RESEARCH ARTICLE

# DESIGN AND DEVELOPMENT OF MANUALLY OPERATED NURSERY VEGETABLE PLANTER FOR CHILLI, BRINJAL AND TOMATO

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**Abstract:** Nursery seedling production is depends on the variety of vegetables and its cultivation practices as well as bad seed emergence, lack of uniformity and weed infestation. Traditional sowing such as broadcasting, manually line sowing is non uniform distribution of seedwhich causes poor germination and uneven growth of seedling as well as labor and time consuming method.Nursery vegetable planter was designed and developed in dept. of FMPE, CAET, Parbhani.Four row vegetable planter was tested in the field and it was found average plant spacing of 2.27 cm, 2.26 cm and 2.40 cm, respectively for chilli, brinjal and tomato against the required spacing of 2.30cm at speed 1.25 km/h. The missing and multiple index were 14.35 % and 8.33 %for chilli, 15.27 % and 8.68 % for brinjal, 18.51 % and 8.79 % for tomato respectively. Effective field capacity of the developed planter was 0.045 ha/hwith field efficiency of 88.66 % for chilli.Cost of planting was 67.2 % less compared to traditional method.

**Keywords**: Nursery vegetable planter, Field efficiency, Germination percentage, Miss index, Multiple index

## INTRODUCTION

Horticulture plays an important role in national economy. India is rich in biodiversity of vegetables and is the primary/secondary center of origin of many vegetables, (Vanitha *et al*., (2013). Vegetables are big sources of proteins, vitamins, minerals, dietary fibers, micronutrients, antioxidants and phytochemicals in our daily diet. The traditional method of seed sowing or planting resulted in irregular seed to seed spacing and sowing depth. There is a chance of planting two or more seeds at a one place, which results in economic loss to the farmers. The labors need to be in continuous long time bending situation while planting of seeds, which in turn may results in serious backache and other health problem (Ahmed, 2003). Increasing incomeper capita, changing lifestyles, urbanization, health awareness, the majority of active working women, and farm owners' transition to high-value vegetables as a result of increased income need the use of low-cost, beneficial machinery. The need for agricultural mechanization in India must use manually operated farm tools, machinery and equipment. The mechanization of
sowing operation is one of the major solutions to overcomethe above limitations. Planter was designed for reducing the efforts of small scale vegetable farmer in raising the seedlings. The care was taken to ensure that the cost of the machine and the safeguarding costs and functioning costs were low. Weight of planter was 14 kg for easy to operate.

## MATERIALS AND METHODS

**Design of manually operated nursery vegetable planter.**

**Power developed by the operator for planter.**

The power generated by human beings to conduct productive labour was supplied according to (Campbell *et al*., 1990), by following formula (Sharma and Mukesh, 2013).

$$HP = 0.35 - 0.092 \log t.$$

**The size of manually operated vegetable planter.**

The size of manually operated vegetable planter calculated as:(Sharmaand Mukesh, 2013)

$$Z = \frac{D}{d}$$

Where,
Z = No of furrow openers in the planter
D = Draft of drill, kgf.
d = draft of each row, kgf.

**Main frame**

The main frame supports the planter machine's many components, such as the driving wheels, handle adjustment, transmission shaft, seed metering, and seed hoper (Borkar, 2012). M. S. angle 400x50x2 mm and M. S. flat plate 400x100x2 mm were used in its construction. With the aid of M. S. angle and M. S. flat plate, the frame was built with dimensions of 400 mm x 80 mm x 50 mm. Four hoppers were connected horizontally at 100 mm intervals on the 400 mm long top side of the frame. 10 mm diameter size nut and bolts, four furrow openers assembly

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were joined to the downside of the main frame at 100 mm distance from both ends of the frame.

**Design of seed box**

Angle of repose was considered for seed box design. Average value of angle of repose for chilli, brinjal and tomato were 27.34, 26.71 and 39.18 in degrees respectively. Seed rate for chilli , brinjal and tomato were 350-500gm for cultivation of one hectare crop (Das *et al.*, 2018). Inner diameter of cover of seed hopper was same 63 mm as seed hopper. The cylindrical seed box was made from plastic having thickness of 1.5 mm. Volume of seed box was given by (Sharmaand Mukesh, 2013)

$$Vb = 1.1 \times Vs$$
$$Vs = Ws/Ys$$

Where,

Vb = volume of seed box, cc

Vs = volume of seed, cc

Ys = Bulk density of seed, gm/cc

Ws = Weight of seeds, gm

**Design of seed metering mechanism-Design of horizontal plate**

Horizontal plate was made of acrylic sheet (Kadlag, 2017). Size of cell on plate was decided based on the size of the vegetable seeds for which it was prepared. The design of horizontal plate was considering the row to row spacing is 10cm for nursery preparation, plant to plant spacing as 1.5-3 cm for chilli, brinjal and tomato. Average seed to seed spacing 2.3 cm was considered for design of planter plate. Cleaning brush was attached at top on the seed plate to remove extra seeds (Kadlag, 2017). According to physical properties of seed cell size was design. Specification of seed plate shown in Table1. Cell diameter for chilli and brinjal was 4 mm which was larger than maximum length of seed (Bandhiya *et al.*, 2016), (Tang *et al.*, 2014). Cell diameter for tomato was 3.5mm shown in Fig. 1 and 2. Seed plate thickness was design according to the maximum thickness of seeds (Rabbani *et al.*, 2016). Acrylic sheet was selected to fabricating seed plate, which was best for fabricating seed plate compare to other material (Kadlag, 2017).

**Table 1.** Specification of horizontal seed plate.

| Sr. No. | Particulars | Specification | | |
|---|---|---|---|---|
| | | Chilli | Brinjal | Tomato |
| 1 | Diameter of plate in mm | 58 | 58 | 58 |
| 2 | PCD of seed cell in mm | 49 | 49 | 49 |
| 3 | Diameter of plate hole in mm | 4 | 4 | 3.5 |
| 4 | Depth of cell, mm | 1 | 1 | 1 |
| 5 | No. of cell | 24 | 24 | 24 |
| 6 | Material of plate | Acrylic sheet | Acrylic sheet | Acrylic sheet |

Number of cells on the plate was calculated by formula, (Sharmaand Mukesh, 2013)

$$Number\ of\ cell\ on\ seed\ plate, n = \frac{\pi D}{ix}$$

Where,

n = number of cells on plate

D = Ground wheel diameter, cm

x = required seed to seed spacing, cm

i = gear ratio (1:1)

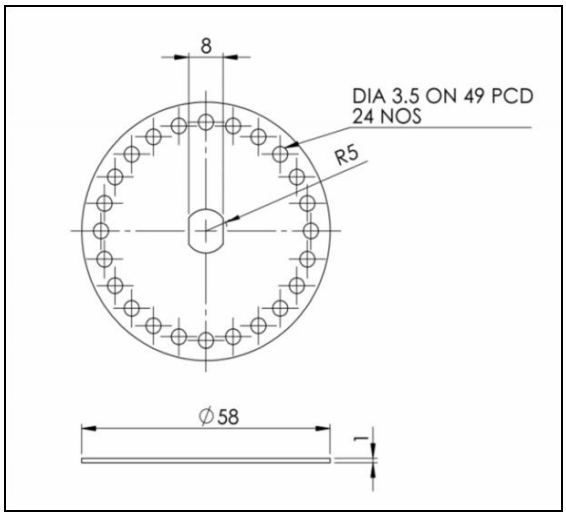


**Fig. 1:** Design of seed plate for Tomato

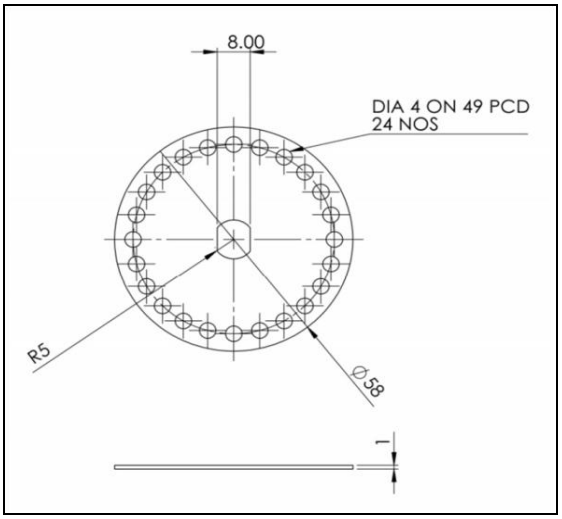


**Fig. 2:** Design of seed plate for Chilli and Brinjal

**Design of Seed tubes.**

Seed tube attached vertically from hopper boot to furrow opener boot. Transparent plastic tube had 20 mm, 24 mm, 100 mm as inner diameter, outer diameter, length respectively (Borkar, 2012). Seed tube thickness was 2 mm.

**Power transmission system**

The vegetable planter was operated manually to make it cost effective for farmer. Power is transmitted after pushing the handle from the drive wheel to the seed metering device through transmission shaft and bevel gears which are shown in Fig. 3 (Rabbani et. al., 2016). 10 mm inner diameter, 15 mm hub diameter, 26 mm outside diameter, 8 mm face width bevel gear used for power transmission. For easy transmission gear ratio was selected as 1:1 for power transmission (Sharma and Mukesh, 2013).

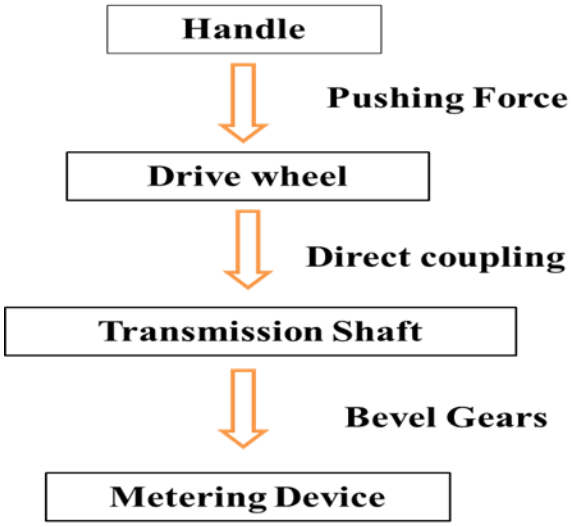


**Fig. 3:** Flow diagram of power transmission system.

**Transmission shaft**

The torque and power were transmitted from the ground wheel to the metering device through the transmission shaft (Rabbani *et. al.*, 2016). The shaft had a diameter of 10 mm and a length of 500 mm, depending on the breadth of the operation. It was constructed of high-carbon steel.

**Ground wheel or Drive wheel.**

Two drive wheels were utilized to drive the planter, which are mounted on an axle to carry the planter on the field. The drive wheels were connected to the transmission shaft by a nut and bolts, which transmits the wheel's motion to the seed metering mechanism by bevel gear assembly (Rabbani *et. al.*, 2017). The ground wheel was attached on both end of transmission shaft. The ground wheel was made from eight M. S. rod of 8 mm diameter and 80 mm length forming the spokes and welded at the centre and periphery of wheel (Sule, 2016). The effective diameter of ground wheel was 180 mm and it was made up from 570mm×40mm×3mm M.S. flat.

**Design of handle**

Push type handle used for drive the planter (Lee *et al.*, 2008). The standard light weight M.S. pipe 27 mm outside diameter and 2 mm thick was used for handle of the planter (Sharma and Mukesh, 2013). The length of handle pipe was calculated based on average standing elbow height of female operators (Lee *et al.*, 2008), (Sharma and Mukesh, 2013). Two rubber groves cover above the pipe for better hand grip. Average standing height of women worker was 100 cm (Sharma and Mukesh, 2013). The operating height can be adjusted at main frame from 95-115 cm (Lee *et al.*, 2008).

Angle of inclination $(\theta h)$ of handle with the horizontal was determined by following formula (Sharma and Mukesh, 2013),

$$\tan(\theta h) = \frac{\text{vertical distance, cm}}{\text{horizontal distance, cm}}$$

**Design of furrow opener**

Design of furrow opener plays important role in manually operated nursery vegetable planter. Considering lower push accessible and simple activity of vegetable planter, a combined furrow opener chose. Angle of furrow opener was 60° for less soil resistance (Omran, 2018). It was assumed that the force on furrow opener for 20-30 mm depth of sowing. M.S. angle 100×40×3 mm selected for furrow opener, which was pointed at the end for low resistant (Anonymus C). Total length of furrow opener was 100 mm. 30 mm seed boot was attached back side of furrow opener to drop seed easily. 20 mm inner diameter and 22 mm outer diameter hollow pipe used as a seed boot (Borkar, 2012).

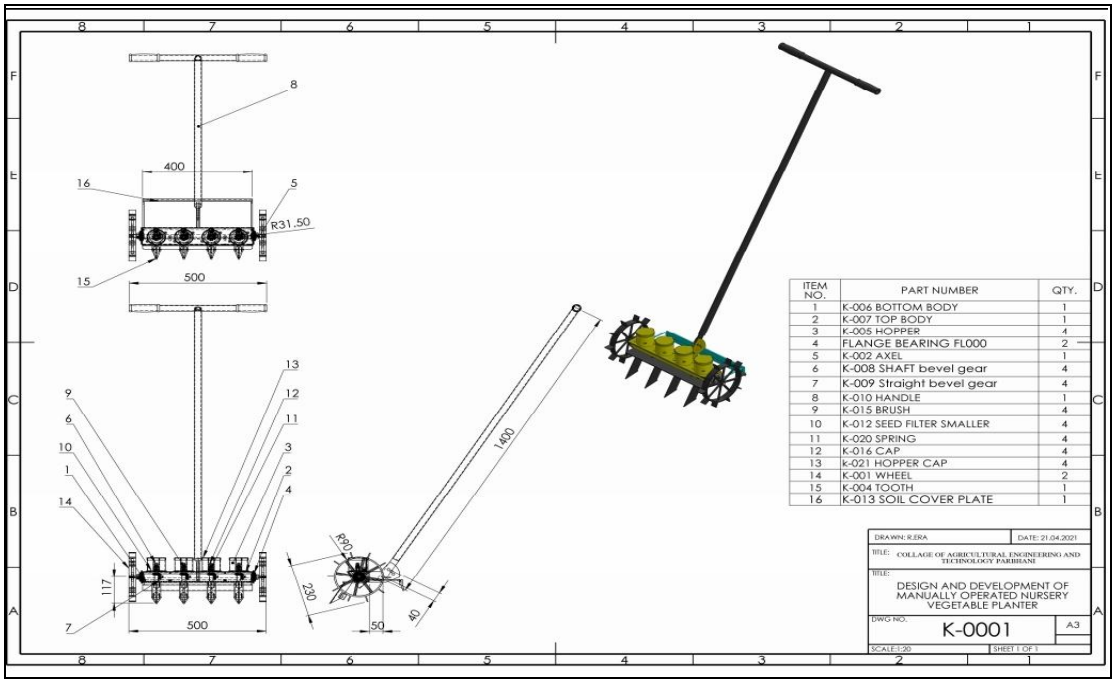


**Fig. 4:** Design views of developed vegetable planter.

**Material consideration for vegetable planter**

Material selection is necessary work in fabrication of any machine, which will helpful for understand the life of machine as well as cost of machine. The obtainment of appropriate materials for the constructing of various planter parts is vital. Standard and conventional sizes, just as semi-finished and completed pieces accessible in the close to nearby local market, will be considered. As a consequence, it was encouraged to use specifications when fabricating machines.

**Table 2.** Selection of material for design of vegetable planter.

| Sr. No. | Parts | Material specifications | Detail specification |
|---|---|---|---|
| 1 | Main frame | M. S. plate | 400×100×3 |
| 2 | Seed hopper | Plastic | 4 Nos, OD=63mm, ID=60mm, H=60mm |
| 3 | Seed boot | Mild steel hollow pipe | 4 Nos, ID=20, OD=22mm, L=30mm |
| 4 | Seed tubes | Polyethylene tubes | 4 Nos, OD=24mm, ID=20, L=100mm |
| 5 | Shaft | High carbon steel | 1 Nos, L=500mm, OD=10mm |
| 6 | Seed plate | Acrylic Sheet | 2×4=8 Nos, OD=58 mm |
| 7 | Handle | M. S. pipe | OD=26mm, L=1300mm, 500mm |
| 8 | Hand grip | Rubber | 2 Nos, 33 mm OD |
| 9 | Furrow opener | M. S. angle iron | 4 Nos, 100×40×3 |
| 10 | Bearings | FL000-K000 | 2 Nos, ID=10mm |
| 11 | Standard finished items | As per standard, used in light engineering industry | Gear, screw, hex head bolts and nuts etc. |

**Evaluation of planter-Laboratory Test**

The techniques and methods for assessing different boundaries relevant to the assessment of the manually operated vegetable planter in lab and field circumstances Field evaluation of the manually operated vegetable planter will be carried on bed having 0.60m×5m size and 0.15m height. The surface of bed should be smooth and well prepared and leveled. Lab test were taken for chilli, brinjal, toamto crop.

**Seed metering test (Seed weight and visible seed damage)**

Calibration was carried out in order to obtain the machine's pre-determined seed rate (Kadlag, 2017). This test was used to determine the seed dropping rates obtained for different crop and when the manually operated vegetable planter was stationary.

This test decides the level of mechanical harm to seeds which will occurred during genuine working at different speed (Kadlag, 2016).

$$Damage\ Seed\ Percent = \frac{Weight\ of\ damaged\ seed}{Total\ weight\ of\ seed\ collected} \times 100$$

**Seed spacing**

The mean spacing was the average of the total number of measured spacings calculated by the following formula (Kadlag, 2016).

$$X = \frac{\sum x}{N}$$

Where,

X = Mean spacing of the seed, cm

∑X = Sum of the observed spacings

N = number of observations

**Field test**

During the test, the following parameters were taken into account.

1. Soil parameters
A. Moisture content
2. Machine parameters
A. Speed of operation
B. Draft requirement
C. Power requirement
D. Theoretical field capacity
E. Effective field capacity
F. Field efficiency
3. Quality parameter
A. Field emergence or seed germination.
B. Seed spacing
C. Depth of sowing
D. Multiple index
E. Miss index

**Fig. 5:** Measurement of draft

**Fig. 6:** Measurement of sowing depth

**RESULTS AND DISCUSSION**

**Performance evaluation of developed manually operated vegetable planter.**

**Laboratory tests**

**Calibration of planter**

The results reveal that different levels of speed have varied effects on seed rate. The average seed rate was2.19, 2.28, 1.37 g/m$^2$for chilli, brinjal and tomato respectively. There was no remarkable variation at different speed for different seed. At full, 3/4, 1/2, and 1/4 hopper levels, the average seed rate for chilli was 2.20, 2.17, 2.21, and 2.14 g/m$^2$, respectively. For three replications at varying hopper levels, there was no significant difference in seed rate across the planter units. Seed rate reduces somewhat as speed rises. Fig. 7 effect of speed on seed rate and visible seed damage percentage. Visible seed damage was found to be 0.19 %, 0.27 %, and 0.46 % for tomato seed at 1, 1.25, and 1.5 km/h. Visible seed damage was found to be 0.26 %, 0.20%, 0.43 % and 0.15 % for tomato seed at full, 3/4, 1/2, and 1/4 hopper levels.

**Table 3.** Calibration and damage percent of different seeds at different speed.

| Sr. No. | Crop | Seed, km/h | Seed rate, g/m$^2$ | Visible damaged, % |
|---|---|---|---|---|
| 1 | **Chilli** | 1 | 2.22 | 0.0 |
| 2 | | 1.25 | 2.19 | 0.0 |
| 3 | | 1.5 | 2.14 | 0.0 |
| 4 | **Brinjal** | 1 | 2.30 | 0.0 |
| 5 | | 1.25 | 2.28 | 0.0 |
| 6 | | 1.5 | 2.18 | 0.0 |
| 7 | **Tomato** | 1 | 1.34 | 0.19 |
| 8 | | 1.25 | 1.37 | 0.27 |
| 9 | | 1.5 | 1.26 | 0.46 |

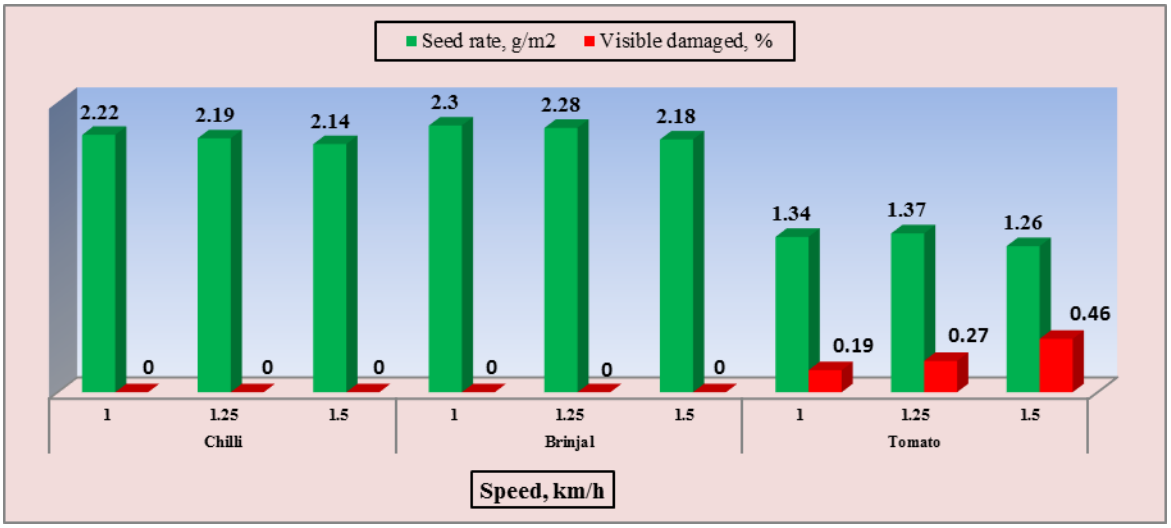


**Fig 7:** Effect of speed on seed rate and visible seed damage percentage.

**Seed spacing**

Average seed spacing were found 2.30 to 2.50cm for chilli, 2.15 to 2.32cm for brinjal and 2.20 to 2.40cm for tomato at 1.0, 1.25 and 1.5km/h.

**Field test**

The designed manually operated vegetable planter was field tested at Central Nursery Farm, VNMKV, Parbhani for chilli, brinjal and tomato. Average moisture content of soil was 11.81%. For 1.5 km/h speeds, the maximum draft was 22 kg-f, while for 1.0 km/h speeds, the lowest draft was 13 kg-f. When the speed of planter raises draft and power also rises. Fig 8 shows effect of speed on draft and power requirement.

**Table 4.** Results of field performance evaluation.

| Particulars | Speed, km/h | | |
|---|---|---|---|
| | 1.0 | 1.25 | 1.5 |
| Moisture content, % | 11.48-17.23 % | | |
| Operating speed, km/h | 1 | 1.25 | 1.5 |
| Draft requirement, kgf | 14.67 | 18.33 | 20.67 |
| Power requirement, hp | 0.06 | 0.09 | 0.11 |
| Theoretical field capacity, ha/h | 0.040 | 0.050. | 0.060 |

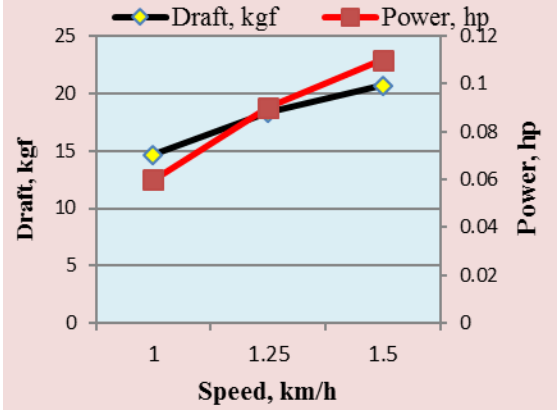


**Fig 8:** Effect of speed on draft and power requirement.

Effective field capacity was found for chilli at 1.0, 1.25 and 1.5 km/h to be 0.036, 0.045 and 0.053 ha/h respectively, and for brinjal it was observed as 0.035, 0.043 and 0.053 ha/h respectively. When speed raises effective field capacity also rises. Seed spacing and sowing depth for all speed found satisfactory. Seed emergence percent at 1.25 km/h observed best as compare to other speed for all crop. Miss index and multiple index was less at 1.25 km/h for all crop as compare to other speed. Fig. 4.9 and 10 describes the effect of speed on the miss and multiple index for chilli, brinjal, and tomato. At 1.0 km/h, the average multiple index for chilli, brinjal and tomato was 10.17, 9.95 and 10.41 percent, respectively.

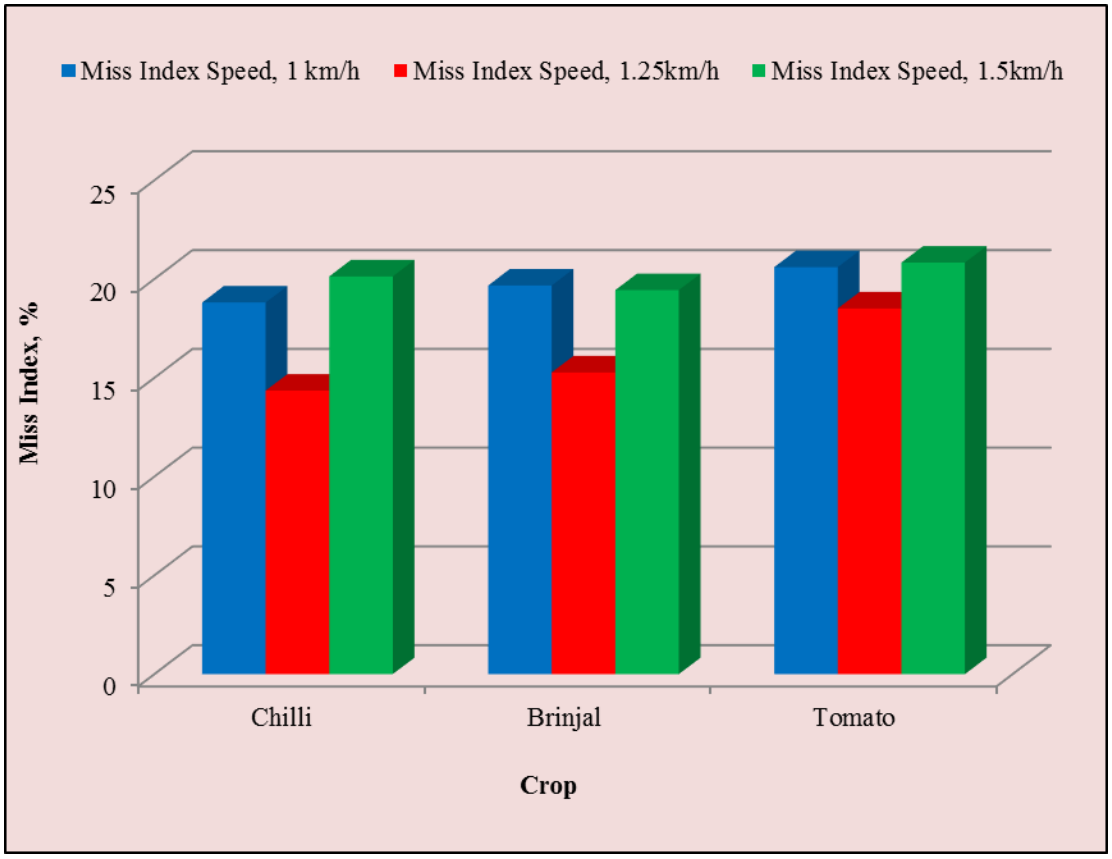


**Fig. 9:** Effect of speed on miss index.

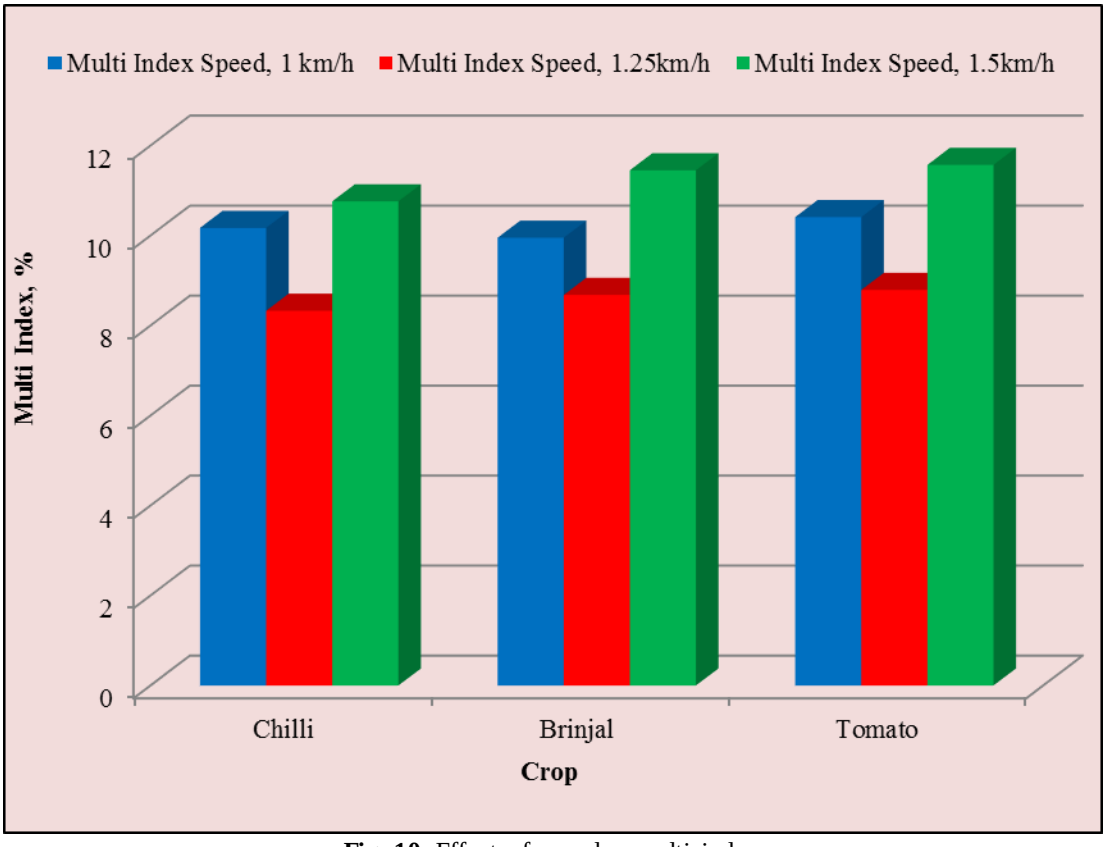


**Fig. 10:** Effect of speed on multi index.

**Table 4.** Results of field performance evaluation.

| Particulars | Chilli | | | Brinjal | | | Tomato | | |
|---|---|---|---|---|---|---|---|---|---|
| | Speed, km/h | | | Speed, km/h | | | Speed, km/h | | |
| | 1.0 | 1.25 | 1.5 | 1.0 | 1.25 | 1.5 | 1.0 | 1.25 | 1.5 |
| Effective field capacity, ha/h | 0.036 | 0.045 | 0.053 | 0.035 | 0.043 | 0.053 | 0.035 | 0.043 | 0.052 |
| Field efficiency, % | 90.00 | 88.66 | 87.22 | 88.33 | 88.00 | 85.55 | 87.50 | 86.67 | 85.56 |
| Seed spacing, cm | 2.38 | 2.27 | 2.45 | 2.13 | 2.26 | 2.32 | 2.24 | 2.40 | 2.41 |
| Depth, cm | 2.12 | 2.14 | 2.16 | 2.06 | 2.08 | 2.12 | 2.02 | 2.06 | 2.0 |
| Seed emergence, % | 80.21 | 82.99 | 77.08 | 80.56 | 86.11 | 79.17 | 81.94 | 83.33 | 76.74 |
| Missing index, % | 18.81 | 14.35 | 20.13 | 19.67 | 15.27 | 19.44 | 20.60 | 18.51 | 20.83 |
| Multiple index, % | 10.17 | 8.33 | 10.76 | 9.95 | 8.68 | 11.45 | 10.41 | 8.79 | 11.57 |

The mean seed spacing is within range of the optimal seed spacing of 2 cm. The mean seed spacing of chilli, brinjal and tomato was observed in the very optimal range of 2.30 cm with all speed.

## CONCLUSION

The vegetable planter used to grow chilli, brinjal, and tomato, and it was accomplish both row to row and plant to plant spacing. Seed metering device performance was acceptable. During field trials, at speed of 1.25km/h the planter gives seed rates of 2.19 g/m$^2$ for chilli, 2.28 g/m$^2$ for brinjal, and g/m$^2$ for tomato, with no seed damage for brinjal and chilli. Average depth of sowing was found to be in the ranged 2.0 cm to 2.16 cm for all crop and at all speed condition. The planter saved 67.2% of the cost of sowing compared to the traditional method. The overall performance of manually operated vegetable planter during the field trial carried in small area was found satisfactory.

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