



E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(5): 569-572
Received: 21-02-2026
Accepted: 26-03-2026

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International Journal of Research in Agronomy

Assessment of germination behaviour and seed spacing accuracy of soybean, pigeonpea and chickpea in intercropping planter system

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i5h.5568>

Abstract

The present study was conducted to assess the germination behaviour and seed spacing accuracy of soybean, pigeonpea and chickpea in an intercropping planter system. Germination tests were carried out under laboratory conditions using standard procedures, while seed spacing performance of the intercrop planter was evaluated using different gear ratios. The results of germination tests indicated satisfactory germination performance of all selected crops. Chickpea recorded the highest mean germination percentage (85%), followed by pigeonpea (83.75%) and soybean (76.50%). The coefficient of variation for normal seedlings was found to be comparatively low, indicating uniform germination behaviour among the tested seed samples. Theoretical seed spacing analysis showed that different gear combinations significantly affected seed spacing. Gear G1 (19 teeth) produced a theoretical seed spacing of 8.94 cm for soybean/chickpea at a speed ratio of 1.35:1, whereas for pigeonpea, gear G2 (30 teeth), G3 (35 teeth) and G4 (40 teeth) produced seed spacing of 24.87 cm, 26.90 cm and 30.31 cm, respectively. The study revealed that the intercrop planter was capable of maintaining desired seed spacing and uniform seed placement for different crops through suitable gear selection. Overall, the developed intercrop planter system performed satisfactorily for precise sowing and crop establishment under intercropping conditions and may be effectively utilized for soybean, pigeonpea and chickpea.

Keywords: Seed spacing, Intercrop planter, germination, dead seeds, gear teeth

Introduction

The intercropping is a multiple cropping practice involving growing two or more crops and have opened up new horizons to augment pulse crop productivity per unit area per unit time. The main purpose of intercropping is to produce a greater yield on a given piece of land by making use of resources that would not be utilized by a single crop efficiently. Intercropping might positively impact on the future food problems in developing countries.

In India, soybean is grown in an area of 10.84 million hectares with an annual production of about 14.48 million tonnes and productivity of 1354 kg/ha. In Chhattisgarh Soybean occupies 121.42 thousand ha area with a yield of 1050 kg/ha (Anonymous, 2016) ^[1]. In Chhattisgarh, maximum area and production of soybean come under Rajnandgoan followed by Kabirdham, Durg, Bemetara, and Mungeli districts. India accounts for 90% of the world's pigeonpea growing area and 85% of the world's production. It is grown in an area of 3.88 Mha with the production of 3.17MT and productivity of 849 kg/ha.

Chhattisgarh state has a good agro-ecological situation for chickpea production. It is grown over an area of 0.2 million hectares with an annual production of 242.7 thousand tonnes and an average productivity of 1035 kg/ha (Anonymous, 2016) ^[1]. Intercropping of pigeon pea with soybean has proved successful without any adverse effect on pigeonpea (Ahlawat *et al.* 1982, Prasad *et al.* 1985, Maurya, 2000 and Maurya and Rathi, 2000) ^[4, 7, 5, 6].

Commercial sowing equipment such as seed drill and seed-cum-fertilizer drill operated by animal, power tiller and tractor which meter high and non uniform seed rate, causing thinning as an extra operation. Pandey (2009) ^[2] reported that the planter provide desired plant population with uniform plant spacing and depth of operation, which results in uniform crop stand and hence, reduces the cost of cultivation by eliminating thinning operation as well as saves seed and

fertilizer. Jiyuan (2025) resulted critical insights for optimizing the nutritional and functional properties of chickpeas via sprouting and established a scientific basis for the development of functional foods from germinated chickpeas, underscoring their potential to support dietary health and wellness. The seed rate in sowing with the seed drill is quite high and thinning becomes essential to maintain the optimum plant stand and to ensure each plant get the desired quantity of sunlight, water and nutrients. This could be achieved by planting of different sizes of seeds with the help of appropriate planters (Kepner *et al.* 1987) [9].

Methodology

The study was conducted to assess the germination behaviour and seed spacing accuracy of soybean, pigeon pea and chickpea in an intercropping planter system. The experiment included laboratory germination testing of seeds and evaluation of seed spacing performance of the developed intercrop planter under field/laboratory conditions.

Selection of Crops and Seed Samples

Healthy and graded seeds of soybean, pigeon pea and chickpea were selected for the study. The physical properties of seeds such as size, shape and seed dimensions were considered for suitability in the seed metering mechanism of the intercrop planter (Table 01).

Table 1: Selected crop for experiment

Particular	Soybean	Pigeonpea	Chickpea
Variety	JS-9752	Rajeev Lochan	JG130
Day of crop (days)	95-100	180-190	110-115
Avg Productivity (q/ha)	20-25	18-20	15-20

Germination Test

The germination test of soybean, pigeon pea and chickpea seeds was conducted using the standard germination test procedure. Random seed samples from each crop were taken and tested under controlled laboratory conditions.

- One hundred seeds from each crop were used for germination testing.
- Seeds were placed on moist germination paper/tray and maintained at suitable moisture and temperature conditions.
- Observations on germination percentage were recorded after the recommended germination period for each crop.
- Normal seedlings were counted and germination percentage was calculated using standard procedures.

The germination percentage was calculated as:

$$\text{Germination Percentage} = \frac{\text{Number of Normal Seedlings} \times 100}{\text{Total Number of Seeds Tested}}$$

Development of Intercrop Planter

The intercrop planter was designed and developed for sowing soybean, pigeon pea and chickpea under intercropping conditions. The design of the planter was based on seed size, crop spacing requirement and operational suitability for intercrop planting. Proper consideration was given to row spacing, seed metering mechanism and frame arrangement to facilitate simultaneous sowing of different crops.

Characteristics of soybean variety

JS-9752 is most common variety in Chhattisgarh which matures in 95-100 days having medium plant height of 60 to 80 cm. This

variety contains 40% protein and 20% oil. The average test weight was 9 to 10g per 100 seed. This variety has prolonged germination capacity. This variety is resistance to yellow vein mosaic, root rot, bacterial spot and diseases. This variety can also be grown in water logged areas and yield potential of 25 to 30q/ha.

Characteristics of pigeonpea variety

Rajive Lochan is the variety developed in IGKV which mature at 180-190 days and its yield is 18-20q/ha.

Characteristics of chickpea variety

Chickpea (*Cicerarietinum* L.) variety 'JG-130' (Jawahar Gram-130) was grown as test crop. It was released from JNKVV, Jabalpur in 2002. Its parentage is (PG 5 × Narsingpur bold) × JG-74. It is a bold seeded variety and having brown seed colors. The crop duration is about 110-115 days and having yield potential 15-20 q/ha.

Agronomical practices

Suitable agronomical condition and practices for higher production in intercropping practices of soybean, pigeonpea and chickpea are given at Table 2.

Table 2: Agronomical parameter for intercropping cropping system

Parameters	Soybean	Pigeonpea	Chickpea
Sowing time	June last week	June last week	October
Temperature (°C)	25-30	26 – 30	24-30
pH	6.0 - 6.8.	5-7	5.5-7
Seed rate (kg/ha)	70-80	12-15	60
Plant density(per sq m)	35-40		25-30
Spacing {row x plant (cm)}	45-60 x15-20	50-60 x 15-20	30-45 x10-12
Depth of sowing (cm)	3-5	5-8	3-5
Productivity (q/ha)	2-15	15-20	20-25

Results and Discussion

Germination Test for Soybean, Pigeonpea and Chickpea

Germination test of soybean

Soybean seeds were kept in wetted bottling crop paper for one week at 25-30 °C to determine the germination percentage. Normal germination percentage was found to be 76.5% whereas 17.75 and 5.5% was observed abnormal and dead respectively as shown in Table 3.

Germination test of pigeonpea

The normal germination was observed to be 83.75% whereas 11.5% was abnormal and 5% seed were dead as shown in Table 4.

Germination test of chickpea

The average germination percentage was found to be 85% are normal for proper seed germination while 9.5% was abnormal and 5.5% seeds were dead as shown in Table 5.

Table 3: Germination test of soybean

S. No.	Normal seed	Abnormal	Dead
Mean ($\bar{x}$)	76.50	17.75	5.5
SD	2.63	0.95	1.73
CV at 5%	3.42	5.39	31.49

Table 4: Germination test of pigeonpea

S. No.	Normal seed	Abnormal	Dead
Avg	83.75	11.25	5
SD	2.5	0.957	2.16
CV at 5%	2.98	8.51	43.20

Table 5: Germination test of chickpea

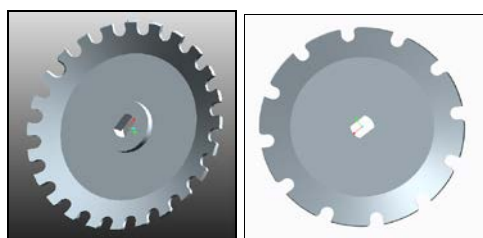
S. No.	Normal seed	Abnormal	Dead
Mean ($\bar{x}$)	85	9.5	5.5
SD	1.41	1.29	0.57
CV at 5%	1.66	13.58	10.49

Seed Spacing Accuracy for Intercropping

The existing multicrop planter was evaluated for sowing soybean and pigeonpea under intercropping conditions. It was observed that the planter was unable to maintain the recommended seed-to-seed and row-to-row spacing of soybean and pigeonpea accurately. In addition, the spacing uniformity of pigeonpea seeds was not satisfactory during sowing operation. To overcome these limitations, an intercrop planter system was assessed for maintaining proper seed spacing and placement accuracy for soybean, pigeonpea and chickpea. The study also included evaluation of germination behaviour of the selected crops under recommended sowing conditions. The germination test for soybean, pigeonpea and chickpea was conducted under laboratory conditions using standard germination procedures. Seed spacing accuracy of the intercrop planter was evaluated by measuring actual seed-to-seed spacing and comparing it with recommended spacing for each crop. There was following parameter were considered:

Metering Plate

There was two inclined metering plate (24 cell and 12 cell) used for soybean, chickpea and pigeonpea. The metering plate that having 24 cell was used to meter the soybean and chickpea at closer distance about 5-10 cm. By using the same metering plate for sowing of pigeonpea higher seed rate obtained and optimum seed to seed spacing 30-35 cm was not maintained. That's why to achieve the same 24 cell was converted to 12 cell by suitable modification in pigeonpea planter Fig.1.

**Fig 1:** Metering plate of 24 cell and 12 cell of inclined plate

Gear Teeth

There were three different gear teeth 30, 35, and 40 used with 12 cell inclined plate to analyze the optimum seed rate and seed spacing for pigeonpea. It was found that 40 gear teeth with 12 cell inclined plate was found suitable for desired seed spacing of 30 cm for pigeonpea in case of pigeonpea planter. 19 gear teeth sprocket were used for soybean and chickpea for dropping closer distance Fig.2.

**Fig 2:** 30, 35 and 40 number of gear teeth for pigeonpea metering

Speed ratio

Speed ratio from drive wheel shaft to metering shaft = (No. of teeth on metering shaft (T_M)/ No. of teeth on drive wheel shaft (T_D),

$$\frac{N_D}{N_M} = \frac{T_M}{T_D} \quad \dots (4.2)$$

Speed ratio for soybean and chickpea

$$\text{Speed ratio for gear 1 (19 teeth)} = \frac{19}{14} = 1.35$$

Initially number of teeth in the seed metering sprocket was 19 in gear G1 and the number of teeth in ground wheel sprocket was 14 so that the speed ratio was 1.35: 1.

Speed ratio for pigeonpea

Three gear teeth 30, 35 and 40 teeth of gear were used in pigeonpea planter for maintain plant to plant spacing of pigeonpea with 19 teeth of gear in ground wheel shaft to metering plateas.

$$\text{Speed ratio for gear 2 (30 teeth)} = \frac{30}{19} = 1.57:1$$

$$\text{Speed ratio for gear 3 (35 teeth)} = \frac{35}{19} = 1.84:1$$

$$\text{Speed ratio for gear 4 (40 teeth)} = \frac{40}{19} = 2.10:1$$

Seed spacing

The theoretical spacing between seed dropped by planter was calculating with the help of the circumference of the ground wheel and the no. of orifice in seed metering plate.

$$\text{Distance covered by the ground wheel in one revolution} = \pi \times D \\ = \pi \times 42 \text{ cm} = 131.94 \text{ cm} = 1.32 \text{ m}$$

$$\text{Length covered by the ground wheel in 20 revolution} = 3.14 \times 42 \text{ cm} \times 20$$

$$= 2637 \text{ cm} = 26.37 \text{ m}$$

$$\text{Area covered by the ground wheel in 20 revolution} = 26.37 \times 3 \text{ m} \\ = 79.2 \text{ m}^2,$$

In seed metering plate (inclined plate) for soybean and chickpea = 24 no of orifices

For pigeonpea = 12 no of orifices

Spacing between two consequently seed dropped by planter in different gear teeth.

Seed spacing of soybean and chickpea

When ground wheel rotate 20 revolution then the 12 time and 6 orifices passes of the seed metering plate of soybean and chickpea during rotation of ground wheel

$$\text{Total no of orifices for soybean and chickpea} = 24 \times 12 + 6 \\ = 288 + 6 = 294$$

$$\text{Spacing between seeds} = \frac{2637}{294} = 8.94 \text{ cm}$$



Fig 3: Seed spacing of soybean and chickpea

Seed spacing of pigeonpea

When ground wheel rotate 20 revolutions the metering plate of 12 cell rotate 7 revolution and 3 cell passes during rotation of ground wheel Fig.3.

Total no of orifices for pigeonpea = $12 \times 7 + 3 = 87$

Then space in gear 40 teeth for pigeonpea

$$= \frac{2637}{87} = 30.31 \text{ cm}$$

In gear 2 (35 teeth) the 20 revolution of ground wheel rotate the 8 revolution of metering plate and 2 orifice passage
Total no of orifices for pigeonpea = $12 \times 8 + 2 = 98$

Then spacing of seed in gear 35 teeth for pigeonpea

$$= \frac{2637}{98} = 26.90 \text{ cm}$$

In gear 2 (30 teeth) the 20 revolution of ground wheel rotate the 8 revolution of metering plate and 10 orifice passage

Total no of orifices for pigeonpea = $12 \times 8 + 10 = 106$

Then spacing of seed in gear 30 teeth for pigeonpea

$$= \frac{2637}{102} = 24.87 \text{ cm}$$

Desired seed spacing soybean were found to be 8.94 cm at 19 gear teeth whereas for pigeonpea it was observed as 30.31 cm at 40 gear teeth with respect to different gear ratio as shown in Table 5.

Table 5: Theoretical seed spacing and seed rate at different gear ratio

S. No.	Types of gear	crops	Speed ratio	Theoretical seed spacing, cm
1	G1 (19 teeth)	Soybean/chickpea	1.35:1	8.94
2	G2 (30 teeth)	Pigeonpea	1.57:1	24.87
3	G3 (35 teeth)	Pigeonpea	1.84:1	26.90
4	G4 (40 teeth)	Pigeonpea	2.10:1	30.31

Summary and Conclusion

The germination behaviour and seed spacing accuracy of soybean, pigeonpea and chickpea were evaluated under the intercropping planter system. Germination tests revealed that all selected crops exhibited satisfactory germination performance suitable for sowing under intercropping conditions.

Among the tested crops, chickpea recorded the highest mean germination percentage (85%), followed by pigeonpea (83.75%) and soybean (76.50%). The coefficient of variation (CV) for normal seedlings was comparatively low in all crops, indicating uniform germination behaviour. However, higher variation was observed in dead seeds of soybean and pigeonpea compared to chickpea.

Theoretical seed spacing analysis of the intercrop planter indicated that different gear combinations significantly influenced seed spacing. For soybean/chickpea, gear G1 (19 teeth) provided a theoretical seed spacing of 8.94 cm at a speed ratio of 1.35:1. In pigeonpea, seed spacing increased with increase in gear size and speed ratio. Gear G2 (30 teeth), G3 (35 teeth) and G4 (40 teeth) produced theoretical seed spacing of 24.87 cm, 26.90 cm and 30.31 cm, respectively.

The results indicated that the intercrop planter was capable of maintaining desired seed spacing for different crops by suitable selection of gear ratios. The planter also showed satisfactory performance in achieving uniform seed placement and proper crop spacing under intercropping conditions.

Overall, the study concluded that the intercrop planter system was effective for sowing soybean, pigeonpea and chickpea with satisfactory germination behaviour and improved seed spacing accuracy. The developed system can be utilized for precise intercropping operations and efficient crop establishment under field conditions.

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