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# Design and development of manually operated gladiolus planter

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## ABSTRACT

Floriculture is an age-old farming activity in India having immense potential for generating self-employment and income to farmers. However, the cost of cultivation of flower is high as compared to cereal crop. Level of mechanization for different field operations is one but foremost reason for the higher cost of cultivation. As most of the Indian farmers are marginal and small, a need for manually operated gladiolus planter was felt. The geometric properties of gladiolus corm were determined for designing the seed metering system and seed hopper of the planter. The planter was evaluated in the field when pulled by two persons as a power source and guided by a person. The coefficient of variation and highest deviation from the mean spacing was observed as 12.93% and 2.65cm respectively. The maximum coefficient of uniformity of 90.59% was observed for a nominal corm spacing of 15cm at 0.56 kmh$^{-1}$ forward speed. An average MISS percentage was observed as 2.65 and 2.25 for nominal corm spacing of 15 and 20 cm. The multiple index was zero for two levels corm spacing and forward speed of operation. The QFI was found in the range of 97.2 and 97.9 percent. The average field capacity of the planter was observed as 0.02 hah$^{-1}$.The average draft requirement of the planter was found as 821 ± 50.3 N.

**Keywords :** Design, Development, Gladiolus, Planter

## INTRODUCTION

Flowers have been socio-culture requirements since time immemorial. In India more than 2.48 million hectare area is under floriculture with a production of 16.58MT loose flowers and 4.72 MT cut flowers in 2014-15 (NHB, 2015). India is the second largest producer of flowers after China. India exported 22,086.10 MT of floriculture products to United States, Germany, United Kingdom, Netherlands and United Arab Emirates and other countries for the worth of Rs. 548.74 crores (82.05 Millions USD) in 2016-17. The major flower crops grown in India are rose, gladiolus, chrysanthemum, orchid, jasmine, tuberose, aster, marigold etc. Gladiolus is a high value cut flower crop grown for it spikes. Gladiolus ranked first among the bulbous crop in terms of area and production as well as returns per unit area. However, it is the second most popular commercial cut flower after rose. In gladiolus cultivation, cost of the corms and labour charges are the two major shares of investment required for the first year but in subsequent years, farmers can get the corm from the previous crop for planting. Labours are required for different operations like tillage, planting, inter-row cultivation and weeding, plant protection and top dressing and harvesting etc. In the traditional method of planting, the furrow of shallow depth is made with spade and gladiolus corms are put in the furrow at required spacing and covered with soil. It is labour intensive, tedious, time-consuming and involve human drudgery. Therefore, mechanized planting operation of gladiolus is of utmost importance. Review of the literature indicates that a number of attempts have been made to develop planter for planting bulbs and corms. Singh and Singh (2017) studied the performance of cup type metering system gladiolus planting and reported that coefficient of uniformity and overall performance was better at 2km/h forward speed. A tractor-drawn gladiolus planter with field capacity of 0.103 ha/h and field efficiency of 76.57% was developed (Singh and Gautam, 2015). The saffron corm planter with cup and belt type metering system planted corms at as pacing of 22cm at 15 cm depth without any damage to corms (Mohhamad and Saiedi, 2006). Most of the Indian farmers are marginal and small and it is difficult to have a planter especially for a particular crop as the area under the crop is small and scattered, hence it was considered that manually operated gladiolus planter may help the marginal and small Indian farmers. Therefore, work on development of single row manually operated gladiolus planter was undertaken with following objectives

I) To determine the crop and soil parameters in relation to design the manual gladiolus planter

ii) To develop and evaluate the manually operated gladiolus planter.

## MATERIALS AND METHODS

The crop parameters were studied for designing the cup of the metering unit seed box and the soil type, depth of placement and other soil parameters were also considered.

### *Determination of dimension of corms*

*Size and shape*

The size and shape of corms were two important factors that helped in deciding shape and size of seed metering cup. The corms were selected from the lot through random sampling technique. 100 numbers of corms were randomly separated three times. The polar and equatorial diameters, three

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principal dimensions that are in three mutually perpendicular directions of the selected corms were measured with Vernier calliper with least count of 0.01 mm. The geometric mean size of corms affects the cup size in seed metering system. The geometric mean dimension (Dg) was determined using relationship given by Mohsenin (1986) as:

$$D_g = (abc)^{1/3}$$

Where,

a = Max Equatorial diameter, mm
b = Min Equatorial diameter, mm
c = polar diameter, mm

Sphericity (⌀) affects the uniform free flow of corms from the metering cups. The criterion used to describe the shape of the seed is sphericity. The sphericity (⌀) was computed by the following relationship as suggested by Mohsenin (1986)

$$\varnothing = \frac{(abc)^{1/3}}{a}$$

*Bulk density*

Bulk density and true density values are used to design the seed hopper. Bulk density was determined using a cube of size 10x10x10 cm. The cube was filled with corms without any compaction, and later on, the corms filling the cube were weighed. Observations were taken for 10 samples and the mean considered as the characteristics value of the bulk density of corms. The bulk density was determined as the ratio of the weight of the corms and volume of a cube by the following relationship:

$$\rho = \frac{W}{V}$$

Where,

ρ = Bulk density, g/cm$^3$
W = weight of the pulse seed, g
V = Volume of the sample, cm$^3$

*True density*

True density of corm was determined by Hexane displacement method (Mohsenin, 1986). The volume and true density were evaluated for 10 samples. The weight of each sample was recorded. The sample was immersed in a jar containing hexane liquid. The displaced volume of hexane was recorded for each sample. True density was calculated as the ratio of the weight of the sample to its volume. Observations were taken for 10 samples and the mean considered as the characteristics value of the density of seeds.

*Coefficient of static friction*

The static coefficient of friction (μ) was determined for four structural materials namely plywood, aluminium, and galvanized MS steel sheet. Corm was placed on an adjustable tilting flat plate faced with the test surface. The corm resting on was inclined gradually until the corm just started to slide down. The angle of tilt (α) was noted from a graduated scale (Dutta *et al*., 1988; Shepherd and Bhardwaj, 1986 and Khura *et al.*, 2013). The coefficient of static friction was expressed by tan (α). The procedure was repeated 10 times and the mean value was calculated.

***Design and fabrication of the components of planter***

A single row gladiolus planter was developed for the planting of gladiolus corms. It consisted of a frame, hopper, furrow opener, metering unit, depth control wheel, drive wheel, Handle and soil covering device. Fig. 1 and 2 show the details of the developed gladiolus planter with their components.

*Handle*

The handle was provided in the front part of the gladiolus planter. It was attached to the main frame with the hinge. The provision was made on the handle to adjust its height of the operators. As the depth of operation is to be 7-10cm, two persons can pull the machine in the well-preparedseed bed with the help of handle. The length and diameter of the handle were 1150mm and 250mm respectively. The handle was provided with a grip.

*Frame*

The frame of the gladiolus planter was rectangular in shape and extended in front portion to merge at the point where the hitch was attached. The overall length and width of the frame were of 1120 and 700 mm respectively. The frame was made of hollow square section mild steel pipe having 40 mm width and 3 mm thickness.

*Main Hopper*

The planter was provided with a hopper and feeding chute. The hopper was designed for a capacity of 10 kg of gladiolus corms to reduce the load and pull requirement during field operation. The upper portion of the hopper was of square shape with overall length and width of 320 mm. The lower portion of the hopper is in a trapezoidal shape with wall inclination of 35$^0$ from the vertical. The angle of inclination of the hopper was kept higher than the angle of repose of the corms.

Provision has been made to adjust the height of the hopper to vary the flow rate of the corms. The lower portion of the hopper was opening of 100X100mm. The total height of the box was 350mm. The feeding chute conveys the corms frm the hopper to cup-belt metering system. It is a channel like structure made of MS and with a gradient of 25$^0$. The slope of the feed chute based on coefficient of frictira of corms over MS sheet.

*Metering Unit*

Cup-belt type metering unit has been used to place the gladiolus corms individually in furrows at the desired spacing. Mild steel cups of size 80 x 55 mm have been fitted on a 100mm width 1450mm long canvas belt. The conveyor belt was fitted with 14 numbers of such cups at a spacing of 100 mm. The belt was run over two pulleys with diameter 200 mm and width 100 mm.

The lower pulley was mounted on 50mm diameter shaft fitted on the base of the frame supporting bearing. The upper pulley got the drive from the ground wheel. The power transmitted from the ground wheel to the upper pulley through chain sprocket. The ratio of teeth of upper and lower sprocket was to get two speed ratio for a forward and connected through the chain. Both the sprockets were fitted on two mild steel shafts of 25 mm diameter.

*Delivery channel*

The metered gladiolus corm from the metering unit was delivered to the delivery channel. The upper end the delivery channel was square in shape of 130X130 mm and height upto 900mm. The upper end of the delivery channel was large in size with funnel shape to receive the metered gladiolus. The bottom end of the delivery channel was narrow down of 80X80mm so that the corms can be dropped in the desired location. The size of the delivery channel selected so that the corms can fall straight to the ground without striking the sides of the channel.

*Tines with furrow opener*

Tyne with shovel type furrow opener was fabricated using 710 mm long mild steel flat of size 50x20 mm for opening furrows. The upper ends of the tines were U-clamped on the front toolbar of the frame. The provision was made to adjust the length of tines for varying the depth of planting. The rake angle of the shovel was kept $22^0$ to minimize the draft requirement.

*Depth Control Wheel*

A gage wheel was provided in front of the furrow opener. The gage wheel not only controls the depth but also steer the planter during the field operation. The gage wheel attached to the main with the pivot joint and the handle fixed on hitch point. The diameter of gauge wheel was 250 mm and 50 mm face width, were provided at the centre of the planter to maintain a uniform depth of planting as well as to support the weight of the machine along with the corms in the hopper. The provision was made to adjust the height of wheels in order to vary the depth of planting.

*Drive Wheel*

Two lug wheels with diameter 400 mm and 70mm width were provided to transmit the traction power of wheel to the metering unit through the chain-sprocket drive. The wheels were located in the rear of the main frame of the planter. The drive wheel was fitted with 16No.of MS lugs that keep the drive wheel always in contact with the ground surface to minimize wheel slippage.

*Power Transmission*

The drive wheels of the planter got the pull force from the manual operator and developed the traction to move the planter forward. The traction wheels also transmit the power to the metering unit through chain sprocket arrangement. These sprockets have been provided to vary the speed ratio to obtain the nominal spacing of 15 and 20 of the corms in f

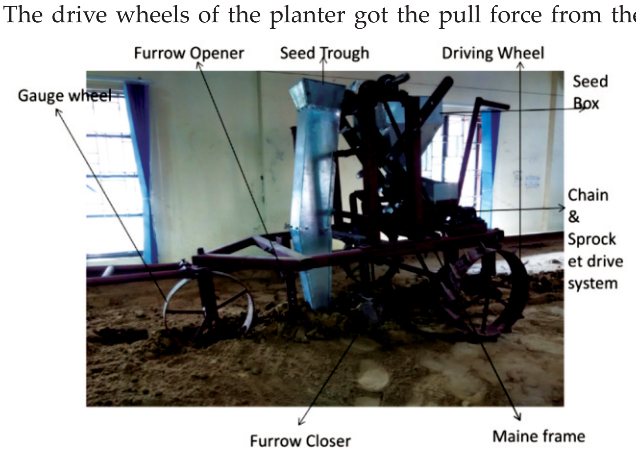


**Fig.1** Main Components of the gladiolus planter

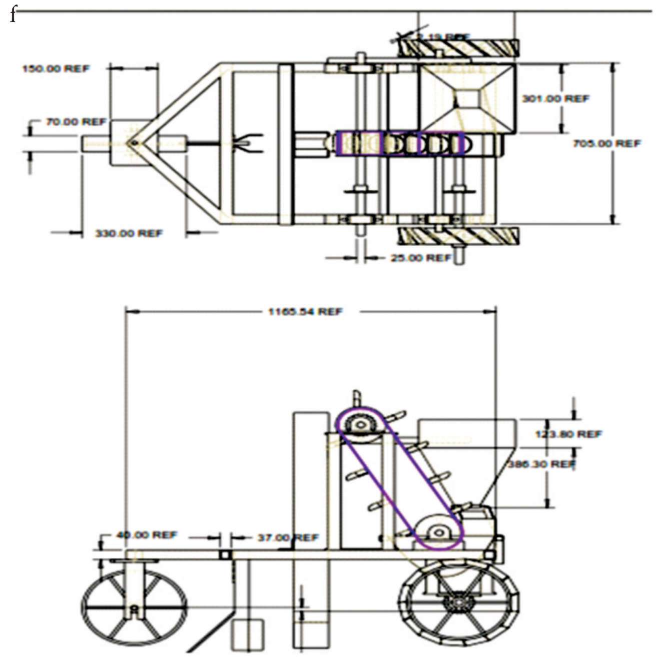


**Fig. 2** Different views of the planter (plane/elevation)

**Fig.3** Filling of the hopper with corms

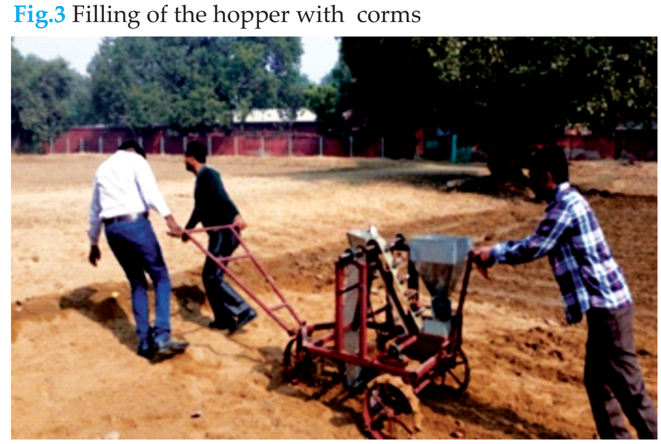

**Fig.4** Field evaluation of the gladiolus planter

***Performance Evaluation of the developed planter***

The developed planter was evaluated in well seedbed (Fig. 3 and 4). The size of the test field for each experiment was taken as 20 m long and 2.5 m wide. The speed of operation of the planter was recorded during the field evaluation. The manual planter can be operated at a maximum speed of 0.98 $kmh^{-1}$ by two operators. The other speed of 0.54$kmh^{-1}$ was selected based on feedback on fatigue level of operators. The nominal spacing of 15 and 20cm was selected as per the recommendation for a different variety of gladiolus. Each experiment was replicated three times to minimize the experimental error and the observations were recorded for analysis. The significance of the observed data was analyzed by using 2-way Completely Randomized Design (CRD). The spacing parameters were determined in terms of missing index (MISS), multiples index (MULTI), quality of feed index (QFI) and precision index (PREC)as per the procedure (Katchman and Smith 1995; Panning *et al.,* 2000, Singh *et al.,* 2005; Bozdogan 2008, Singh and Mane 2011 and Yang *et al.,*2016).Number of corms dropped per unit length in a row was also recorded. Statistical parameter i.e. standard deviation (SD), coefficient of variation (CV) and coefficient of uniformity (CU) were calculated to determine the variations in corm spacing. The following equations were used to determine the performance parameters.

*Miss index*

Miss index (MI) is an indicator of how often a seed skips the desired spacing. It is the percentage of spacing greater than 1.5 times the theoretical spacing and expressed as

$$MI = \frac{n''}{N}$$

Where,

N = Total number of seed spacing, and

n″ = Number of spacings in the region greater than 1.5 times of the theoretical spacing

*Multiple index*

Multiple index (MULTI) is an indicator of dropping more than one seed within the desired spacing. It is the percentage of spacing that is less than or equal to half of the theoretical spacing.

$$MULT = \frac{n}{N}$$

Where,

N = Total number of seed spacing, and

n = Number of spacing's in the region less than or equal to 0.5 times of the theoretical spacing

*Quality of feed index*

Quality of feed index (QFI) is the measure of how often the seed spacing was close to the theoretical spacing (Kachman and Smith, 1995). It is the percentage of spacing that is more than half, but not more than 1.5 times the theoretical spacing calculated. The quality of feed index is mathematically expressed as follows:

$$QFI = \frac{n'}{N}$$

Where,

N = Total number of seed spacing, and

n′=Number of spacings between 0.5 times the theoretical spacing and 1.5 times of the theoretical spacing

*Precision index*

Precision index (PI) is the coefficient of variation of the spacing (length) between the nearest seeds in a row that are classified as singles after omitting the outliers consisting of missing and multiples.

$$PI = \frac{s}{x}$$

Where,

$S = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$ (standard deviation of seed spacing)

$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$

$x_i$= is the $n^{th}$ seed spacing

## RESULTS AND DISCUSSION

***Physical properties of gladiolus corms***

Physical crop parameters related to the design of corms planter were determined. The size, shape, bulk density, and coefficient of static friction for corm were measured and average values were determined. The extreme equatorial diameters and a polar diameter of the corms were 42.84±5.94 and 48.51±5.68 and 20.65±3.36cm respectively (Table 1). The geometric mean, sphericity, coefficient of friction on three different surfaces (wooden, Aluminium and MS sheet), bulk and true density were determined 34.91±4.11,0.51±0.08, 0.53±0.04, 0.47±0.04,0.53±0.03 and 1.11±0.32g/cc, respectively.

**Table 1:** Physical properties of corms

| S.N. | Property | Values |
|---|---|---|
| 1 | Equatorial diameter, mm (Max(a) /Min(b)) | 48.51±5.68 /42.83±5.94 |
| 2 | Polar Diameter, mm | 20.65±3.36 |
| 3 | Geometric mean,mm | 34.91±4.11 |
| 4 | Sphericity | 0.72±0.04 |
| 5 | Coefficient of friction | |
| | Wooden | 0.51±0.08, |
| | Aluminium | 0.53±0.04 |
| | MS sheet | 0.47±0.04 |
| 6 | Bulk density, g/cc | 0.53±0.03 |
| 7 | True Density, g/cc | 1.11±0.32 |

The size of the cup of the meter unit was designed based on dimensions, geometric mean and sphericity of the corms. The average values bulk density, true density and coefficient of friction were used to design the seed box.

***Evaluation of the planter***

*Spacing of corm along the row*

The performance of the planter evaluated for spacing along the row by measuring the actual spacing during the field operation for two levels of nominal corm spacing and two levels of forward speed. It was observed that actual spacing was quite close to the desired nominal spacing of the corms. The highest coefficient of variation and deviation from the mean spacing was observed as 12.93% and 2.65cm respectively (Table 2). It analysed observations also indicated that the deviation and coefficient of variation increased with the increase in nominal corm spacing and forward speed of operation. This may be due to the skidding of the drive wheel of the planter, which was transmitting power to metering units. The lower value of PI (<10%) indicated better uniformity in corm spacing (Table 2). The observed value of the ratio of mean to nominal spacing was close. This indicated that the observed spacing is very close to the required nominal spacing.

*Coefficient of Uniformity*

Higher coefficient of uniformity was observed for lower corm to corm spacing at a lower speed of operation. The maximum coefficient of uniformity of 90.59% was observed for a nominal corm spacing of 15cm at 0.56kmh$^{-1}$ forward speed. The minimum uniformity coefficient was observed as 88.29% for corm spacing of 20 cm at 0.98kmh$^{-1}$forward speed. Higher coefficient of uniformity at lower forward speed may be due to the fact that at the lower forward speed of planter vibration was lower as compared to the higher speed and lower spacing may be due to the fact that the cups of the metering device was getting sufficient time for self-filling and vice versa. The statistical analysis (Table 3) showed significant effect of nominal spacing and forward speed of operation on coefficient of uniformity at 5 percent significance level.

*Missing Percentage*

MISS percentage was low for lower speed of operation and higher nominal spacing similar finding has been reported (Katchman and Smith 1995; Singh *et al.*, 2005, Bozdogan 2008). An average MISS percentage was observed as 2.65 and2.25 for nominal corm spacing of 15 and 20 cm. The MISS was observed for 0.56 and 0.98kmh$^{-1}$forward speeds as 2.3% and 2.6% respectively. In wider spacing and lower forward speed provides more time for self-filling of the cups of the metering device as compared to lower corm to corm spacing and higher speed may be the reason for a less missing percentage of corms at wider spacing. The result of statistical analysis indicated a significant effect of nominal spacing and forward speed on missing percentage at 5 percent significance level. However, the interaction terms of both the parameters were observed not significant (Table 3).

*Multiple Index*

It was observed that all the levels of corm spacing and forward speed of operation the multiple index was zero. This means that singulation of the cup metering mechanism was performed well and none of the corms was dropped at spacing ≤0.5 times the nominal spacing.

*Quality of Feed Index*

The observed QFI was in the range of 97.2 and 97.9 percent. The average QFI for 15 and 20cm nominal corm spacing at forward speeds of was observed as 97.35 and 97.75 respectively. The QFI at forward speeds of 0.54 and 0.98 kmh$^{-1}$ was for 15 and 20 cm nominal spacing observed as 90.1 and 89.3% respectively (Table 2). The value of QFI was observed higher for low forward speeds and wider nominal spacing. The observed QFI was more than the acceptable limit of has been suggested as ≥85% for precision seeders.

**Table 2:** Performance parameters of manual gladiolus planter

| Speed,km/h | Nominal, cm | OMS | SD | CV | CU | NCPML | Miss | Mult | QFI | PI |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.56 | 15 | 15.19 | 1.44 | 9.48 | 90.47 | 1.11 | 2.5 | 0 | 97.5 | 8.04 |
| 0.56 | 15 | 15.12 | 1.45 | 9.61 | 90.39 | 1.04 | 2.53 | 0 | 97.5 | 8.12 |
| 0.56 | 15 | 15.33 | 1.44 | 9.41 | 90.59 | 1.09 | 2.47 | 0 | 97.5 | 7.92 |
| 0.56 | 20 | 20.8 0 | 2.15 | 10.34 | 89.66 | 1.06 | 2.1 0 | 0 | 97.9 | 8.85 |
| 0.56 | 20 | 20.84 | 2.1 0 | 10.08 | 89.92 | 1.05 | 2.08 | 0 | 97.9 | 8.59 |
| 0.56 | 20 | 20.76 | 2.2 0 | 10.60 | 89.4 | 1.05 | 2.12 | 0 | 97.9 | 9.11 |
| 0.98 | 15 | 15.03 | 1.61 | 10.71 | 89.95 | 0.97 | 2.8 | 0 | 97.2 | 8.56 |
| 0.98 | 15 | 15.09 | 1.63 | 10.80 | 89.86 | 1.03 | 2.76 | 0 | 97.2 | 8.65 |
| 0.98 | 15 | 14.97 | 1.79 | 11.94 | 90.05 | 0.98 | 2.84 | 0 | 97.2 | 8.46 |
| 0.98 | 20 | 20.44 | 2.29 | 11.20 | 88.29 | 1.01 | 2.4 | 0 | 97.6 | 9.91 |
| 0.98 | 20 | 20.5 0 | 2.65 | 12.93 | 88.51 | 0.96 | 2.37 | 0 | 97.6 | 10.0 |
| 0.98 | 20 | 20.38 | 2.63 | 12.90 | 89.06 | 1.01 | 2.43 | 0 | 97.6 | 9.45 |

OMS: Actual Mean Spacing, CU: Coefficient of uniformity, NCPML: Number of corms per meter length, Miss: Miss Index, Mult: Multiple Index, QFI:Quality of Feed Index,PREC: Precision Index

*Number of Corm per unit Length*

The number of corms per meter length was observed for two levels of corm spacing and forward speed of operation. The theoretical requirement of corms per unit length was calculated as per the nominal spacing. The number of corms per meter length was observed for lower speeds of 0.54 and 0.98 kmh$^{-1}$ for 15 and 20cm nominal spacing and compared with the calculated requirement. However, the observed number of corms per meter length was less with the increase in forward speed which is due to a higher missing percentage. The statistical analysis (Table 3) showed a significant effect of nominal spacing and forward speed at 5 percent significance level, however, the interaction terms were observed not significant.

**Table 3:** ANOVA of various parameters

| Source | Observed spacing | Uniformity | Missing | Number of corms /length |
|---|---|---|---|---|
| Nominal spacing | 17929.820** | 57.171 ** | 505.263 ** | 293.463** |
| Speed | 43.771** | 30.298** | 284.211 ** | 21.148** |
| Interaction | 4.628 ** | 3.197** | .003 NS | 1.888 NS |

** Highly significant at P≤0.05 NS; Not Significant

*Mechanical Damage*

There was no visible damage was observed as at both the level of nominal spacing and forward speed.

*Other Performance Parameters*

The average field capacity of the planter was observed as 0.02 $hah^{-1}$. The average draft requirement of the planter was found as 821 ± 50.3 N.

## CONCLUSION

Based on the field evaluation it could be concluded that the planter should be operated ataforward speed between 0.5-1.0 $kmh^{-1}$ for its satisfactory operation. In addition, the lower speed has given minimum variation in corm spacing. The result also indicated that the planter is more suitable for wider nominal spacing as indicated by its lower coefficient of variation. Thecoefficient of variation was also found higher for higher forward speed and lower nominal spacing. The average field capacity of the planter was found as 0.02 $hah^{-1}$.

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