., Maddux L.D. 2004. Effect of planter speed and seed firmness on corn stand establishment". *Applied Engineering in Agriculture*, **20**: 573-580.

Staggenborg, S.A., D.L. Fjell, D.L. Devlin, W.B. Gordon, L.D. Maddux, and B.H. Marsh. 1999. Selecting optimum planting dates and plant populations for dry land corn in Kansas. *J. Prod. Agric.* **12**: 85–90.