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RESEARCH ARTICLE

Testing of the pneumatic planter with okra seed under laboratory conditions

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SUMMARY

Seeding of costly vegetable, oil and pulse seeds are highly expensive and labour consuming. In order to get optimum plant stand and damage free precise seeding, the concept of pneumatic planting was developed at various places but could not well adopted by the farmers. It may be due to lack of knowledge about machine adjustment for different seeds and desired seed rates. Various pneumatic planting machines are procured for demonstration and on farm testing at various Agricultural /Government's farms and University farms but not being properly utilized. Therefore, a detailed study was planned for different machine parameters and speed of tractor on the performance of pneumatic planter. Planting of okra and other vegetables crops where row to row as well as plant to plant distance is essential for the seed saving and better crop production. The seeds are sown in line at desired depth with two seeds per hill maintaining the desired spacing between row and plants. In pneumatic planter seed sowing produced more consistent row to row distribution of seeds and a numerical reduction in plant stand variability. Pneumatic planting seed metering concept is based on the suction pressure developed in the seed metering system. The laboratory study on the suction pressure in the pneumatic disc for holding okra seed under positive pressure over the seed metering orifices were carried out. The performance of pneumatic precision planter for okra crop was evaluated on the basis of laboratory conditions. Average weight (50.62 g) of okra seed obtained in third gear of main shaft of first combination of gears was nearly equal to the weight obtained by calibration 50.20 g in 20 revolutions of ground wheel. So, the III gear of main shaft of first combination of gears is most suitable for sowing of okra crop. Precise planting of okra seed by pneumatic planter is feasible. In lab test pneumatic planter for okra seed were found suitable with 4 mm disc hole diameter at 750 rpm engine speed.

Key Words : Testing, Pneumatic planter, Laboratory condition

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It is estimated that India requires 12 days for a production of one quintal of grains where as USA requires only 4 minutes. This remarkable achievement by the USA is accomplished mainly through precision and timely operations using the advanced agricultural machines (Wanjura and Hudspeth, 1968).The traditional methods of sowing are behind country plough, bullock operated or tractor drawn seed cum fertilizer drills leads to uneven seed distribution. In order to complete the planting of costly hybrid seeds, there was a need to design and develop tractor operated modular planting equipment. The bio-scientists were in the need of such a machine for accurate row and seed to seed spacing in experiments all plots. Improved tools and implements facilitate efficient use of inputs insuring timeliness and placing the seeds in proper environments. Establishments of required plant population are one of the agronomic requirements that influence the yield. The main purpose of sowing/planting is to place the seeds at a desired spacing and depth in the seedbed. Broadcasting and sowing the seeds in lines in excess quantities followed by thinning the plants after germination achieve the desired plant population. This process is labour intensive as

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it does not allow the use of proper machines for weeding and intercultural. Besides, costly seeds are wasted thereby increasing the total cost of cultivation. Several factors affect uniformity of crop stand including accuracy of seed metering and placement mechanism of the planters, seed drop accuracy, seed germination and plant survival. Drilling of seed is easier and cheaper than other methods of sowing/planting, but gives random distribution of seeds in the rows. The drilled crop requires thinning of plants desired level of plant population. In planting one or two seeds are dropped in each hill at desired spacing. But there is a possibility of missing of seeds. It is essential to cover large area in stipulated time at higher speeds with uniform seed distribution. Further pneumatic seeding research has led to the development of pneumatic seed metering devices (Guarella *et al*., 1996). This mechanism has the advantage of metering of irregular shaped seed, besides the spherical seeds. Single seeds are released placed in furrows as per the desired plant spacing. Seed spacing uniformity determined in laboratory tests was higher than, or equal to, seed spacing uniformity determined in field tests. This indicated that the laboratory test method may be useful to screen out planters or planter units with poor uniformity of seed metering. Field-testing of planter that performs well in laboratory tests must be conducted to adequately determine the seed spacing uniformity of those planters in the field (Panning, 2002). Precision planter using vacuum for seed pickup and concluded that the vacuum seed pickup planter selected single seeds 77 % of the times, reduced the amount of seed required by 90 % and reduced thinning labour by 45 %. This vacuum seed pickup planter represents a distinct advance over the bulk metering type of planter now in conventional use (Giannni *et al*., 1967).

MATERIAL AND METHODS

Operation of machine:

Pneumatic planting concept is based on suction pressure. An aspirator is used to develop suction pressure in metering chamber inside the pneumatic disc. The drive to the blower is obtained through tractor PTO and through corrugated flat belt and pulley. The blower suction is connected to, the pneumatic discs with help of hosepipes. Air sucked through a rotating plate having various holes radically. A few seeds are allowed to hold till it reaches to the position where the suction pressure is cut off. A groove is provided to connect the joint of release to the atmosphere. The seeds fall due to gravity as soon as the suction pressure is cut off (the suction pressure is increased to the atmospheric pressure). The fall of seed is synchronized with the predetermined seed is lifted under suction, no mechanical damage takes place. The suction pressure created can be varied by changing the engine throttle settings. The engine rpm for which minimum missing and multiple occurred for different crop need to be set before operation of machine. For different crops, the pressure required in the seed chamber is different. Therefore, the rpm of blower to develop required pressure is to be set for the crop being sown. Care is taken during rotation of seed plate; seeds are picked up due to suction created.

Aspirator blower:

A blower is provided to suck the air from the plate chamber and create suction. The blower is operated through a telescopic shaft by the tractor PTO. It has one impeller of diameter and covered by casing. Its dimension is given in the. Table A.

Table A: Description of pneumatic planter

Sr. No.	Component	Material	Dimension, mm	Remarks
1	Main frame	Square bar of angle iron	70 x 70 x 5	For mounting suction blower, seed box, set of sprockets and furrow openers.
2.	Modular unit	No	6	Consists box seed and pressure plate
3.	Seed box with hopper	MS sheet	Capacity of each hoper about 8-10 kg	Separate box and hopper for each furrow for seed
4.	Pressure and seed plate assembly	Aluminum	Thickness: 20	Number of hole on periphery: 16, Hole size different: 2-6 mm
	Diameter		210	
5.	Furrow opener	M.S	600 mm 600-750 mm to 900-1000 mm	Shoe type/inverted ‘T’ type one furrow opener for each modular unit
6	Ground wheel	MS Flat iron	30 x 5	No of sprocket on hub
	No. of pegs: 12	MS Flat iron	30 x 5	: 2
	Diameters:	-	400	Teeth: T_1:20 T_2: 14
7.	Blower casing	MS sheet	5	To create vacuum to suck seed for holding against the hole.
	Rotor impeller	Radial		
	Impeller diameter:	Type: Centrifugal	400	
8.	Corrugated blower hub	MS sheet	35	To increase PTO speed
9.	PTO corrugated pulley	MS sheet	350	PTO speed increase by 10 times

Seed plate:

A 210 mm diameter, 20 mm thick aluminum casting plate is provided for seed metering. The release point is fixed to drop the seed from the lowest most position of the disc. A hole of 25 mm is drilled through an extended pipe to connect the vacuum disc to the aspirator inlet. The support plate provided forms a tube over the slit made on the ear of the disc to increase the vacuum pressure equal to atmosphere. View of seed plate is shown in Fig. A.

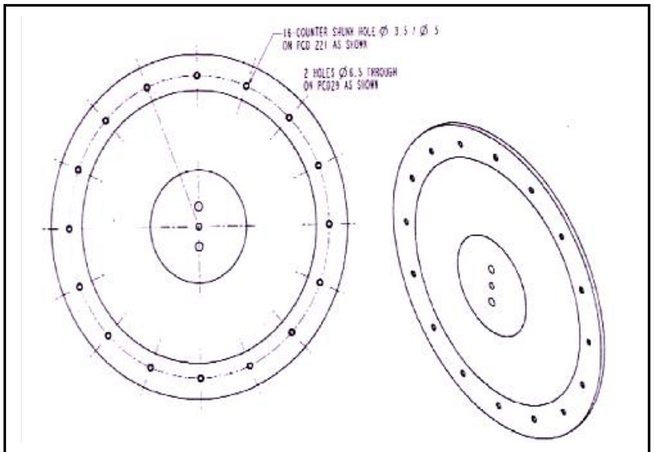

Fig. A: Pneumatic seed plate (All dimensions are in mm)

Sprockets system of pneumatic planter:

There are various sprockets in pneumatic seed planter. The number of teeth in each sprocket is as follows, and given in Table B.

Number of teeth on primary sprockets of main shaft:

In left hand side and right hand side, there are two sprockets aligned in one main shaft.

The number of teeth in small sprocket (S_5): 14 (T_{14}).

The number of teeth in big sprocket (S_6): 20 (T_{20}).

Number of teeth on secondary set of main shaft:

There are five sprockets in secondary set of main shaft. Numbers of teeth are as follows in these sprockets:

– In first sprocket, (S_9): -26 (T_{26})
– In second sprocket, (S_{10}): -22 (T_{22})
– In third sprocket, (S_{11}): - 20 (T_{20})
– In fourth sprocket, (S_{12}): - 16 (T_{16})
– In fifth sprocket, (S_{13}): - 14 (T_{14}).

Idler sprockets for driving seed plates:

There are provided between main shafts and counter shaft. Idler sprockets are to tight/loosening chain and to change power flow.

– Number of teeth in idler sprockets -14 (T_{14}).
– Number of sprockets of C.S -12 (T_{12}).
– Number of teeth in planting plate driving sprocket – 21 (T_{21}).

Power source and transmission system:

The power source to operate the pneumatic planter was a 45 hp MF 241 DI tractor, for centrifugal air blower and during lab test ground wheels was operated manually. The tractor PTO was jointed to the centrifugal blower for operation. The PTO was operated on, varied engine speeds high and low speeds (1.77-0.46). There were different sprockets for different speed of metering plate and sowing seed at predetermined row spacing.

Speed adjustment in pneumatic planter:

The speed adjustment is done by replacing chain of sprocket in different shafts. The main speed is reduced by five sprockets placed in main shaft. This is done on the basis of basic sprocket ratio formula:

$$\frac{N_1}{N_2} = \frac{T_2}{T_1}$$

where N_1 and N_2 represent number of revolutions of first

Table B : Description of sprockets used on power transmission

Sr. No.	Sprocket symbol	No. of teeth	Sr. No	Gear symbol	No. of teeth
1.	S_1	20	14.	S_{14}	12
2.	S_2	14	15.	S_{15}	12
3.	S_3	20	16.	S_{16}	12
4.	S_4	14	17.	S_{17}	12
5.	S_5	14	18.	S_{18}	12
6.	S_6	20	19.	S_{19}	12
7.	S_7	14	20.	S_{20}	21
8.	S_8	20	21.	S_{21}	12
9.	S_9	26	22.	S_{22}	21
10.	S_{10}	22	23.	S_{23}	21
11.	S_{11}	20	24.	S_{24}	21
12.	S_{12}	16	25.	S_{25}	21
13.	S_{13}	14	-	S_{26}	-

and second sprockets, while T_1 and T_2 represent number of teeth in first and second sprockets, respectively. It is obvious that speed of sprockets inversely proportional to the number of teeth represent in sprockets. Hence, sprockets having more teeth will have less speed. As the teeth of sprockets in main shaft of planter increases the corresponding speed in metering mechanism of sprockets will decrease hence there is decrease in revolutions of metering plate and thereby the amount of seed decreases in the collection samples.

Precision planting mechanism of pneumatic planter:

As the PTO of the tractor rotates, the aspirator air blower also rotates, thus creating high suction pressure in the metering chamber inside the pneumatic disc. The high suction pressure is carried by the six tubes. These tubes connect the aspirator air blower and the pneumatic disc together. These tubes which are used to carry such high suction pressure should be leak proof, so that pressure does not leak through any portion of these tubes. Hence, these tubes normally made of H.D.P.E.The seed plate is made of aluminum. Grooves are created along the periphery of this speed metering plate. In these grooves seeds are accumulated held against vacuumed. Seeds are allowed to hold till it reaches to the position where the suction pressure is cut off. The seeds fall due to gravity as soon as the suction pressure is cut off (the suction pressure increases to the atmospheric pressure).The machine has provision to change speed of seed plate by having different sets of sprockets for giving drive to the seed plate shaft. For the different crops, different seed plates are used having the desired number of holes. The extract planting of single seed is obtained since the seed is lifted under suction no mechanical damage occurs. The machine requires high quality of seeds for best performance. The machine is equipped with chain and sprocket mechanism, which transmits power from the ground drive wheel to the seed plate. A blower is used to generate the necessary suction pressure for operation of planter. The drive to the blower is obtained from tractor PTO through flat corrugated belt (ribs) and pulley shaft.

Laboratory test procedure:

The pneumatic planter was jacked up to height of about 6-7 cm above the ground level. Then the rated amount of okra seed was put into the individual hopper in the pneumatic planter. Then the poly-ethylene bags were put under the furrow opener for seed collection. The tractor PTO was connected to the aspirator air blower lying on the main frame of the planter. The sprocket combination at left and right hand side of ground wheel was set and the main driving shaft of sprocket was laid on the first sprocket. Then the ground wheel was rotated for, 20 revolutions with a, constant speed, manually. The seeds were collected in poly- ethylene bags underlying the furrow openers (Plate A). The seed quantity in the collection seeds were measured individually for each six furrow openers. Average weight of these six furrow openers was taken as average seed weight for 1st sprocket of main driving shaft for first combination of sprockets, giving speed ratio1.76. Similar procedure was adopted for the different set of sprockets of main driving shaft at same setting of side sprockets of ground wheel. After this the reading for the first combination of sprockets was completed. Then side sprockets combination of ground wheel was changed for second combination of sprockets and again the observations were taken at different sprockets of main driving shaft as earlier. Then the similar methodology was adopted for next set of reading. For speed ratio adjustment of sprockets, there is lever given the seed hopper which loosens the idler sprocket and by this the sprocket of main driving shaft were easily changed.

Plate A : View of the calibration of the pneumatic planter

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Speed ratio under different sprocket combinations:

As it is clear from the layout plan of power transmission system of the tractor pneumatic planter have provision to change the various speed ratios from ground wheel to the seed disc by shifting respective chain and sprockets. The sprockets mounted on the ground wheel, main shaft, counter shaft 1-2, and seed disc shafts have been numbered from S_1 to S_{26}. There could be various speed ratios between ground wheels to the seed disc but due to difficulty in shifting only four combinations of power transmission was studied with different seeds. The power flow in the first combination in LHS is shown as $S_1 \rightarrow S_5$ / $S_9 \rightarrow S_{14}/S_{19} \rightarrow S_{20}$ giving SR 1.77 and similarly from the RHS power flow $S_3 \rightarrow S_{7/}S_9 \rightarrow S_{14}/S_{21} \rightarrow S_{26}$ giving 1.77 SR.

The Power flow in the second combination in LHS is shown as $S_1 \rightarrow S_5$ / $S_{10} \rightarrow S_{14/}S_{19} \rightarrow S_{20}$ giving SR 1.50 and similarly from the RHS power flow $S_3 \rightarrow S_7/S_9 \rightarrow S_{14}/S_{21} \rightarrow S_{26}$ giving 1.50. The Power flow in the third combination in LHS is shown as $S_2 \rightarrow S_6$ / $S_9 \rightarrow S_{14}/S_{19} \rightarrow$SR S_{20} giving SR 0.87 and similarly from the RHS power flow $S_4 \rightarrow S_8/S_9 \rightarrow S_{14}/S_{21} \rightarrow S_{26}$ giving 0.87 SR. The Power flow in the first combination in LHS is shown as $S_2 \rightarrow S_6$ / $S_{10} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$ giving SR 0.73 and similarly from the RHS power flow $S_4 \rightarrow S_8/S_{10} \rightarrow S_{14}/S_{21} \rightarrow S_{26}$ giving 0.73 SR (Table 1).

Seed quantity obtained from different combination of sprockets :

Average weight of seed obtained from different combination of sprockets is given in Table 2. For lab testing, the seed quantity of okra crop required for twenty revolutions of ground wheel has been calculated theoretically and found 50.24 g.

Table 1 : GW to Disc Speed ratio under different gear combinations

Gear combination	Power flow through sprockets	Speed ratio
I.	$S_1 \rightarrow S_5 / S_9 \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	1.77
II.	$S_1 \rightarrow S_5 / S_{10} \rightarrow S_{14}/ S_{19} \rightarrow S_{20}$	1.50
III.	$S_1 \rightarrow S_5/ S_{11} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	1.36
IV.	$S_1 \rightarrow S_5/ S_{12} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	1.09
V.	$S_1 \rightarrow S_5 / S_{13} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	0.95
VI.	$S_1 \rightarrow S_6/ S_9 \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	1.24
VII.	$S_1 \rightarrow S_6/ S_{10} \rightarrow S_{14}/ S_{19} \rightarrow S_{20}$	1.04
VIII.	$S_1 \rightarrow S_6/ S_{11} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	0.95
IX.	$S_1 \rightarrow S_6/ S_{12} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	0.76
X.	$S_1 \rightarrow S_6 / S_{13} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	0.67
XI.	$S_2 \rightarrow S_6 / S_9 \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	0.87
XII.	$S_2 \rightarrow S_6/ S_{10} \rightarrow S_{14}/ S_{19} \rightarrow S_{20}$	0.73
XIII.	$S_2 \rightarrow S_6/ S_{11} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	0.66
XIV.	$S_2 \rightarrow S_6/ S_{12} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	0.53
XV.	$S_2 \rightarrow S_6/ S_{13} \rightarrow S_{14}/S_{19} \rightarrow S_{20}$	0.46

First combination of sprockets :

Table 2 revealed that the wt. of seed of okra crop theoretically recommended for pneumatic planter as obtained above is found in third sprockets combination. It can be observe that for first combination of sprockets, average wt. of seed obtained in I, II,IV and V sprocket of main driving shaft is about 68.36 g, 46.61 g and 42.71 g, respectively (Fig. 3) which are not as calculated in calibration of planter while it should be 50.24 g. So I, II, IV and V sprockets of main driving shaft should be range. Average weight of seed obtained in III sprocket is about 50.62 g which is nearly equal to the weight obtained in calibration. Hence, we can conclude that seed rate obtained in III sprocket is obtained as recommended by calibration. So the III sprocket of main shaft of I combination of sprockets is found good for okra crop in pneumatic planter.

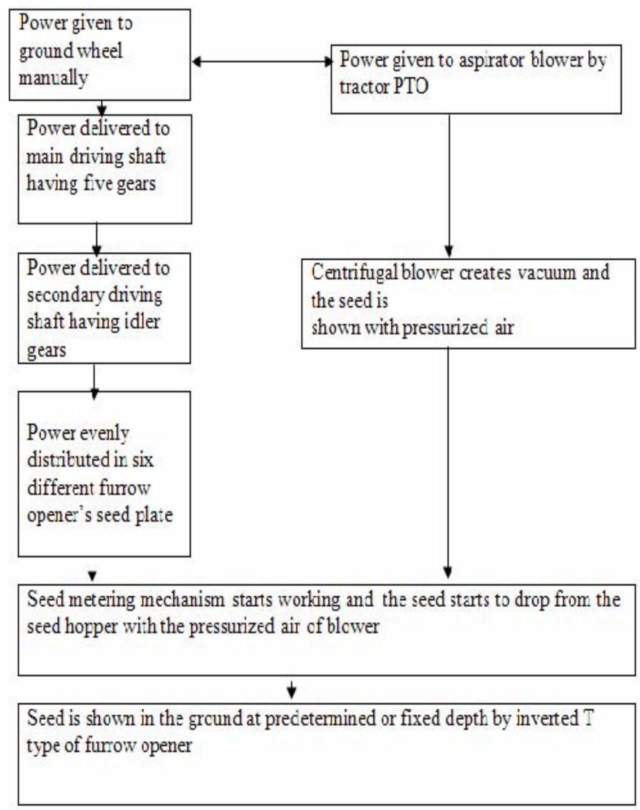

Fig. 1 : Power flow diagram of pneumatic planter in lab

Second combination of sprockets:

Average weight of seed obtained in I, II, III, IV and V sprockets is about 64.10 g, 60.96 g, 46.39 g, 40.30 g and 34.33 g, respectively (Fig. 3) which are not equal as theoretically calculated seed of okra crop. Hence we found that seed rate obtained in this combination of sprockets of main diving shaft is not equal as recommended seed rate. So

Table 2 : Average seed weight (g) of okra seed, obtained from different combination of sprockets in 20 revolution of GW

Sprocket combination	Seed weight, g				
	First gear	Second gear	Third gear	Fourth gear	Fifth gear
I.	68.36	68.36	50.62	46.61	42.71
II.	64.10	68.36	46.39	40.30	34.33
III.	59.03	68.36	41.35	35.63	28.60
IV.	47.63	68.36	37.89	32.84	26.81

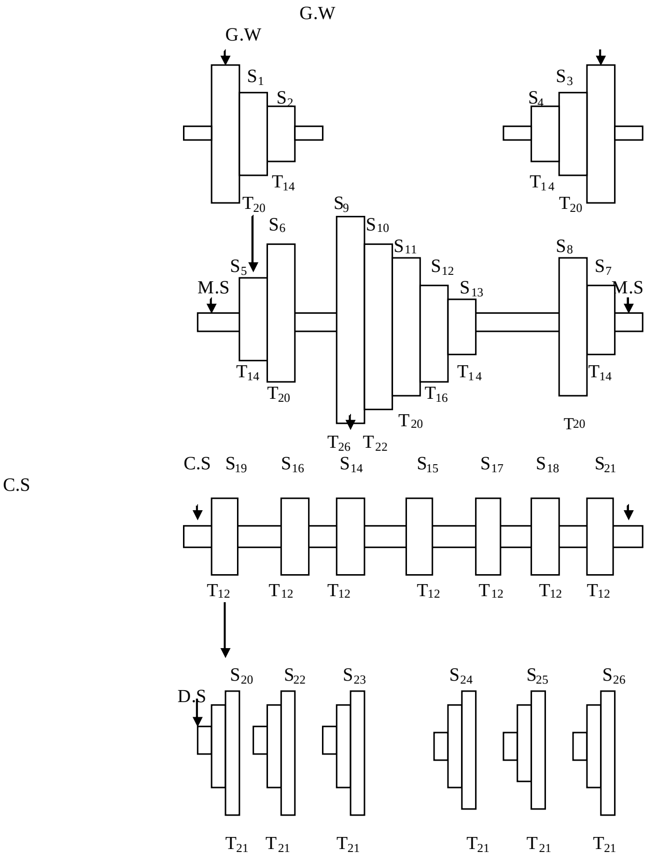

Fig. 2: **Layout plan of power transmission system in the pneumatic planter for first combination of sprockets S_1-S_{26}: Sprockets Number, G.W: Ground wheel, C.S: Counter shaft, M.S: Main shaft, D.S: Disc Shaft $T_{1\text{-}21}$: Indicates number of teeth on the sprockets**

this combination of sprockets is not good for okra crop in pneumatic planter.

Third combination of sprockets:

Average weight of seed obtained in I, II, III, IV, and V sprocket is about 59.03 g, 48.35 g, 41.35 g, 35.63 g and 28.60 g, respectively (Fig. 3) . Which are not equal as calculated in calibration of planter, while it should be 50.24 g. Hence, we can conclude that seed rate obtained in all sprockets of main driving shaft is not coming as recommended. So this combination of sprockets is not good for okra crop in pneumatic planter.

Fourth combination of sprockets :

Average weight of seed obtained in I ,II ,III , IV, and V sprocket is about 47.63 g, 44.62 g,37.89 g, 32.84 g and 26.81 g, respectively (Fig. 3) which are not as calculated in calibration of planter while it should be 50.24 g.

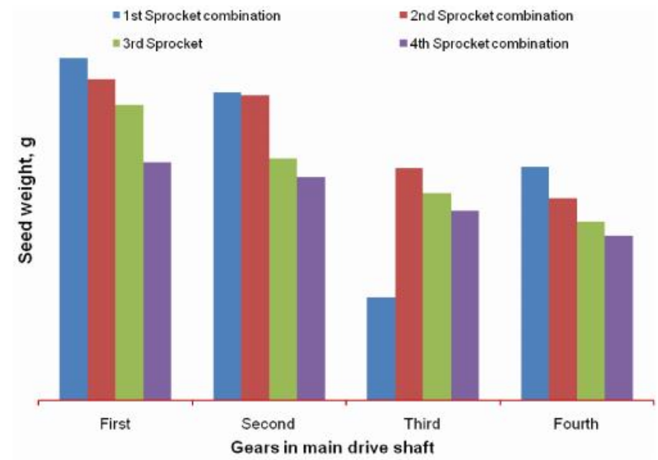

Fig. 3 : **Seed weight of Okra crop obtained in different combination of gears**

Hence, we observed that seed rate obtained in all sprockets of main driving is not obtained as recommended seed rate. So, this combination of sprockets is not good for okra crop in pneumatic planter.

Conclusion:

The performance of pneumatic precision planter for okra crop was evaluated on the basis of laboratory conditions. Average weight (50.62 g) of okra seed obtained in third gear of main shaft of first combination of gears was nearly equal to the weight obtained by calibration 50.20 gram in 20 revolutions of ground wheel. So, the III gear of main shaft of first combination of gears is most suitable for sowing of okra crop. Precise planting of okra seed by pneumatic planter is feasible. In lab test pneumatic planter for okra seed were found suitable with 4 mm disc hole diameter at 750 rpm engine speed.

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