RESEARCH ARTICLE

DESIGN AND DEVELOPMENT OF VACUUM CYLINDER METERING MECHANISM FOR PLANTING OF BOLD SEEDS

Priya Sinha* and Ajay Verma

**FAE, IGKV, Raipur*

Received-09.07.2016, Revised-29.07.2016

Abstract: Groundnut, maize and pigeonpea are major bold seeds crop in India. Planting of these bold seeds is a very drudgery and time consuming operation. To address this issue, there is a need to design and develop the vacuum cylinder metering mechanism for planting of bold seeds like groundnut, maize and pigeonpea. The design of the seed metering cylinder (length 1630 mm and diameter 80 mm) was based on the physical property of the bold seeds. It was made of an M.S. sheet. Seeds are held to the metering hole of the cylinder by suction pressure. The size of circular metering orifice was kept as 2.5 mm. Total 54 orifices having same size was made on the seed metering cylinder at 9 different locations. Each location is having 6 orifices, at an angular distance of 60^0. The vacuum rod and the metering cylinder are placed concentrically. The length of the rod is 2320 mm and the diameter of rod is 25mm. The size of the hole in the vacuum rod is 6 mm and total no. of holes are 18, placed at 9 different locations (2 on each location at an angular distance of 180^0). Vacuum is created in this rod and goes down the vacuum cylinder. The metering cylinder rotates over rod and pick up the seeds through the seed hopper while passing through it.To evaluate the performance of vacuum cylinder pickling % & metering efficiency of metering mechanism were considered under different suction pressure i.e. for groundnut seed 4500 Pa, 5000 Pa and 5500 Pa, for maize seeds 3500 Pa, 4000 Pa and 4500 Pa while for pigeonpea seeds 1500Pa, 2000 Pa and 2500 Pa. On the basis of superior performance the optimum suction pressure inside the vacuum cylinder for groundnut seed was found to be 5000 Pa with a metering efficiency of 106.67 % and maximum picking percentage of 96%. Similarly the optimum suction pressure for maize seed was found to be 4000 Pa with a metering efficiency of 108.88 % and maximum picking percentage of 97% while for pigeonpea seed these values were found to be 2000 Pa, 110 % and 92 %. Hence it was concluded that the designed and developed vacuum cylinder metering mechanism is capable and suitable for planting of bold seeds like groundnut, maize & pigeonpea.

Keywords: Seed, Maize, Groundnut, Pigeonpea, Harvest

INTRODUCTION

In India, Groundnut, Pigeonpea and Maize are the major bold seeds crop. Groundnut (Arachis hypogaea L.) is a member of Fabaceae family which forms the important edible oil seed crops in the world. In terms of cultivated area and production of Groundnut in the world, India ranks second. In India about 5.5 million hectares area is under cultivation annually and the production is about 6 million tonnes. Maize is the third most important food crops after rice and wheat. It is also considered as an alternative crop to summer paddy, looking to lesser water requirement. According to advance estimate it is cultivated in 8.7 m ha (2014-15) mainly during Kharif season. Pigeonpea (Cajanus Cajan, L.), is one of the major pulse crops. India is the largest producer with 3.4 million ha. In India bold seeds (Groundnut, Maize and Pigeonpea) planting is conventionally done by manual dibbling. The seeds are dibbled in lines at a depth of 30 mm with two seeds per hill maintaining the desired spacing between the rows and plants. The labour requirement for planting bold seeds is high. This results higher cost of cultivation. Generally, the ridge planting is a practice that eliminates conventional seed bed preparation or which combines with planting operation.

Vacuum type seed metering mechanism

Vacuum metering mechanism is a relatively new concept of planting the seeds. These machines use vacuum seed metering principle. The principle offers several advantages, especially the single seed picking, no mechanical damage to the seed and their capability to deal with bolder seeds. Several researchers in India and abroad have developed tractor operated pneumatic planters. Adoption of these machines has been quite limited, due to their higher initial cost. Still considering the high accuracy and precision of the machinery, these machines have great potential for production of high value cash crops; especially requiring highly viable seeds.Presently, among different sowing techniques, precision sowing is the preferred method since it provides more uniform seed spacing than other methods. Bold seeds grown in a ridge-and-furrow system are better suited to mechanical harvesting than the bold seeds grown in the non ridged or flat, conventional system. The timely operation of bold seeds ensuring weed control, infiltration and storage of runoff water in turn helps in moisture conservation.

MATERIAL AND METHOD

Physical Characteristics of Bold Seeds (Groundnut, Maize and Pigeonpea)

Physical properties such as length, width, thickness, sphericity, bulk density and thousand grain weights

*Corresponding Author

were studied for seeds like groundnut, maize and pigeonpea.

Concept of Vacuum Metering Mechanism

The vacuum planting concept is based on the suction pressure. Vacuum metering systems are used for accurate metering of single seed in precision planters. In this system an aspirator is used to develop suction pressure in the metering chamber inside the vacuum rod where a particular negative air pressure (vacuum) is maintained. Negative air pressure holds the seeds in pockets on a cylinder until the seeds are conveyed up to the bottom where the suction pressure is cut-off and the seeds are dropped into the seed tube to gravity. The flow through tube conveys the seeds to the furrow openers and deposits them to the furrow (Varshney, A. C., 1999).

Design of Vacuum Type Pricision Seed Metering Mechanism

Precision seeding is such a phenomenon that two processes have to be performed and the objective is to precisely place seeds at the required seed spacing. Seeds are held in cells on rotating cylinder by negative pressure, and dropped into seed tube with the effect of gravity. Capture of seeds in the holes of vacuum cylinder is very important for efficient of seeding. The vacuum cylinder is made of Galvanized M.S. sheet. Size of orifice on plate was decided based on the average size of the bold seeds viz. Groundnut, Maize and Pigeonpea.

The mechanism was designed and developed by Shrikant Gowardhan (progressive farmer) in Suresh Engineering Workshop, Mungeli. The design of vacuum type metering mechanism consists of several steps and requires basic information viz. seed characteristics, source of power etc.

Size of the seed metering orifice

The size of metering orifice on the seed metering plate was decided practically on the basis of dimensions of the bold seed i.e. length, width and thickness. The digital vernier caliper was used to measure the dimensions of the seed. The size of metering orifice was determined from the following relationship (Bosoi, 1987):

$$d_{\circ} = 0.6 b_{av}$$

Where,

$d_{\circ}$ = size of metering orifice, mm

b_{av} = average width of seed to be held, mm

Then, the seed exposed area was determined from the following equation;

$$A = \frac{\pi}{4} d^2$$

Where,

A = Seed exposed area in, mm^2,

d_0 = Size of metering orifice, mm

Design of Seed Metering Cylinder

The design of the seed metering cylinder is based on the physical property of the bold seeds. The metering cylinder orifices are made to achieve minimum band width with uniform plant spacing along and across the row, and the holes were made at same pitch circle diameter. It was made of an M.S. sheet. Seeds are held to the metering hole of the plate by suction pressure. The metering cylinder rotates concentrically outside the vacuum rod and pick up the seeds through the seed hopper while passing through it. 2-D and 3-D view of the designed vacuum cylinder is shown in Fig.1 & Fig. 2 respectively. The Specifications of the vacuum metering cylinder are given in Table 1.

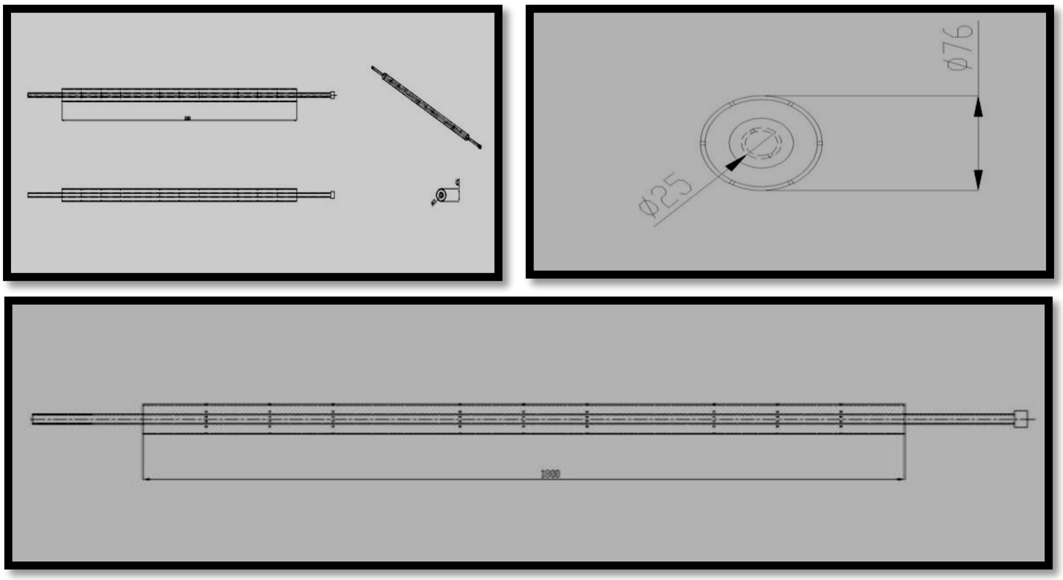

Fig. 1. 2D View of vacuum metering cylinder

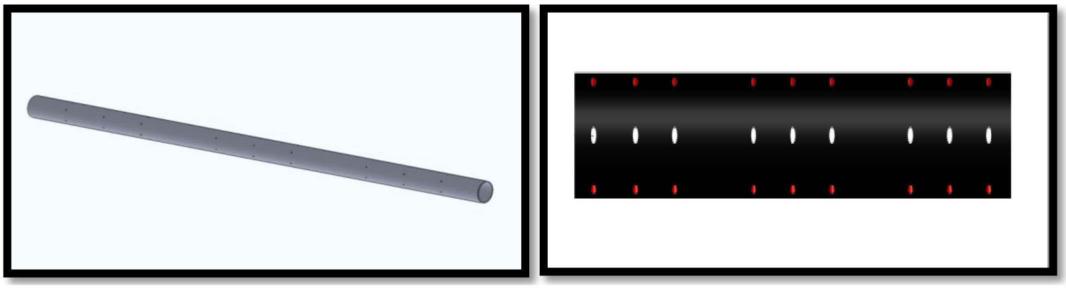

Fig. 2. 3-D View of vacuum metering cylinder

Table 1. Specification of the vacuum metering cylinder

S. No.	Particulars	Specification
1	Length of cylinder	1630 mm
2	Diameter of cylinder	80 mm
3	No. of orifices in cylinder	54
4	Size of orifices	2.5 mm
6	Angle between the orifices	60°
7	Horizontal distance between orifices	150 mm
8	Material of cylinder	m.s. galvanized coated

Design of the Vacuum Rod

The vacuum rod and the metering cylinder are placed concentrically. The length of the rod is 2320 mm and the diameter of rod is 25 mm. The size of the hole in the vacuum rod is 6 mm and total no. of holes are 18, placed at 9 different locations (2 on each location at an angular distance of 180^0). Vacuum is created in this rod and goes down the vacuum cylinder. The metering cylinder rotates over rod and pick up the seeds through the seed hopper while passing through it. View of vacuum rod (2-D and 3-D) , assembly of vacuum rod and cylinder is shown in figures through 3 to 5 and details of fabrication of vacuum cylinder and rod shown in Fig. 6

Table 2. Specification of the vacuum rod

S. No.	Particulars	Specification
1	Length of rod	2320 mm
2	Diameter of rod	25 mm
3	No. of orifices in rod	18
4	Size of orifices	6 mm
6	Angle between the orifices	90°
7	Horizontal distance between orifices	150 mm
8	Material	Mild steel

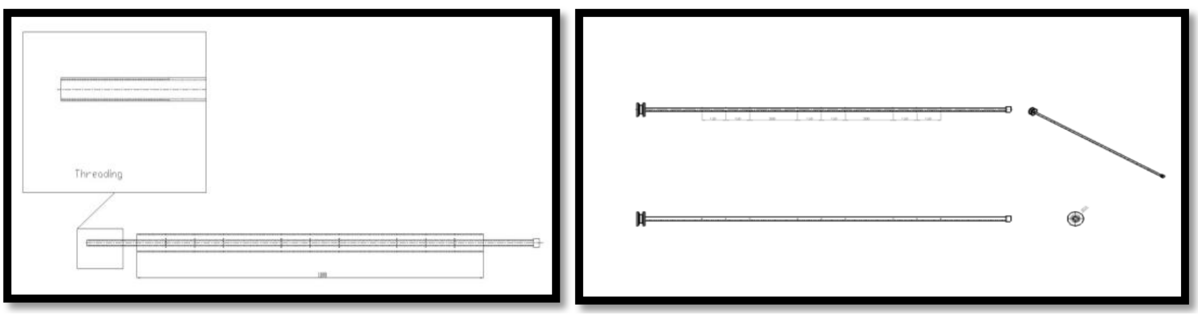

Fig. 3. 2-D View of vacuum rod

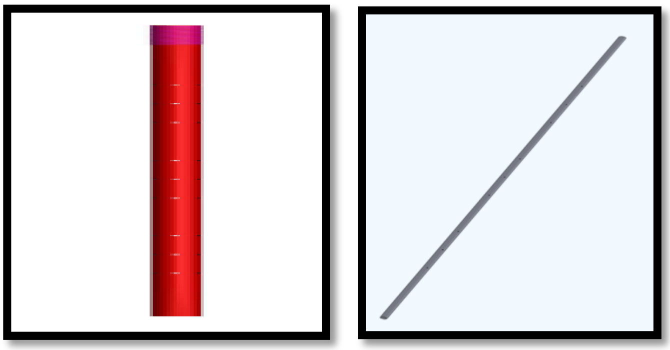

Fig. 4. 3-D View of vacuum rod

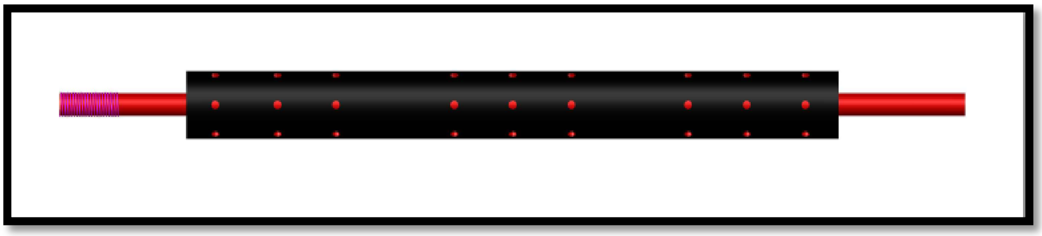

Fig. 5. Design of vacuum metering cylinder with vacuum rod

Fig. 6. Assembly of vacuum cylinder and vacuum rod

Design of Seed Box

It is a straight section of mild steel connected above the vacuum cylinder in which seeds are placed. It is made up of 1.5 mm thick mild steel folded in cylindrical section. The length of seed box is 1630 mm, width is 90 mm and is mounted on the main frame at a height of 350 mm from the main frame .

Blower

A blower (driven by petrol, 4 stroke engine) for developing suction pressure was used and fitted at one end of the planter. A rubber hosepipe connects the blower and the vacuum rod for developing necessary suction pressure in the vacuum chamber of the stationary vacuum rod. The blower was provided with the provisions to control the suction pressure ranging from 4500 to 5500 Pa for groundnut seeds, 3500 to 4500 Pa for maize seeds and 1500 to 2500 Pa for pigeonpea seeds.

RESULT AND DISCUSSION

Physical Properties of different Bold Seeds

Physical properties such as length, width, thickness, sphericity and thousand grain weights were studied for seeds like groundnut, maize and pigeonpea.

Table 3. Physical properties of different bold seeds

S. No.	Variety	Seeds	Length (mm)	Width (mm)	Thickness (mm)	Sphericity (s), %	1000-seed weight (g)
1	Vaishali	groundnut	11.55	7.68	6.98	64.27	445
2	TMMH 801	Maize	10.58	8.24	4.44	76.55	437.0
3	Rajivlochan	pigeonpea	5.52	6.16	4.37	92.2	107.92
	Average		9.21	7.36	5.26	77.67	329.97

The bulk density of groundnut seeds, maize and pigeonpea was found to be 610 kg/m^3, 720 kg/m^3 and 674 kg/m^3 respectively. The moisture content of groundnut seeds, Maize and pigeonpea was found to be 9.02%, 8.09% and 4.07% respectively

Size of the Seed Metering Orifice

The size of circular metering orifice was found by using the Equation $d_o = 0.6b_{av}$ It was worked out to be 4.5 mm. However, to make it suitable for some smaller bold seed also the size was kept as 2.5 mm. This also ensures efficient holding of the seeds under study. The metering orifices were made on the same pitch circle diameter (PCD) of the seed metering cylinder. Total 54 orifices having same size was made on the seed metering cylinder at 9 different locations. Each location is having 6 orifices, at an angular distance of 60^0.

Laboratory Test

Performance of the vacuum cylinder under varying suction pressure for bold seeds

The suction pressure was optimized based on the highest percentage frequency of the desired number of seeds dropping. The study was carried out with a vaccume rod placed inside the vacuum drum. The length of both rod and drum was 2320 mm while the pressure hole size was 6 mm and 2.5 mm respectively for rod and drum. The pressure hole was placed at nine different locations spaced at 20 cm matching with the seed tube along the length. These pressure holes were placed at an interval of 90 degree and 60 degree respectively on the periphery of rod and drum. This resulted in total number of 54 seed metering orifice (6 on each seed tube location) of 2.5 mm on the periphery of drum. The pressure was varied and observations on seed drop was recorded and presented in Table 4 to 6 for groundnut, maize and pigeonpea seeds respectively.

Table 4. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for groundnut seed.

S. No.	Suction pressure inside vaccume cylinder, Pa	Particulars of seeds per hill	(%) picking
1	4500	Skip (0)	15
		Single (1)	85
		Multiple (>1)	0
2	5000	Skip (0)	0
		Single (1)	96
		Multiple (>1)	4
3	5500	Skip (0)	0
		Single (1)	93
		Multiple (>1)	7

*desired number of seeds per hill (1).

Table 5. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for maize seed.

S. No.	Suction pressure inside vaccume cylinder, Pa	Particulars of seeds per hill	(%) picking
1	**3500**	Skip (0)	**14**
		Single (1)	**86**
		Multiple (>1)	**0**
2	**4000**	Skip (0)	**0**
		Single (1)	**97**
		Multiple (>1)	**3**
3	**4500**	Skip (0)	**0**
		Single (1)	**94**
		Multiple (>1)	**6**

*desired number of seeds per hill (1).

Table 6. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for pigeonpea seed.

S. No.	Suction pressure inside vaccume cylinder, Pa	Particulars of seed per orifice	(%) Picking
1	**1500**	Skip (0)	**17**
		Single (1)	**83**
		Multiple (>1)	**0**
2	**2000**	Skip (0)	**0**
		Single (1)	**95**
		Multiple (>1)	**5**
3	**2500**	Skip (0)	**0**
		Single (1)	**92**
		Multiple (>1)	**8**

*desired number of seeds per hill (1)

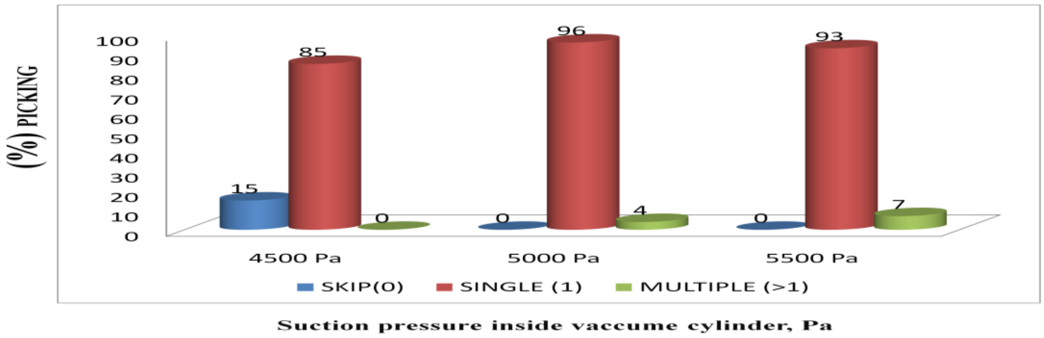

Fig. 7. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for groundnut seed.

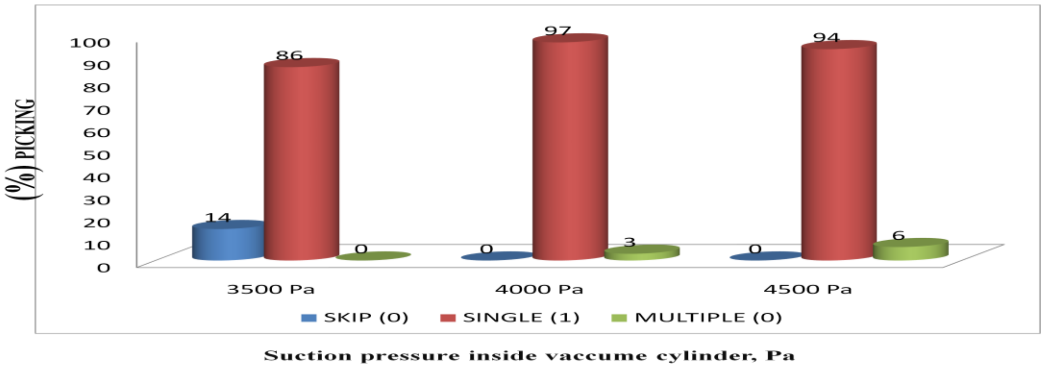

Fig. 8. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for Maize seed

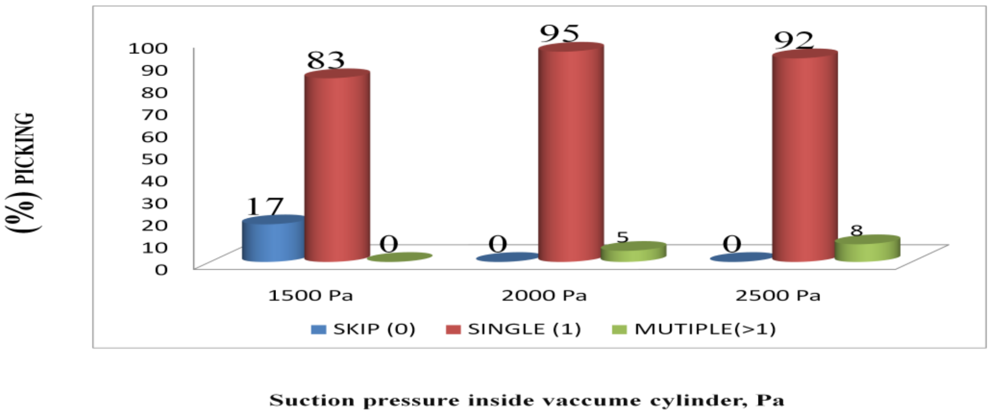

Fig. 9. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for Pigeonpea seed

Metering efficiency of vacuum planter

Metering efficiency of the vacuum planting at different pressure levels and is presented in Table 4.5 it was observed that with the increase in suction pressure inside the vaccume cylinder the metering efficiency also increased from 93.33 to 111.33 percent as pressure increased from 4500 to5500 Pa for groundnut seeds and for maize seeds metering efficiency increased from 90 to 112.22 percent as pressure increased from 3500 to 4500 Pa and for pigeonpea seeds metering efficiency increased from 91.11 to 113.33 percent as pressure increased from 1500 to 2500 Pa.

Table 7. Effect of suction pressure in the vacuum drum on the metering efficiency of metering mechanism, for groundnut maize and pigeonpea seeds

S. No.	Seeds	Suction pressure in vacuum rod, Pa	Metering efficiency of metering mechanism ,(%)
1	Groundnut	**4500**	**93.33**
		5000	**106.67**
		5500	**111.33**
2	Maize	**3500**	**90**
		4000	**108.88**
		4500	**112.22**
3	Pigeonpea	**1500**	**91.11**
		2000	**110**
		2500	**113.33**

Seed: Groundnut

At suction pressure of 5000 Pa and 5500 Pa the metering efficiency was more than 100 percent (106.67 and 111.33). This was because the number of seeds per hill was more than the desired one (1). It is seen from the Table 7 and Fig. 10 that metering efficiency is sensitive to supply suction pressure. Because the increased suction pressure sucked the more number of seeds. Similar findings were reported by(Shearer and Holmes, 1991). The metering efficiency of the planting system was obtained 106.67 percent at suction pressure 5000Pa. While the same pressure gave maximum percent frequency (96 %) for the desired number of seeds (1). Thus it is conclude that the pressure 5000 Pa is sufficient to meter groundnut seed.

Seed: Maize

At suction pressure of 3500, 4000 and 4500 the metering efficiency was more than 100 percent (108.88 and 112.22). This was because the number of seeds per hill was more than the desired one (1). It is seen from the Table 7 and Fig. 11 that metering efficiency is sensitive to supply suction pressure. Because the increased suction pressure sucked the more number of seeds. The metering efficiency of the planting system was obtained 108.88 percent at suction pressure 4000 Pa. While the same pressure gave maximum percent frequency (97 %) for the desired number of seeds (1). Thus it is conclude that the pressure 4000 Pa is sufficient to meter maize seed.

Seed: Pigeonpea

At suction pressure of 1500, 2000 and 2500 the metering efficiency was more than 100 percent (110 and 113.33). This was because the number of seeds per hill was more than the desired one (1). It is seen from the Table 7 and Fig 12 that metering efficiency is sensitive to supply suction pressure. Because the increased suction pressure sucked the more number of seeds. The metering efficiency of the planting system was obtained 110 percent at suction pressure 2000 Pa. While the same pressure gave maximum percent frequency (92 %) for the desired number of seeds (1). Thus it is conclude that the pressure 2000 is sufficient to meter pigeonpea seed.

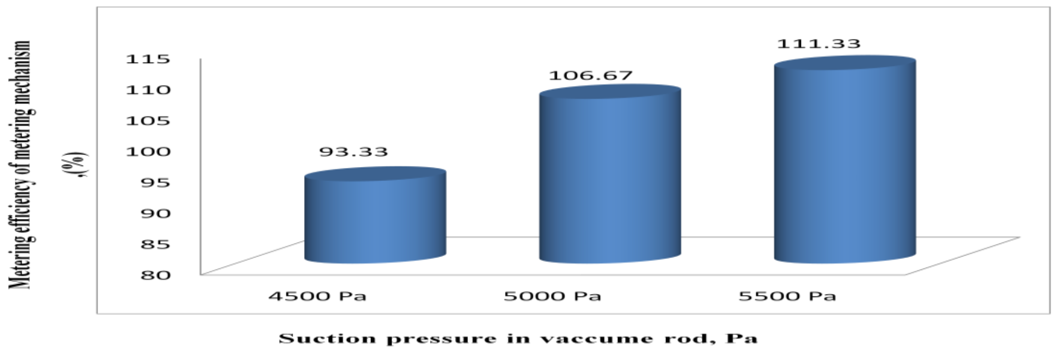

Fig. 10. Effect of suction pressure in the vacuum drum on the metering efficiency of metering mechanism for Groundnut

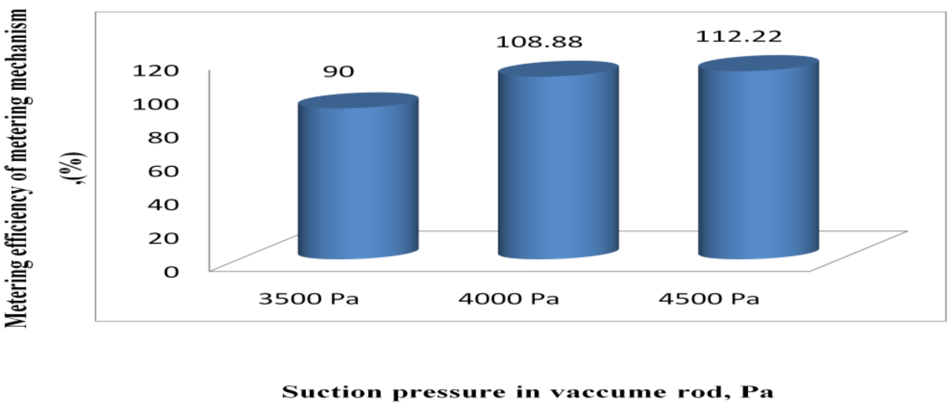

Fig. 11. Effect of suction pressure in the vacuum drum on the metering efficiency of metering mechanism for Maize

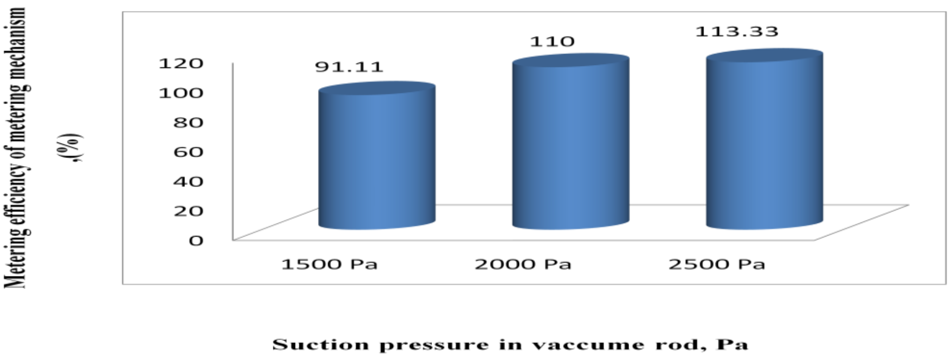

Fig. 12. Effect of suction pressure in the vacuum drum on the metering efficiency of metering mechanism for pigeonpea.

CONCLUSION

1. Suitable planting mechanism attachment enables the implement to perform planting of groundnut, maize and pigeonpea seeds.
2. Metering cylinder mechanism performed well with the metering efficiency of 106.67 % for groundnut , 108.88 % for Maize and 110 % for pigeonpea seed.

REFERENCES

Barut, Zeliha Bereket. Ozmerzi, Aziz, (2004). Effect of Different Operating Parameters on Seed Holding in the Single Seed Metering Unit of a Pneumatic Planter.Turk J Agric For 28 435-441.

Bosoi E.S,: Vernieav, O.V..; Smirnov, 1.1 and Sultan shakh E.G., (1987). Theory, construction and Calculation of Agricultural Machinery. 3rd edition. Oxonian Press Pvt.Ltd. New Delhi, Calcutta. Pp261

Datta, R. K., (1974) Development of some seeders with particulars refrence to pneumatic seed drill. Harvester. 16(1) : 26-29.

Davies M. R., (2009) Some Physical Properties of Groundnut Grains Research Journal of Applied Sciences, Engineering and Technology 1(2): 10-13, 2009 ISSN: 2040-7467

Karayel, D., and Ozmerzi, A., (2002) Effect of tillage methods on sowing uniformity of maize. Canadian Biosystems Engineering, 44: 2.23-2.26.

Kumar Ranjeet, Nandede M. B., Padhee D. and Singh Vardhan Harsh October (2012) Performance evalution of pneumatic planter using pigeonpea seeds Engineering and Technology in India Volume 3, Issue 2, 120-123

Li Yang, Bingxin Yan,Tao Cui, Yiming Yu, Xiantao He, Quanwei Liu, Zhijie Liang, Xiaowei Yin, Dongxing Zhang, (2016) Global overview of research progress and development of precision maize planters Int J Agric & Biol Eng, 9(1): 9—26.

Orozco C. Jonathan design and development of vaccume type multicropo planterwith focus on corn seeding Philippine agricultural mechanization journal vol XVIII No. 1

Wankhade P. Chetan, M. R. Kotwal R. M. A, (2014) review paper on various seed sowing metering devices International journal of pure and applied research in engineering and technology; Volume 2 (9): 429-435

Yazgi Arzu, Degirmencioglu Adnan, Onal Ismet and Bayram, (2010) Emine mathematical modeling and optimization of the performance of a metering unit for precision corn seeding journal of Agricultural Science, 6(2), 107 – 113

Yasir Satti Hassan, Liao Qingxi, Yu Jiajia, & He Dali 16 March, (2012) Design and test of a pneumatic precision metering device for wheat Agric Eng Int: CIGR Journal Vol. 14, No.1.