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Development and Performance Evaluation of an Animal Drawn Single Row Zero Till Seed Drill for Sowing Pea (*Pisum sativum*)

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A B S T R A C T

In hills Area, sowing of various crops are generally done by manually broadcasting of seeds into the field, and due to which higher amount of seed rate consumed which cause uneven distribution of seed pattern into the field and at improper depth and moisture due to which poor germination of seeds were occurred in the field and it consequence on lower the yield and productivity of crops. In hilly region contour cultivation is a sustainable way of farming where farmers plant crops across or perpendicular to slopes to follow the contours of a slope of a field. In hilly areas the land distribution is very small and sloppy in nature due to which tractor power is not adopted for sowing of crops. To overcome these problems, a light weight single row animal drawn zero-till seed drill suitable for hill farming was developed in farm machinery and power engineering department of GBPUA&T Pantnagar for line sowing of wheat, maize, lentil, pea etc. for hilly small field and easily carried by the farmers on the shoulder. The machine consisted of fluted roller seed metering mechanism which is made of aluminum alloy material and inverted T- type furrow opener was used to make a furrow line at shallow depth into which seed of pea was dropped through seed delivery tube by gravity action. In the field operations two persons were required to operate the machine one person operated the bullocks and one person carried the handle of machine in hand and moving behind the machine. The result was found that the required seed rate of 110 kg/ha was obtained at 10.5 mm exposure length of fluted roller. The visible mechanical damage was found as 1.18 % which is within the acceptable limit and the actual field capacity of the drill was found as 0.051 ha/h with observed field efficiency of 78 % at an average speed of 2.6 km/h. The plant populations were recorded as 64 and 63 plants per square meter area at 20 and 45 DAS. The average yield of vegetable pea was found to be126 q/ha respectively.

Introduction

Agriculture, especially crop production, is the main stay of Indian economy, contributing about 19.5 percent in GDP and supports about 115.5 Million farm families. India has a total geographical area of 328.9 million hectare out of which the net sown area has raised from 118.75 Million-ha to141.06 Million-ha having a compound annual growth of 0.4%. In India about 84.80% of the distribution of farm holding is dominated by small and marginal farmers (Agriculture Statistics 2010-11) and 67.04 % of marginal land holding which is less than one hectare occupied by the maximum populations of farmers in India and in Uttarakhand the operational average land holding was 0.89 ha in 2010-11. Rainfed agriculture constitutes about 60% of the net sown area of the country.

The area is the major domain of oilseeds, pulses and coarse cereal production. The use of advance input to agricultural production has raised the food grain production from 81.6 million tonnes in 1962-63 to 295.67million tonnes in 2019-20. Sowing/planting is one of the most important operations in the crop production which involves factors like correct seed rate, appropriate depth of placement and required seed spacing which determines the crop production. The time and method adopted for sowing decisively influence the germination and hence production. Sowing and planting equipments play important role because the time of sowing coincides in number of villages resulting in scarcity of agricultural labourers during the peak sowing period. Therefore to cover maximum area more efficiently within less available turn-around-time, the use of drills and planters becomes more important over the conventional method of sowing. The use seed-cum-fertilizer drill not only just conserve energy but also saves about 20% of seed and increases the yield by 15 percent through better placement and more effective utilization of fertilizers and seeds (Bansal *et al.*,1983).

However, unlike in plains, the green revolution has very little impact in hilly areas. The reasons could be difficult terrain with undulating topography with small and scattered land holding on steep slopes. Mechanization of agricultural operations in plains has played a vital role in efficient field operations thereby reducing the production cost. Whereas, Indian hill farming is almost untouched as far as mechanization is concerned.

The productivity of cereals is much lower than the productivity of those crops observed in plains. This may be due to poor germination and plant population because traditionally broadcast sowing is more popular in hills. Broadcast sowing not only requires more seed rate but also makes the intercultural operations cumbersome and labor intensive. Due to lack of a proper sowing device, the adoption of line sowing is almost negligible in hill farming. In hills, agriculture is performed on small zigzag terraces and farmers are resource poor.

The bullocks available with the farmers are smaller in size and their draft ability is poor compared to animals in plain region. Considering these points of views a single row animal drawn zero-till drill was developed in department of Farm Machinery and Power Engineering. The drill was demonstrated at farmer's field in hill region. Since the fields in hill region is quite small, the farmers had to lift this drill in order to make a turn. Farmer felt it difficult to do so frequently due to more weight of drill which is 18 kg. Also it was difficult to carry this drill from one field to another. Keeping this point in view, the present study was under taken to reduce the weight of seed drill so that farmers were easily carried it on the shoulders and moved from one field to another field.

Materials and Methods

The following criteria were considered in designing the single row seed drill. To designing the seed box, furrow opener, seed metering mechanism of single row drill, physical and morphological parameters like length, breadth, thickness, bulk density, test weight and angle of repose of pea seed was determined in the laboratory. Pea seed was used during field and laboratory test conditions.

Determination of physical properties of pea seed

Seed size

The size of pea seeds were determined in terms of its length(l), width(b) and thickness(t). For this purpose 100 seeds, were taken and their geometric mean was calculated and the data was averaged out to determine the average size of the pea seed.

Geometric mean, (mm) = $\sqrt[3]{lbt}$

l = length of seed, mm

b = width of seed, mm

t = thickness of seed, mm

Shape

The sphericity was calculated with the following equation.

$$\text{Sphericity} = \frac{D_e}{D_c} = \frac{\sqrt[3]{lbt}}{l}$$

D_e= Diameter of sphere having same volume as that of sphere.

D_c=Diameter of the smallest circumscribing sphere.

Thousand seed weight

Thousand seeds were taken and their weight was determined using electronic balance. The average of all five samples was calculated to determine the average weight of thousand seed. The average weights of thousand seeds were found to be 355 g.

Bulk density of seed

The following relationship was used to determine the bulk density of the seed. The average bulk density of seed was found to be 0.6 g/cc.

Bulk density, (g/ cc)

$$= \frac{\text{mass of seed in measuring cyclinder,g}}{\text{volume of cyclinder,cc}}$$

Angle of repose

The angle of repose was determined using the following relationship.

$$Ø = \tan^{-1}\left(\frac{2h}{D_p}\right)$$

Where :

Ø = angle of repose, degree

h = height of heap, cm

D_p = Diameter of the base plate, cm

Coefficient of friction

The coefficient of friction between the granular materials is equal to tangent angle of inclination is measured which is the coefficient of friction of the grain sample. The average value of internal friction of seed was found to be 0.5.

Field parameter

Moisture content of soil

Moisture content of the soil was determined by oven dry method. The following relationship was used to determine the moisture content of soil. The average value of moisture content was found to be 17.11%.

Moisture content, %(d.b)

$$= \frac{W_1 - W_2}{W_2}$$

Where,

W_1= wet weight of soil sample, g

W_2 = weight of oven dry sample, g

Determination of cone index

For determination of cone index, the cone penetrometer was used. The cone index was determined from the following relation. The average value of cone index was found to be 1.74 kg/cm^2.

CI=0.025Y+0.099

Where:

CI=Cone index, kg/cm^2

Y= Gauge deflection, subdivisions.

Bulk density of soil

Bulk density of soil was determined by standard technique. The following relationship was used to determine the bulk density of soil. The average bulk density was found to be 1.64 g/cc.

Bulk density of soil (g/cc)

$$= \frac{\text{Dry weight of soil, g}}{\text{Volume of core sampler, cc}}$$

Machine parameters

Description of animal drawn zero till seed drill

The major components of the animal drawn single row zero till seed drill used in the study were seed box, main frame, furrow openers, power transmission systems, seed metering device and adjustable beam. Figure 1 show description of animal drawn seed drill.

Seed box

Seed box provided space for placing the seeds of pea. The seed box is made of mild steel sheet of 2.3mm thickness. The size of seed box was decided on the basis of average size of field available with hill farmers. In general, the available working field size in hills is approximately 2 Nalies (0.04 ha), which requires 4 kg seed at 100 kg/ha seed rate.

This can be achieved in keeping the number of fills two. The capacity of the hopper was decided as 2 kg to make the drill light weight. Therefore the number of fills required to row 2 Nalies of land will be two to achieve the seed requirement of 4 kg.

Design of seed box

Average field size for hills= 0.04 ha(2Nali)

Seed required for this area at 100 kg/ha if the hopper is filled twice = 0.04x100/2 =2 kg

Bulk density of pea seed = 0.6 g/cm^3 (Singh, 1992)

Volume of 2 kg seed without freeboard = 3333 cm^3

Required volume of seed box with 10% freeboard = 3666 cm^3

The seed box is having a combination of trapezoidal as well as rectangular cross-section. Figure 2 show the front, top, side view of seed box and hence its volume can be calculated by the following formula.

Volume = $\frac{1}{2}$ x (B+H) x width…. (1)

Where,

B = length of smaller (lower) parallel side.

H = length of larger (upper) parallel side.

Volume of seed box

$V_b = 1.1 \times V_s$

Where,

V_b= volume of box, cm^3

V_s = volume of seed, cm^3

Hence

$V_b = 1.1 \times V_s$

Also, $V_s = \frac{W_s}{\gamma_s}$

Where,

W_s = weight of seed in the box, g

γ_s = bulk density of seed, g/cc

Putting $V_s = \frac{W_s}{\gamma_s}$

For light weight and easy operation of the drill, let 2.0 kg seed is filled in the box at a time.

$V_b = 1.1 \times 2 \times 1000/ 0.6$

[γ_s = 0.6 g /cc for pea seed]

V_b=3666.66 cm^3

Mathematical calculation of volume of seed box

From figure 1, its volume is calculated as:

$V_b = V_A + V_B$

Where,

V_b = volume of seed box

V_A= volume of (section –A) of box

V_B=volume of (section – B) of box

Now, $V_A = b \times b \times h_1$

$V_B = \frac{1}{2} \times \{a + a + l + l\} \times h_2 \times b$

$= \frac{1}{2} \times \{2a + 2l\} \times h_2 \times b$

Let we assumed h_2=11 cm and a=7.5 cm

The angle of repose of pea seed ranged from 25^0 to 28^0. The design of seed box should be such that angle of repose is more than $28^0$for easy flowing of seeds. Therefore we considered $\theta = 74^0$

$l = h_2 \times \cot\theta$

$= 11 \times \cot 74^0 = 3.15$ cm

Also from fig 3.

$b = a + 2l = 7.5 + 2 \times 3.25 = 14$ cm

$V_b = V_A + V_B$

$= b \times b \times h_1 + \frac{1}{2} \times \{a + a + l + l\} \times h_2 \times b$

Hence, $3666 = 14 \times 14 \times h_1 + \frac{1}{2} \times \{2 \times 7.5 + 2 \times 3.15\} \times 11 \times 14$

$3666 = 196h_1 + 1655.50$

$196h_1 = 2010.50$

$h_1 = 10.25$ cm

Main frame

Main frame provides support and space for mounted the seed box. It is made of angle iron of size 23 x 23 mm. Two assembly points are provided such that the seed box can be slid over it to vary the exposure length of fluted roller to change the seed rate.

Furrow opener

The developed zero till seed drill utilizes an inverted T-type furrow opener was shown in figure 1 to make narrow slit without much soil disturbance. The working face and lower portion of the blade is coated with hard surfacing electrode to provide enough hardness in order to prevent the edges from excessive wearing.

This increases the useful life of the furrow opener blade. After welding it was grinded to obtain V-shape sharp working edge. Both sides of the blade were also hard surface to provide strength. A 45 mm wide bottom plate and 5 mm thick,60 mm long stiffener is provided at the back of the furrow opener to avoid buckling of the blade. The depth of cut can be adjusted by adjusting the holes provided in the shank and rake angle of the furrow opener.

Design of furrow opener shank

An inverted T-type furrow opener was fitted at one end of the shank and the section modulus of the shank was computed using classical flexure formula (Kumar *et al.*, 1986) as given below.

$$f_b = \frac{M_b Y}{I} \quad .(2)$$

Where,

f_b = bending stress, kgf /cm^2

Mb = bending moment, kgf-cm

Y = distance from the neutral axis to centre line, cm

I = moment of inertia for rectangular cross-section about the neutral axis, cm

From the equation number (2) section modulus was given below

$$Z = \frac{I}{Y} = \frac{M_b}{f_b} = \frac{db^2}{6} \ldots(.3)$$

$M_b = D_d\, L$...(4)

Where

D_d = design draft (kgf) which is kept 3 to 5 times of actual draft for safety point of view. A factor of safety of 5 has been considered for this design

L = length of shank

Actual draft = k_oA….(5)

Where,

k_o = soil resistance, kgf/cm^2

A = cross- section area of furrow,cm^2

Therefore,

$M_b = 5\, k_oA\, L$… (6)

From there equation (2)

Here the length of shank (L) = 30 cm

Area of cross-section of furrow = 4.0 cm^2

f_b for mild steel rectangular cross-section = 1000 kgf/cm^2

It is assumed that b:d = 1:4 or d = 4b

$b^3 = 0.36$

b = 0.71 cm say 7 mm

Therefore d = 28 mmmm say 30 mm

Standard MS flat of size 30 x 7 mm size was used for fabricating the shank of furrow opener.

Bottom part of combined furrow opener

Since, the draft force is very low, this portion was not designed from strength point of view.

Transmission system

Chain and sprocket type power transmission was used. It consists of two sprockets of 11(at drive wheel) and 22 (at fluted roller shaft) teeth. The smaller sprocket was mounted on one side of 18.5 mm diameter shaft. A lug wheel of 280 mm diameter has been mounted on the other side of this shaft for transmitting power from ground to fluted roller shaft. In this seed drill ground wheel acts as power wheel as well as depth control wheel.

The ground wheel is made of Mild steel round bar of size 12 mm. Fields are stony and undulated in the hills, therefore, lugs were provided on the periphery of ground wheel for uniform power transmission to the fluted roller shaft. Length of lug was kept at 38 mm to increase effective diameter of the ground wheel and also to provide better traction with lesser slippage.

Power transmission system design

Chain length is calculated by the following formula:

$$L_n = \frac{2C}{P} + \frac{Z_1 + Z_2}{2} + \left(\frac{Z_1 - Z_2}{2\pi}\right)^2 X \frac{p}{C} \quad \text{.................(7)}$$

Where,

L_n = number of chain links

C = center to center distance between two sprockets, 400mm

Z_1 = number of teeth in driver pulley, (teeths =11)

Z_2 = number of teeth in driven pulley, (teeths = 22)

P = pitch of chain, (15mm)

$$L_n = \frac{2\times400}{15} + \frac{(11+22)}{2} + \frac{(22-11)^2}{4\pi^2} \times \frac{15}{400}$$

L_n = 53.33 + 16.50 + 0.115= 69.99 = 70

Chain length (L) is given by

$L = L_n \times p$
= 70 × 15
= 1049 mm

Center to center distance is calculated from

$$C = \frac{p}{4}\left\{\left[L_n - \left(\frac{Z_1 + Z_2}{2}\right)\right] + \sqrt{\left[L_n - \left(\frac{Z_1 + Z_2}{2}\right)\right]^2 - 8\left[\frac{Z_2 - Z_1}{2\pi}\right]^2}\right\} \quad \text{...(8)}$$

C = 15/4{[70—16.5] +√ [70—16.5]^2 — 8×3.06}
= 400 mm

Seed metering mechanism

The seed metering mechanism used in this drill is of fluted roller type as shown in figure 3. A seed feed cup is mounted at the bottom of the seed box. A fluted roller having 5 grooves and diameter 50 mm is mounted over a roller shaft of 16.5 mm diameter. The provision has been made to change the exposure length to adjust the seed rate requirement.

Determine the length of a fluted roller

The volume of seed dropped per meter length of row if given by:

$$V_s = \frac{s \times r}{10 \times \rho}$$

$$V_s = \frac{110 \times 0.19}{10 \times 0.6} = 0.348\ cm^3$$

Where,

S = seed rate for a crop in kg/ha

ρ = bulk density of seed in g/cm^3

r = row spacing in m

The area of a semi- circular flute is given by

$$A_f = \frac{\pi d_f^2}{8}$$

Where: d_f = diameter of flute in cm.

$$A_f = \frac{\pi \times 0.9^2}{8} = 0.317\ \text{cm}^2$$

The delivered volume per revolution of the roller is given by:

$$V_d = A_f \times N_f \times I_f$$

$$V_d = 0.317 \times 5 \times 0.096 = 0.153\ cm^3$$

Where:

Af = area of semicircular flute in cm^2

N_f = number of flutes and

I_f = exposed length of flute in cm.

The number of revolutions of a fluted roller, n_f is given by:

$$n_f = i \times n_g$$

$$n_f = 2 \times 50 = 100\ revolutions$$

Where:

I = transmission ratio and

n_g = number of revolutions of the ground wheel. (say 50 revolutions)

The distance, D_g covered by the ground wheel per revolution is given by:

$$D_g = \pi \times d_g$$

Where : d_g = diameter of ground wheel in m.

$$D_g = \pi \times 0.28 = 0.87\ m$$

The volume of seed per centimeter travelled by the ground wheel is given by:

$$V_s = \frac{V_d \times i}{\pi d_g}$$

$$V_s = \frac{0.153 \times 2}{\pi \times 28} = 3.48 \times 10^{-3}\ cm^3$$

$$V_d = \frac{\pi d_g \times r \times s}{\rho \times i \times 10}$$

$$V_d = \frac{\pi \times 0.28 \times 0.19 \times 110}{0.6 \times 2 \times 10} = 0.153\ cm$$

Where:

V_d = volume of seed dropped per rotation of feed roller, cm^3

d_g = diameter of ground wheel, m

s = seed rate, kg/ha

ρ = bulk density of seed, g/cc

r = row spacing, m

Now, number of flutes on the metering roller s periphery can be decided from the formulagiven below

$N_f = \frac{\pi \times d_g}{x \times i}$

Where:

N_f = number of flutes or slots/roller

x = linear spacing of seeds on the ground, cm

d_g = diameter of ground wheel, cm

i = Transmission ratio, (i=2)

$N_f = \frac{\pi \times 28}{10 \times 2} = 4.9 = 5\ number\ of\ fluted\ roller$

[now, the linear spacing changes to 96 mm which is acceptable]

The exposed length of the fluted roller is derived by combining equations 7 to 12 as follow

$$l_f = \frac{8 \times s \times r \times d_g}{10 \times \rho \times d_f^2 \times N_f \times i}$$

$$l_f = \frac{8 \times 110 \times 0.19 \times 0.28}{10 \times 0.6 \times 0.9^2 \times 5 \times 2} = 0.096\ cm = 10\ mm$$

Working volume released by fluted roller in one rotation (V_d) is given by

$V_d = V_{slot} + V_{active}$

Where,

V_d = volume of seeds falling in slots

V_{active} = volume of seeds thrown out from the active layer

V_{slot} = volume of seeds falling in slots.

$V_d = V_{slot} + V_{active}$

$= A_f.N_f.L_f + A_a.N_f.L_f$

$= L_f.N_f.(A_f + A_a)$

Where:

A_f = cross sectional area of one flute

N_f = number of flutes/roller

L_f = length of flute

A_a = cross sectional area of active layer

Now, Assume

$A_a = 0.7A_f$

$V_d = L_f \times 6 \times (A_f + 0.7\ A_f)$

$0.153\ cm^3 = L_f \times 6 \times (A_f + 0.7\ A_f)$

length of flute = 4.73= 50 mm

The diameter of fluted roller is determined by the desired number of flutes and their spacing and is given by

$$d_r = N_f \times \frac{(d_f + s_f)}{\pi}$$

d_r = diameter of the fluted roller in mm

d_f = diameter of the flute in mm

s_f = spacing between flutes in mm

d_r = 22.92 mm=2.29 cm

The circumferential speed of the fluted roller as a function of the ground wheel forward speed, assume no slip occurred in this conditions, is as follows:

$$V_r = i \times \left(\frac{d_r}{d_g}\right) \times V_g$$

i= 2(transmission ratio)

ground wheel has a forward speed of 2.6 km/h

then

$$V_r = 2 \times \left(\frac{22.92}{280}\right) \times 2.6 \ = 118 mm/s$$

Hence a fluted roller of 22.92 mm diameter with 5 flutes, which are semicircular and each with a diameter of 9 mm, will be able to meter the desired seeding rate of 100 kg/ha of pea seed when the exposure length of the flute is approximately 10 mm. It is recommended that the dimensions of fluted roller should be accurately maintained so that inter row variation would be within ± 4 % of the required seeding rate.

Adjustable beam and handle

Adjustable beam has been provided to make it suitable for different height of animals. The beam is made of wood 2400mm long. Variable hitching points are provided between 220 mm from top and 550 mm from bottom. The beam is fitted with the frame with help of nuts and bolts. A handle has been provided to control the seed drill during operation. While designing the handle, the ergonomic aspect was taken into consideration for comfort ability point of view of the farmers during operation of machine in the field such that 95 percentile of user population were statistically operated it.

The height of handle provided for the operator can be adjusted according to the height of the operator using two point linkage systems such that backbone pain was not occurred during field operation.

The maximum and minimum heights of which could be adjusted for the operator are 810 mm and 760 mm respectively (Table 2).

Results and Discussion

Physical characteristics of pea seeds

Physical characteristics of pea seeds are given in Table 1. The shape of pea seeds was spherical faces. The average length, breadth, thickness and frontal area were found to be 8.015mm, 6.375mm, 5.195 mm and 50.51 mm^2respectively. It was observed that bulk density, angle of repose and weight of thousand pea seeds were 0.60 g/cc, 27^0 and 355 g respectively.

Laboratory test

Calibration of zero till seed drill

The bullock drawn zero till seed drill was calibrated for desired seed rate of 100 kg/ha. The calibration of seed drill was done by filling the seed in the seed box to its full, $3/4^{th}$ and half capacity. Table 3 shows the average quantity of seed obtained at different fluted roller exposure lengths. At full exposure of fluted roller the average quantity of seed dropped in 50 revolutions varied between 480.87g to 529.4 g with an average of 506.49 g. At $3/4^{th}$ exposure length seed dropped varied between 381.08 g to 403.31 g. At half exposure these values varied between 239.4 g to 254.39 g. This indicates that the quantity of seed obtained is higher with more exposure length of seed metering device which was obvious. The data also indicates that the seed rate decreased with decrease in amount of seed available in the box. This may be due to problem in free flow of seed into the hopper and internal friction between the seeds.

Visible mechanical damage

The pea seed after passing through the metering device was collected in the polythene bag from furrow opener for determination of visible mechanical damage. The data show that the percent visible grain damage ranged between 1.28 and 1.07 percent. The average value of mechanical grain damage was observed as 1.18 percent.

Field performance of Seed Drill

Tested in actual field conditions

The bullock drawn zero till seed drill was tested in actual field conditions. Fig. 4 shows the seed drill working in the field with seed distribution pattern. During field test the data regarding depth of sowing, draft, speed of operation, field capacity and slippage percentage were recorded. The data was shown in Table 4. The depth of sowing varied between 2.67 to 3.0 cm with an average the field capacity was observed as 0.051 ha/h with a field efficiency of 78 percent. During the field test wheel slip was measured which was found as 7.13 percent.

Draft of seed drill

According to Campbell *et al.,* (1990) the power of useful work done by human being is given by

hp =0.35-0.092 log t ….(9)

Where t= time of operation, in minutes

Now for 3-4 hours continuous work the power developed by the operator would be 0.10-0.13hp (say 0.11 hp)

$$hp = \frac{push\ (kgf) \times speed\ (\frac{m}{s})}{75}$$

The operating speed of machine wasfound to be 2.33-2.76 km/h

Therefore draft (kgf) $= \frac{hp \times 75}{speed}$.. (10)

The draft of seed drill was varied from 10.76 to 12.74kgf.

Observation crop parameters

Germination count and yield

The data pertaining to germination count was collected after 20 days and again on 45 days of sowing and the results have been presented in Table 5 and showed in figure 5.

The data reveal that the germination count varied from a minimum of 43 to a maximum of 89 plants per square meter. On an average the germination count was found to be 64 plants per square meter area after 20 DAS.

The plants were also counted after 45 DAS, which varied from 43 to91 with an average of 63 plants per square meter area.

It is evident from the data that the crop yield varied between a minimum of 65 q/ha to a maximum of 234 q/ha with an average yield of 126 q/ha (Table 6).

Table.1 Dimension of different pea seeds

Sl.no	Parameters	Minimum	Maximum	Average
1	Length , mm	7.51	8.52	8.015
2	Breadth,mm	7.53	5.22	6.375
3	Thickness ,mm	5.18	5.21	5.195
4	Frontal area,mm^2	56.55	44.47	50.51
5	Weight of 1000 seeds, g	355		
6	Shape and size of seed	round shape of seeds		
7	Bulk density, g/cc	0.60		
8	Angle of repose, degree	27^0		
9	Moisture content,%	10		
10	Germination,%	85		
11	Variety	Arkel Pea		

Table.2 Major specifications of the animal drawn seed drill

Parameters	Values
Top length of seed box	140 mm
Bottom length of seed box	75 mm
Top width of seed box	140 mm
Bottom width of seed box	40 mm
Height of section A (h_1)	103.3 mm
Height of section B (h_2)	110 mm
Total weight, kg	13.5 kg
Number of row	1
Capacity of seed box	2 kg
Material of box	MS sheet
Speed of operation	2.33 to 2.76 km/h
Power source	Manual (two men required)

Fig.1 Development of animal drawn single row seed drill

Table.3 Result of calibration of seed drill

Sl.NO	Replications	Quantity of seed dropped in 50 revolutions at different exposure length of metering device				
		Hopper capacity	Full exposure 35 mm	3/4th exposure 26 mm	Half exposure 17mm	1/4 Exposure 8 mm
			g	g	g	g
1	R1	Seedbox completely filled	529.4	390.38	250.70	**87.90**
2	R2		498.97	397.10	248.71	**84.79**
3	R3		522.24	403.31	254.39	**935.89**
Average			**517.0**	**396.93**	**251.29**	**88.46**
1	R1	Three-fourth filled seed box	512.41	386.25	245.60	**84.79**
2	R2		488.63	394.00	239.40	**82.21**
3	R3		511.89	398.66	251.29	**94.48**
Average			**504.24**	**392.97**	**245.43**	**87.16**
1	R1	Half filled seed box	509.31	381.08	243.53	**78.59**
2	R2		480.87	390.90	244.05	**85.31**
3	R3		504.66	398.66	244.05	**85.31**
Average			**498.25**	**390.18**	**243.87**	**83.07**

Table.4 Field Performance test result of the single row seed drill for Pea in CRC Research Centre

Replicat i-on	Depth of sowing (cm)	Distance between two line (cm)	Speed of operation (km/h)	Draft (kgf)	Time (sec)	Area coverage (m^2)	Theoretical field capacity (ha/ h)	Actual field Capacity (ha /h)	Field efficiency (%)
R1	3.0	18.0	2.76	10.76	2191	420	0.069	0.052	76
R2	3.0	20.0	2.38	12.47	2791	460	0.060	0.048	80
R3	2.7	23.0	2.33	12.74	2658	480	0.065	0.054	83
R4	3.0	16.6	2.56	11.60	3120	520	0.060	0.043	71
Average	**2.92**	**19.26**	**2.556**	**11.736**	**2705.8**	**472.8**	**0.0634**	**0.0496**	**78**

Table.5 Crop parameter recorded from experimental field at CRC research centre

Sl.No	No of plants/ m^2 20 DAS	No of plants/ m^2 45 DAS	Number of pod/ plant	Weight of pods/plant (g)	Yield (q/ ha)
1	78	78	6	19	148
2	76	74	5	15	111
3	78	76	6	20	152
4	80	80	3	10	80
5	75	78	6	30	234
6	52	50	4	15	75
7	89	91	8	35	319
8	43	45	6	25	113
9	69	64	4	20	128
10	70	70	5	20	140
11	50	47	6	25	118
12	52	50	5	15	75
13	73	70	7	20	140
14	48	45	4	15	68
15	45	43	4	15	65
16	54	52	3	15	78
17	46	43	4	15	65
18	60	62	6	25	155
Average	**64**	**63**	**6**	**20**	**126**

Table.6 Field performance test result of the seed drill for sowing pea in CRC research centre

Sl.No	Particulars	Values
1	Seed germination,%	85
2	Area of land under sowing (ha)	0.2
3	Seed rate, kg/h	100 to 110
4	Row spacing, mm	190
5	Depth of sowing, mm	29
6	Speed of operation, km	2.33-2.76
7	Effective field capacity, ha/h	0.06
8	Time required (man-hr/ha)	17
9	Plant stand after emergence (plants/sq. m)	63 to 65
10	Draft force, N	105.44 to 124.85 N (115.14 N)
11	Field efficiency, %	71 to 83 (78)

Fig.2 Top view and side view of seed box

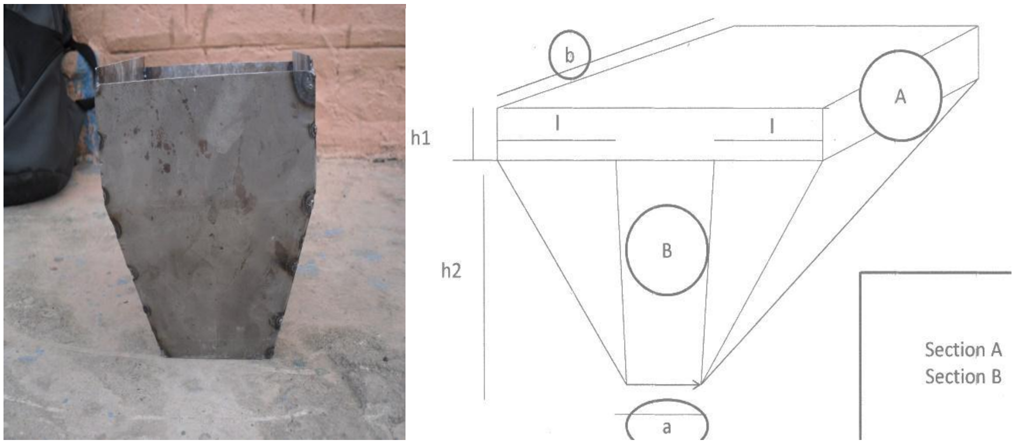

Fig.3 Furrow opener and fluted roller

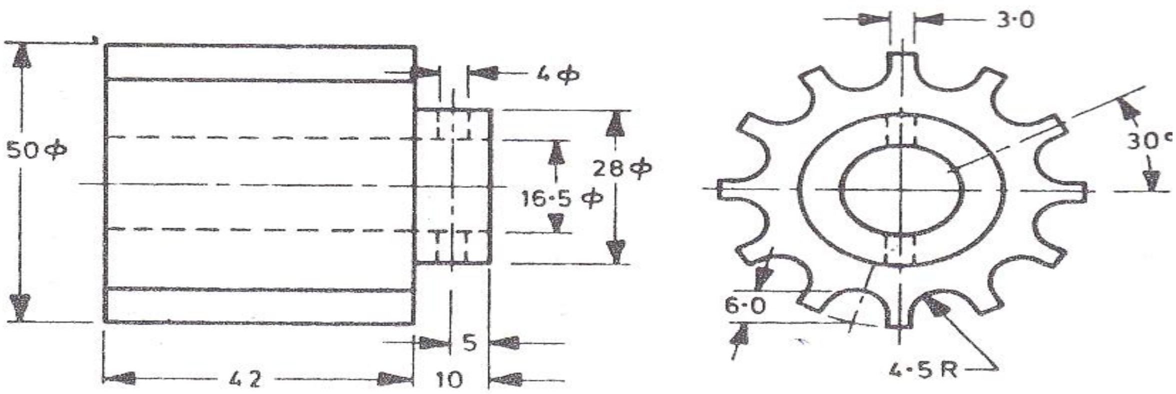

Fig.4 Performance of seed drill in field and distribution of seed in furrow line

Fig.5 Germination of plant counted per meter square area after 20 and 45 DAS.

The variation in crop yield may be due to less number of healthy pods per plant at some location as well as less weight of individual pods per plant.

The following conclusion may be drawn from the study

The average effective field capacity, field efficiency and average draft were found to be 0.05ha/h, 78% and 11.736 kgf. The required seed rate of 110 kg/ha was obtained at 10.5 mm exposure length of fluted roller.

The visible mechanical damage was found as 1.18 % which is within the acceptable limit.

The average plant stand population was recorded as 64 and 63 plants per square meter at 20 and 45 DAS. The average yield of vegetable pea was found as126 q/ha respectively.

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