



Physical Properties of Soybean, Pigeonpea and Chickpea Seeds

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ABSTRACT

Physical properties namely, length, width, sphericity, seed weight, angle of repose and bulk density of soybean, pigeonpea and chickpea seeds were evaluated as design parameters for a planter. There was a specific variety was selected and 20 seeds were taken randomly for the study which most popular in Chhattisgarh for measuring the physical property for designing the planter. The results of this research can be used for designing and adjustment of agricultural machinery of these varieties. Bulk density, moisture content and angle of repose which are major affect the drooping of seeds through metering plate.

Keywords: length width, sphericity, bulk density, angle of repose

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INTRODUCTION

Physical properties are important in the design of appropriate machines for harvesting, processing, transporting, packaging and storage of soybean, pigeonpea and chickpea. Bhatia *et al.* [1] found that the effective planting, handling, processing and storage of legumes is largely dependent on the knowledge of the engineering properties of the seed, which will in turn aid in better design and fabrication of machines for different stages of their production and processing. The general objective of this study is to provide data on some moisture dependent mechanical properties of pigeon pea necessary for the design of appropriate processing methods and machines. Seed flow through a planter/ seed drill is dependent on size, shape, sphericity, density and angle of repose of seeds. In addition, the impact of seeds on the internal components

of the planter is influenced by the coefficient of restitution of seeds on various impinging

Pigeon pea (*Cajanus cajan* (L.) millsp.) is a multipurpose leguminous crop that can provide food fuel wood and fodder for the small-scale farmer in subsistence agriculture and is widely cultivated in India.

In India, Soybean is grown in an area of 10.84 million hectare with an annual production of about 14.48 million tones and productivity of 1354 kg/ha. In Chhattisgarh Soybean occupies 121.42 thousand ha area with a yield of 1050 kg/ha [2]. In Chhattisgarh, maximum area and production of soybean comes under Rajnandgoan followed by Kabirdham, Durg, Bemettara, Mungeli and Rajnandgaon districts. India accounts for 90% of world's pigeonpea growing area and 85% of world's production. It is grown an area of 3.88 Mha with the production of 3.17 MT and productivity of 849 kg/ha. In Chhattisgarh it occupies an area of 134.43 thousand ha with production of pigeonpea 90.06 thousand ton and productivity of 670 kg/ha (Anonymous, 2014). Chickpea is one of the most important pulse crop cultivated throughout the world. India is the largest producer and consumer of chickpea in the world. There are two major varieties of Chana-Desi and Kabuli. Around 80% of the chickpea produced worldwide is of Desi type and the rest is of Kabuli variety. Chickpea ranks first in area cultivated in India, grown over an area of 8.25 million hectare with production of 7.34 million tones with average productivity of 889 kg/ha [In during [3]. Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Karnataka are the major chickpea producing states sharing over 95% area. Chhattisgarh state has good agro-ecological situation for chickpea production. It is grown over an area of 0.2 Million hectare with an annual production of 242.7 thousand tonnes and an average productivity of 1035 kg/ha during [2]. The general objective of

this study is to provide data on some moisture dependent mechanical properties of pigeon pea necessary for the design of appropriate processing methods and machines.

MATERIALS AND METHODS

Quality of seeds:

The quality and variability of seed are important factors which affects germination. The seed of popular varieties of wheat and soybean are selected for experiment. Physical properties are measured the variety of soybean JS-9752- which is most common variety in Chhattisgarh which matures at 95-100 days having medium plant height 60 to 80 cm. This variety contains 40% protein and 20% oil. The average test weight is 9 to 10g per 100 seed. This variety has prolong germination capacity. This variety resistance to yellow vein mosaic, root rot, bacterial spot and diseases. This variety can also be grown in water logged areas and yield potential 25 to 30q/ha. Rajive Lochan is the variety of Pigeonpea and developed in IGKV which mature at 180-190 days and its yield potential of this variety is 18-20q/ha. Chickpea (*Cicer arietinum* 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⁻¹. All the crop taken for experiment for measuring physical properties for planter. There are following parameter were measured given below by adopting standardized procedure.

Average length (L), width (W) and thickness (T)

The size of the seed was specified by length (L), width (W) and thickness (T) for all seeds and the axial and lateral dimension of the seeds was measured by using vernier caliper (least count 0.01). Twenty seeds were selected randomly for the dimension [4].

$$L = \frac{\sum_{i=1}^n L}{n}$$

$$W = \frac{\sum_{i=1}^n W}{n}$$

$$T = \frac{\sum_{i=1}^n T}{n}$$

Where,

L = largest intercept (length), mm;

W = width, mm; and

Geometric mean diameter (D_p)

The geometric mean diameter (D_p) was calculated by using the following relationship [5].

$$D_p = (LWT)^{1/3}$$

Where,

L = largest intercept (length), mm;

W = width, mm;

T = thickness, mm.

Sphericity (φ)

Sphericity defines the ratio of the diameter of a sphere of the same volume as that of the particle and the diameter of the smallest circumscribing sphere or generally the largest diameter of the particle [6]. This parameter shows the shape character of soybean, pigeonpea and chickpea seeds relative to the sphere having the same volume.

$$\text{Sphericity} = \frac{\text{Volume of the particle}}{\text{Volume of circumscribed sphere}} = \frac{(LWT)^{1/3}}{L}$$

Where,

L = largest intercept (length), mm;

W = width, mm;

T = thickness, mm.

Mass of soybean, pigeonpea and chickpea seeds

To obtained the mass, 100 randomly selected soybean, pigeonpea and chickpea seeds were weighed by using electronic balance with a least count up to 0.001g as shown in Fig. 1 and Fig 2.

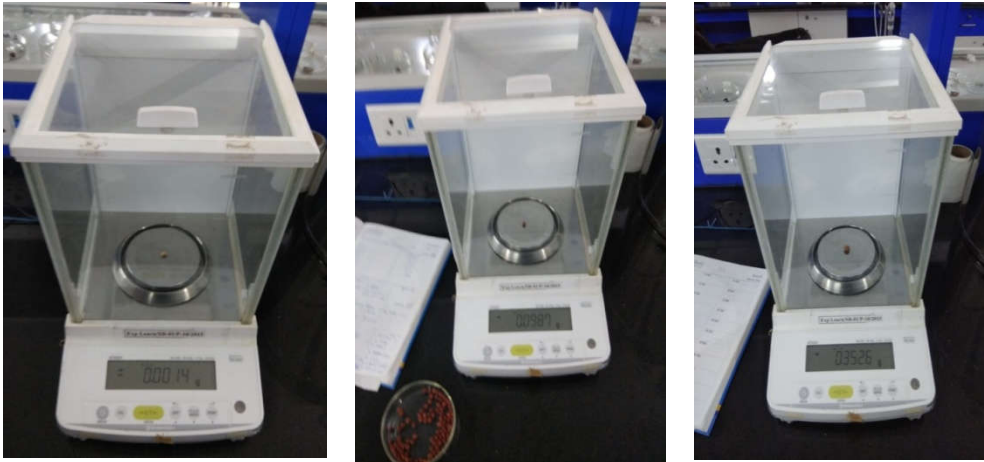


Fig.1 Unit weight of soybean, pigeonpea and chickpea by digital weighing balance



Fig.2 Test weight of Soybean, pigeonpea and chickpea by digital weighing balance

Bulk density of soybean, pigeonpea and chickpea seeds

Bulk density of soybean, pigeonpea and chickpea seeds was calculated by placing the sample of seeds in a cylinder which has 7 cm of diameter and 9.6 cm of length. [7]. The sample placed in the cylinder is then weighed by using electronic balance with least count of 1g. Bulk density was calculated by using the relationship.

$$b_d = \frac{W_t}{L \times (\pi d^2 / 4)}$$

Where,

b_d = Bulk density, kg/m³;

W_t = Weight of sample, kg;

L = Length of cylinder, m; and

d = Diameter of cylinder, m.

Angle of repose

The angle of repose is the angle between the base and the slope of the cone formed vertical fall of the granular material on a horizontal plane. The size shape, moisture content and orientation of seeds affects the angle of repose.

A wooden frame with varying top surface as aluminum, iron sheet and wood, full of soybean, pigeonpea and chickpea seed sample was mounted on tilting top drafting table. The table top was tilted till the soybean, pigeonpea and chickpea seed starts moving over the inclined surface. The angle of inclination was measured which shows the angle of repose of the soybean, pigeonpea and chickpea seeds. Five samples were taken for determination of angle of repose and calculated by following relationship.

$$\tan \phi = \frac{2(H_a - H_b)}{D}$$

In which, ϕ , H_a , H_b and D are angle of repose, the height of cone, height of platform and diameter of the platform.

RESULT AND DISCUSSION

Physical characteristics of seeds

The design of intercrop planter involve the design of metering mechanism system which needs the proper shape and size viz.length, width, thickness ,sphericity, geometric mean diameter of seed for proper functioning. All the mentioned parameters are depicted precisely which shows the representative size of soybean, pigeonpea and chickpea seeds used in the preliminary laboratory and field test of the intercrop planter.

Physical parameters of soybean seeds

The length, width, thickness, sphericity and geometric mean diameter of 20 seeds were selected randomly and measured with the help of digital vernier caliper in mm. The average length, width, thickness, sphericity and geometric mean diameter were 2.71mm, 1.65mm, 0.88, 0.57 and 1.55 mm respectively. Where the maximum length was found 3.78 mm while maximum width was 2.19 mm, maximum thickness was observed 1.41mm.The maximum sphericity and geometric mean diameter were 0.75mm and 2.19mm as shown in Table 1.

Table 1 Physical parameter of 20 soybean seeds

S.No	Length	Width	Thickness	Sphericity	Geometric Mean Dia
1	2.66	1.83	0.74	0.57	1.53
2	2.33	1.39	0.96	0.62	1.45
3	3.11	1.17	0.83	0.46	1.44
4	3.78	1.41	0.59	0.38	1.46
5	2.89	1.65	0.95	0.57	1.65
6	2.85	2.06	0.99	0.63	1.79
7	3.51	2.15	1.41	0.62	2.19
8	2.45	2.19	1.18	0.75	1.84
9	1.72	0.88	0.47	0.51	0.89
10	2.05	1.12	0.58	0.53	1.1
11	3.29	2.12	0.69	0.51	1.68
12	2.69	1.94	1.17	0.67	1.82
13	2.47	1.82	1.09	0.68	1.69
14	2.86	1.81	0.81	0.56	1.61
15	2.79	1.65	1.09	0.61	1.71
16	2.96	2.11	1.1	0.64	1.9
17	1.96	1.01	0.65	0.55	1.08
18	2.96	1.65	0.64	0.45	1.34
19	2.47	2.11	0.63	0.55	1.38
20	2.48	1.01	1.09	0.64	1.60
Avge	2.71	1.65	0.88	0.57	1.55
SD	0.505136	0.43	0.25	0.087	0.31
CV (%)	18.61	26.21	28.89	15.26	19.68

Physical parameters of Pigeonpea seeds

The length, width, thickness, sphericity and geometric mean diameter of pigeonpea 20 seeds were selected randomly and measured with the help of digital vernier caliper in mm. The average length, width, thickness, sphericity and geometric mean diameter were 2.06 mm, 2.96 mm, 4.18 mm, 1.44mm and 2.93 mm respectively which is given in Table 2. Maximum length was 2.78 mm while maximum width was 3.68 mm, maximum thickness was observed 4.49 mm .The maximum sphericity and geometric mean diameter were 1.81mm and 3.54 mm as shown in Fig 3.



Fig.3 Physical parameter measurement of soybean, pigeonpea and chickpea by vernier caliper

Table: 2 Physical parameter of pigeonpea

S.No	Length	Width	Thickness	Sphericity	Geomteric Mean Dia
1	1.57	2.65	3.96	1.62	2.54
2	1.97	2.89	4.03	1.44	2.84
3	2.22	3.25	4.36	1.42	3.15
4	1.97	2.87	3.92	1.42	2.8
5	2.62	2.57	4.94	1.22	3.21
6	1.99	2.94	3.86	1.42	2.82
7	1.98	3.06	4.18	1.48	2.93
8	2.78	3.80	4.23	1.27	3.54
9	2.47	2.81	4.18	1.24	3.07
10	2.04	3.19	4.49	1.50	3.08
11	2.52	2.69	4.59	1.24	3.14
12	2.12	2.72	4.4	1.38	2.93
13	2.52	3.2	4.02	1.26	3.18
14	1.85	2.54	4.18	1.45	2.69
15	1.89	2.81	4.12	1.47	2.79
16	1.59	2.57	3.96	1.59	2.52
17	1.61	3.68	4.21	1.81	2.92
18	1.67	2.98	4.02	1.62	2.71
19	1.98	3.12	3.87	1.46	2.89
20	1.91	2.97	4.17	1.5	2.87
Avge	2.06	2.96	4.18	1.44	2.93
SD	0.35	0.34	0.26	0.15	0.24
CV%	17.21	11.52	6.40	10.43	8.34

Physical parameters of chickpea seeds

The length, width, thickness, sphericity and geometric mean diameter of pigeonpea 20 seeds were selected randomly and measured with the help of digital vernier caliper in mm. The average length, width, thickness, sphericity and geometric mean diameter were 2.06 mm, 2.96 mm, 4.18 mm, 1.44mm and 2.93 mm respectively which is give in Table 3. Maximum length was 9.21 mm while maximum width was 7.02 mm, maximum thickness was observed 6.63 mm .The maximum sphericity and geometric mean diameter were 0.86 mm and 7.42 mm.

Test weight of soybean, pigeonpea and chickpea

Test weight of single seed of soybean, pigeonpea and chickpea was taken by digital weighing balance where it was observed that weight of soybean was lowest weight averagely 0.07g and 100 test weight of 8.71g while 0.11 g single seed weight and 10.14 g and test weight of chick pigeonpea taken by randomly.

Highest seed weight was chickpea of 0.296 of single seed weight and 23.57 of test weight of 100 seed weight as shown in Table 4.

Table:3 Physical parameter of chickpea

S.No	Length	Width	Thickness	Sphericity	Geometric Mean Dia
1	8.72	7.06	6.63	0.85	7.41
2	8.86	6.27	6.23	0.79	7.02
3	8.59	6.60	6.15	0.81	7.03
4	8.89	6.35	6.02	0.78	6.97
5	9.21	7.02	6.32	0.8	7.42
6	8.54	6.30	5.87	0.79	6.8
7	8.81	5.91	5.68	0.75	6.66
8	8.75	6.78	6.45	0.82	7.25
9	8.05	6.97	6.69	0.89	7.21
10	8.67	6.44	6.08	0.8	6.97
11	8.27	6.90	6.32	0.86	7.11
12	9.38	6.59	6.23	0.77	7.27
13	8.39	6.68	6.28	0.84	7.06
14	7.67	6.00	5.79	0.84	6.5
15	8.89	6.16	5.55	0.75	6.72
16	7.69	6.26	5.87	0.85	6.56
17	8.36	6.47	5.47	0.79	6.66
18	7.41	5.79	5.5	0.83	6.17
19	8.41	5.74	5.01	0.74	6.23
20	8.23	6.76	6.47	0.86	7.11
Avge	8.48	6.45	6.03	0.81	6.90
SD	0.50	0.40	0.43	0.04	0.35
CV %	5.95	6.24	7.20	5.13	5.20

Table 4 Test weight of soybean, pigeonpea and chickpea seeds

Single seed weight	Soybean (g)	Pigeonpea(Rajeev Lochan) (g)	Chickpea (g)
1	0.080	0.119	0.353
2	0.083	0.101	0.336
3	0.095	0.120	0.274
4	0.011	0.112	0.252
5	0.087	0.099	0.265
average	0.07	0.11	0.29
100 seed weight (g)	8.71	10.14	23.57
SD	0.03	0.01	0.04
CV%	47.92	8.92	15.32

Angle of repose

Angle of repose is important parameter for designing any planter which pickup the seed at a proper angle of repose of seeds which measured with the help of aluminum sheet. Maximum angle of repose was 28.03° for chickpea while 28.21° and 26.10° for soybean and pigeonpea. Angle of repose is very necessary for design of any planter for dropping of seeds. It was observed maximum 30.98° out of 10 replication while 28° for pigeonpea and 30.05° for chickpea as shown in Table 5.

Table 5: Angle of repose of soybean, pigeonpea and chickpea

Angle of Repose	Soybean (°)	Pigeonpea (°)	Chickpea (°)
1	26.35	25	25.05
2	27.25	28	28.30
3	26.45	26	26.30
4	30.98	25	29.10
5	27.54	26	26.04
6	28.55	25	28.45
7	29.99	27	30.05
8	26.54	28	28.90
9	27.98	26	27.80
10	30.45	25	30.35
Avge	28.21	26.10	28.03
SD	1.72	1.19	1.74
CV%	6.11	4.58	6.23

Table 6: Moisture content of soybean, pigeonpea and chickpea

Moisture Content(D.B.)	Soybean (%)	Pigeonpea (%)	Chickpea (%)
1	7.08	10.20	11.4
2	9.12	15.10	20.5
3	15.13	12.20	17.4
4	10.09	16.50	24.1
5	11.23	20.40	23.8
6	14.12	18.10	15.4
7	12.11	15.30	25.6
8	8.13	13.50	19.3
9	10.02	18.20	24.2
10	15.09	20.30	22.1
Avge	11.21	15.98	20.38
SD	2.85	3.38	4.54
CV%	25.45	21.16	22.29

Moisture content and Bulk density

Moisture content of soybean, pigeonpea and chickpea were measured with the help of oven as dry basis. Moisture content of chickpea was highest 20.30% observed as compared to pigeonpea 15.98% and 11.21% of soybean. Bulk density of soybean, pigeonpea and chickpea were evaluated by mass per unit volume where the averagely 709.53 kg/m³ for chickpea which was maximum than the soybean and pigeonpea due the heavy weight and large size as given in Table 7. It was also observed 694.30 (kg/m³) and 666.64 (kg/m³).

Table 7: Bulk density of soybean, pigeonpea and chickpea

Bulk Density	Soybean(kg/m ³)	Pigeonpea(kg/m ³)	Chickpea(kg/m ³)
1	645.08	640.28	690.05
2	670.10	680.12	695.05
3	650.20	640.14	710.02
4	690.22	660.20	720.04
5	720.40	650.25	690.09
6	680.30	670.28	715.03
7	750.45	684.51	730.02
8	655.98	675.08	725.08
9	730.10	681.23	690.09
10	750.20	684.33	730.06
Avge	694.30	666.64	709.55
SD	40.65	17.69	16.89
CV%	5.85	2.65	2.38

CONCLUSION

The present study provides the information regarding physical parameters of soybean, pigeonpea and chick which is most suitable for designing or optimizing any seed drill or planter for effectively. From the study it was also study that chickpea size and shape are irregular and highest bulk density posses than soybean and pigeonpea.

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