Determination of Physical Properties of Chickpea Seeds and their Relevance in Germplasm Collections

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The physical properties of seeds are important for processing and storage as well for assessing seed quality. Seed shape is an important qualitative character that determines the seed appearance and uniformity. Fifty chickpea germplasm accessions representing *desi*, *kabuli* and intermediate types were examined for various morphological and physical properties. High diversity for different seed traits was observed among the chickpea accessions. The extent of variation was wide for seed related traits especially in the pea-shaped chickpea accessions. These results are useful in refining the descriptor states of qualitative traits of chickpea seed and effectively utilizing germplasm in further crop improvement programmes.

Key Words: Chickpea, Diversity, Germplasm, Seed Colour, Seed Shape

Introduction

Chickpea (*Cicer arietinum* L.) is an annual grain legume cultivated in over 50 countries across all continents. During 2011, the global chickpea area was about 13.20 million ha, with a production of 11.62 million metric tons (FAOSTAT 2013). Two main types of chickpea are well recognized–small seeded, with coloured seed coat, angular shaped *desi* type and the beige coloured, large seeded, owl's head shape *kabuli* type. There is an intermediate type that is–dark or light coloured, small or medium sized and round (pea) shaped seeds (IBPGR/ICRISAT/ICARDA, 1993). Chickpea seeds are consumed in a variety of ways with or without seed coat. Agbola *et al*. (2002) described seed quality traits (colour, size and 'dhal' recovery rate) and common uses of chickpea varieties in India. Along with dietary value, chickpea quality is also judged by physiochemical and cooking traits (Patane, 2006). The physical properties of seeds are important in designing equipment and structures for handling, transporting, processing and storage, and also for assessing seed quality (Nikobin *et al*., 2009; Ayman *et al*., 2010). Mechanical resistance of seeds is a physical property that effects/gets affected by the technological process. Limited studies have been made to classify chickpea seeds on the basis of shape. Methods for measuring the seed shapes that are reliable, cost effective and have potential for wide acceptance are highly desirable (Meena *et al*., 2004).

Germplasm collections offer the much needed diversity for important morpho-agronomic traits for utilization in crop improvement research. The ICRISAT Genebank, Patancheru, India, conserves 20,267 accessions of chickpea from 60 countries. The collection represents wide diversity for important morpho-agronomic traits including seed characters. The physical properties of seeds are important for processing germplasm samples and some of the traits are important attributes of seed quality, consumer demands and market premiums. In chickpea, seed coat colour has overriding importance in determining market quality and acceptance of improved cultivars and hence breeders need access to diverse genetic resources. Information on the physical properties of chickpea seed especially the pea shaped intermediate types, and their use in crop improvement, is limited. Better knowledge on extent of variation for physical properties of seeds adds value to the genebank collections, especially when they are related to the useful seed quality parameters. Results from a study on the morphological and physical properties of 50 chickpea germplasm accessions representing *desi*, *kabuli* and the intermediate (pea) types from the chickpea collection conserved at the ICRISAT genebank are reported in this paper.

Materials and Methods

The 50 chickpea germplasm accessions selected for this study represent landrace/traditional cultivars (41), breeding lines (6) and advanced cultivars (3). These accessions were grown in Vertisols (black soils) during 2011 post-rainy season at ICRISAT, Patancheru, India. Each accession was planted in two rows of four meter

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length, with a row to row spacing of 60 cm and plant to plant spacing of 10 cm. Freshly harvested seed samples were hand-threshed and cleaned samples were stored in short-term storage conditions (25ºC and 40% RH) for two weeks to attain equilibrium moisture content (emc). During this period, the moisture content of the samples was estimated at two-day intervals and the emc was ascertained when the seed samples in all accessions showed stable moisture levels.

Observations were recorded on 17 important seed related traits. These include – seed moisture content, 100-seed weight, seed colour, shape, surface texture, seed coat content; and principal dimensions of seed size such as length, width and thickness, geometric mean diameter (GMD), surface area, sphericity/roundness index, shape aspect, volume, bulk density, true density and porosity.

Seed Moisture Content

The equilibrium moisture content (emc) of equilibrated seed samples under controlled environment was estimated on wet weight basis (w.b.) following oven-dry method (ISTA, 1993).

100-Seed Weight

100-seed weight of the chickpea accessions was measured on randomly selected 100 seeds and weighing them using a sensitive balance and weight was recorded in grams.

Seed Colour, Shape and Surface Texture

Observations on seed colour, shape and surface texture were recorded on bulk sample of 200 g following the descriptors for chickpea (IBPGR/ICRISAT/ICARDA, 1993).

Seed Coat Content

An accurately weighed sample of 10 seeds in each accession was soaked in distilled water for 16 hours at room temperature. After the water was drained, the soaked seeds were dried on blotting paper and the seed coat was completely removed with tweezers. The seed coats were dried in an oven at 60ºC for 24 hours, followed by cooling in a desiccator (Tizazu and Emire, 2010). The seed coats were weighed and the percent seed coat content was calculated.

Seed Size

Seed size was measured in millimeters on principal dimensions such as length, width and thickness. Twenty randomly selected seeds from each accession were used to measure length, width and thickness using electronic digital caliper and mean values were calculated.

The Geometric Mean Diameter (GMD)

The three mutually perpendicular diametrical dimensions of length, width and thicknesses of seed of chickpea were determined and used for calculating the geometric mean diameter in mm (Sreenarayanaa *et al*., 1988).

Surface Area, Sphericity and Shape Aspect

Sphericity is the state or form of being spherical. It is the ratio of the surface area of a given object to the surface area of a sphere with the same volume. The sphericity and shape aspect of chickpea seeds were determined as percentages using the procedures suggested by Mohsenin (1986) and Omobuwajo *et al*. (1999), respectively.

Seed Volume, Bulk Density, True Density and Porosity

Seed physical parameters such as volume, bulk density, true density and porosity (%) are dependent on morphological seed traits and the moisture content. Hence these were estimated on seed samples at equilibrium moisture contents. For determining the bulk density, true density and the porosity of seed a sample size of 100 g was used. Bulk density of the seed was calculated by dividing the weight of each sample on its volume (cc), measured by using a graduated cylinder (Ayman *et al*., 2010). True density and volume were determined by toluene solution displacement method (Mohsenin, 1986). Bulk density and true density were expressed as g/cc at given seed moisture conditions. The porosity was determined as the percentage of densities of bulk seeds (Jha, 1999).

Mean standard deviation and correlations were determined using Genstat 14th Edition.

Results

Based on the observations recorded, the tested accessions were classified into 14 seed colours following the descriptors for chickpea. Orange (11 accessions), beige (10) and light orange (10) were the major seed colours followed by light brown (6). Seed shapes were represented by pea (42 accessions – intermediate type), angular (4 – *desi* type) and owl's head (4 – *kabuli* type); and seed surface texture as smooth (32 accessions) and rough (18 accessions). On the basis of morphological traits and seed characteristics, the 50 accessions represented *desi*

(4), *kabuli* (4) and intermediate type (42) of chickpea. Diversity among accessions for seed colour, shape and surface texture is depicted in Fig. 1 and 2.

The physical properties of seeds of chickpea germplasm accessions used in the study are presented in Table 1. Significant differences were observed among accessions for these traits and the test accessions were classified into 4-6 classes (Table 2) considering the range of variation and the users of germplasm. Correlations among physical properties of seed are presented in Table 3. Seed moisture content is an important measure of seed quality influencing the physical parameters, seed handling procedures and storage behavior of seeds in the genebanks. The mean emc was 8.5% and accessions representing the smallest and largest *desi* type had maximum and minimum emc, respectively. Forty five intermediate and *kabuli* type accessions had similar emc (8.0-9.0%). The seed moisture content was negatively correlated to various seed size parameters and positively related to the sphericity and seed shape aspect and based on the observations the accessions were classified in to four emc groups. Likewise, 100-seed weight ranged from 9.2 to 58.5 g with a mean of 23.8 g. The small size (<15 g)

Fig. 1. Diversity for seed colour in chickpea germplasm accessions used in the study

Table 1. Mean, range and standard deviation of seed physical properties of chickpea germplasm accessions

Observation	Mean	Minimum	Maximum	SD (±)
Moisture content (%)	8.5	7.1	9.2	0.37
100-seed weight (g)	23.8	9.2	58.5	10.08
Seed coat content (%)	9.6	4.0	16.2	2.74
Length (mm)	8.5	6.9	12.3	1.02
Width (mm)	6.9	4.8	9.2	0.94
Thickness (mm)	6.8	4.8	9.0	0.89
Volume (mm³)	419.0	166.0	1000.0	162.2
Geographic mean diameter (mm)	7.4	5.5	10.0	0.91
Surface area (mm²)	173.0	95.0	314.0	43.60
Sphericity (%)	86.6	70.7	95.5	4.18
Seed shape aspect (%)	81.6	58.0	96.1	6.28
Bulk density (g/cc)	0.68	0.59	0.73	0.028
True density (g/cc)	1.37	1.25	1.46	0.047
Porosity (%)	49.6	44.7	54.5	2.55

Table 2. Frequency distribution for seed physical properties of chickpea germplasm.

Seed emc (%)	Frequency	GMD (mm)	Frequency
<8.0	4	<6.0	3
8.0-8.5	25	6.0-7.5	24
8.6-9.0	20	7.6-9.0	20
>9.0	1	>9.0	3
100-Seed weight (g)	Frequency	Surface area (mm²)	Frequency
<15.0	7	<100	1
15.0-25.0	25	100-150	15
25.1-40.0	14	151-200	23
>40.0	4	201-250	7
Seed coat content (%)	Frequency	251-300	3
<5.0	5	>300	1
5.0-10.0	21	Sphericity (%)	Frequency
10.1-15.0	22	<80.0	4
>15.0	2	80.0-85.0	9
Length (mm)	Frequency	85.1-90.0	28
<7.0	2	90.1-95.0	8
7.0-8.0	14	>95.0	1
8.1-9.0	23	Seed shapeaspect (%)	Frequency
9.1-10.0	8	<80.0	17
>10.0	3	80.0-85.0	22
Width (mm)	Frequency	85.1-90.0	9
<5.0	1	90.1-95.0	1
5.0-6.0	7	>95.0	1
6.1-7.0	18	Bulk Density (g/cc)	Frequency
7.1-8.0	19	<0.60	1
8.1-9.0	4	0.60-0.65	8
>9.0	1	0.66-0.70	33
Thickness (mm)	Frequency	>0.70	8
<5.0	1	True Density (g/cc)	Frequency
5.0-6.0	7	<1.30	4
6.1-7.0	19	1.30-1.35	18
7.1-8.0	19	1.36-1.40	18
>8.0	4	>1.40	10
Volume (mm³)	Frequency	Porosity (%)	Frequency
<200	2	<45.0	2
200-400	23	45.0-48.0	10
401-600	20	48.1-51.0	25
601-800	3	51.1-54.0	10
>800	2	>54.0	3

is represented by seven accessions and the extra-large (>40 g) by four accessions (ICC 15744, 15428, 15574 and 11745). Seed size is significantly correlated to all physical dimensions of seed and positively contributed to the sphericity and seed shape aspect and negatively to the bulk density and porosity. Significant differences were observed in the seed coat content of the tested accessions. The seed coats of *desi* are thicker than *kabuli* chickpeas. Five accessions had seed coat content <5%. The test accessions were classified into four groups based on the seed coat content and the variation is depicted in Fig. 3.

Observations on physical dimensions showed significant differences among accessions (Table 1 and 2). Seed length of the accessions ranged from 6.9 to12.3 mm with a mean of 8.5 mm. Eleven accessions had a seed length >9.0 mm including three accessions with >10.0 mm length. Similarly the seed width ranged from 4.8 to 9.2 mm. Five accessions had a seed width >8.0 mm. Seed thickness value ranged from 4.8 to 9.0 mm with a mean of 6.9 mm. Four accessions had a seed thickness >8.0 mm. The seed volume of tested accessions ranged from 166 to 1000 mm³ with a mean of 419 mm³. Forty-six accessions had seed volume between 200 and 800 mm³. Based on the seed size dimensions the accessions were classified into four groups for geographic mean diameter (GMD), five groups for length, thickness and volume and six groups for width. The mean GMD of tested accessions was 7.4 mm and ICC 4948 had the lowest and ICC 11745 had the highest GMD. Four

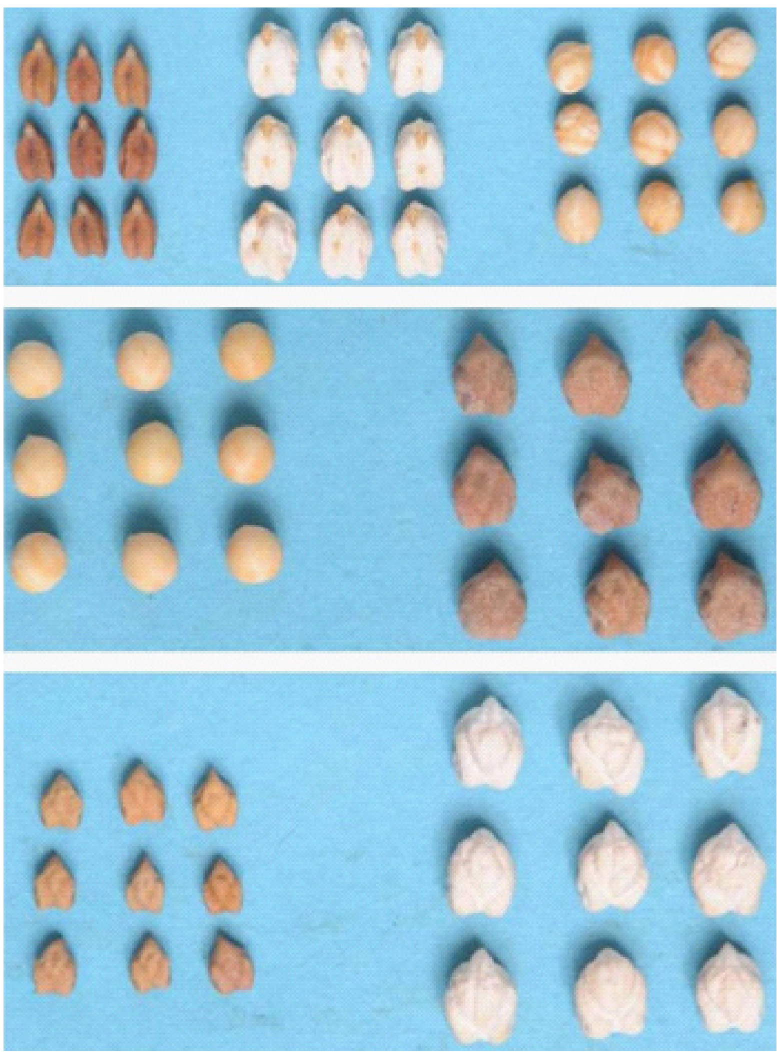

Fig. 2. Chickpea accessions differing in seed shape – angular, owl's head and pea (top), surface texture – smooth and rough (middle) and seed size/weight – small and large (bottom)

Fig. 3. Chickpea accessions differing in seed coat content – low and medium (top left) and high and very high (bottom left) and seed coats removed (right)

accessions (ICC 2296, 4948 16220 and 16960) were grouped as the smallest and four accessions (ICC 11745, 15428, 15574 and 15744) as largest for various seed size measurements.

Surface area of chickpea accessions ranged from 95 to 314 mm² with a mean of 173 mm². The smallest seed surface area was recorded in ICC 4849 followed by ICC 2296, 16220 and 16960 while ICC 11745 had highest seed surface area followed by ICC 15574, 15428 and 15744. Seed sphericity and shape aspect are related traits and are useful in defining the roundness of chickpea seeds. Observations on sphericity of chickpea seeds showed significant differences among tested accessions (Fig. 4). The sphericity ranged from 70.7 to 95.5%. The sphericity was lowest in ICC 16868 followed by ICC 4948 and ICC 13766 with angular seed shape (*desi* type) and ICC 16220 having owl's head shape (*Kabuli* type). The seed shape aspect ranged from 58.0 to 96.1% with a mean of 81.6%. The seed shape aspect was lowest in ICC 16868 followed by ICC 4948 and 13766 with angular seed shape and 16220 having owl's head shape. Based on the measurements the accessions were classified in to six groups for seed surface area and five groups for sphericity and shape aspect.

Bulk density, true density and porosity of chickpea seeds showed significant differences among accessions. The bulk density ranged from 0.59 to 0.73 g/cc with a mean of 0.68 g/cc. The lowest bulk density was observed in ICC 4973 (a *kabuli* type accession), followed by ICC 2296 an intermediate type with smooth surface texture. The highest bulk density was observed in ICC 5905 (rough surface) followed by ICC 5674 (smooth surface intermediate type). The true density ranged from 1.25 to 1.46 g/cc with a mean of 1.37 g/cc. The lowest true density of chickpea seeds was observed in angular shaped *desi* type (ICC 16868) which had highest seed coat content. Porosity of chickpea accessions ranged from 44.7 to 54.5%. The lowest porosity was observed in ICC 10338 and highest in ICC 16960, both representing intermediate type accessions with pea shape and smooth seed surface. Porosity of seeds has influence on packaging and storage behavior of germplasm accessions. The test accessions were classified into four groups for bulk density and true density and five groups for porosity.

Discussion

Seed shape directly affects the seed appearance and uniformity of chickpea and is often used as a quality indicator for importers and consumers. There is increasing demand on lighter seed coat colour and pea-shaped seed and pink colour *desi* types and the white or beige seed coat colour and extra-large *kabuli* (>55 g/100 seed) chickpea command very high premium price in the markets (Yadav *et al*., 2007). The pea shaped chickpea is popular in central India. Consumers in North and South America, Europe, the Middle East and Africa prefer the *kabuli* type. Hence, techniques to precisely measure specific seed shapes and to discriminate the possible shape variants are required to meet specific market demands. Several methods are used to measure seed shape characteristics. Of these, the low cost traditional visual assessments of

Table 3. Correlations among physical properties of chickpea germplasm seeds

Trait	SWT*	SCC	SL	SW	ST	SV	GMD	SSP	SSa	SSA	SBD	STD	SP
EMC	-0.301	-0.332	-0.421	-0.208	-0.199	-0.273	-0.278	0.268	0.237	-0.276	0.071	0.127	-0.027
SWT		-0.229	0.913	0.927	0.942	0.988	0.966	0.254	0.252	0.981	-0.240	0.116	-0.273
SCC			-0.071	-0.273	-0.262	-0.223	-0.219	-0.380	-0.373	-0.221	0.348	-0.104	0.356
SL				0.799	0.842	0.923	0.910	-0.068	-0.073	0.920	-0.230	-0.035	-0.163
SW					0.986	0.948	0.974	0.538	0.538	0.965	-0.200	0.322	-0.380
ST						0.960	0.988	0.472	0.454	0.977	-0.208	0.290	-0.365
SV							0.984	0.279	0.277	0.996	-0.216	0.158	-0.282
GMD								0.349	0.340	0.996	-0.219	0.213	-0.322
SSP									0.993	0.315	-0.020	0.605	-0.425
SSa										0.310	-0.027	0.592	-0.421
SSA											-0.218	0.186	-0.303
SBD												0.098	0.740
STD													-0.596

Significance levels : <0.05% = 0.288 and <0.01% = 0.372
* SWT = 100-seed weight; EMC = Equilibrium moisture content; SCC = Seed coat content; SL = Seed length; SW = Seed width; ST = Seed thickness; SV = Seed volume; GMD = Geographic mean diameter; SSP = Seed sphericity; SSa = Seed shape aspect; SSA = Seed surface area; SBD = Bulk density; and STD = True density; SP = Seed porosity

seed appearance have mainly been used to determine the segregation for seed shape among chickpea populations (Meena *et al*., 2004). The seed moisture content is an important measure for handling the germplasm collections in the genebanks. The range of variation in the emc of the observed chickpea accessions was significant even under controlled environment conditions. The mean emc was 8.5% and accessions representing the smallest and largest *desi* type had maximum and minimum emc, respectively. Forty-five intermediate and *kabuli* type accessions had similar emc (8.0-9.0%). The seed sizes are expressed at given moisture contents of the seeds. The seed size is an important trait of *kabuli* type chickpea

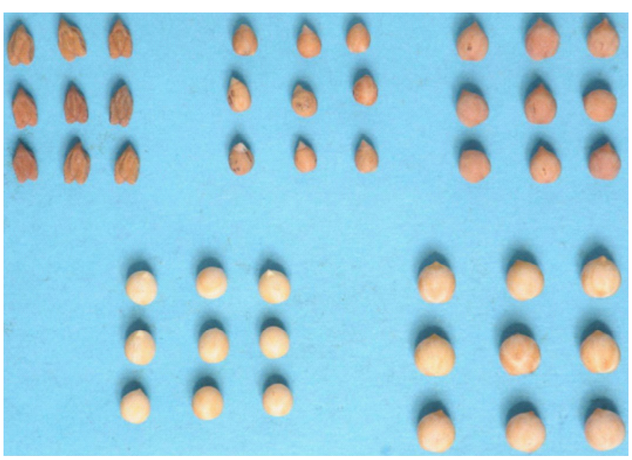

Fig. 4. Chickpea accessions differing in sphericity – lowest (top left) and highest (bottom right)

and a 100-seed weight of >40 g garner higher market price as they are preferred by consumers (Gowda *et al*., 2011). The market price of chickpea is primarily decided by the appearance (size, shape and colour) of the seed. However, the consumer preferences for chickpea seed traits may change over times. Consumers prefer the large-seeded types for whole seed consumption, confectionary products, salads, and savory meals (Regan *et al*., 2006). The extra-large (>50 g/100 seed) *kabuli* cultivars are sold at three times the price of *desi* and twice the price of medium-size *kabuli* types with a 100-seed weight from 25 to 40 g in India (Gaur *et al*., 2006). Four accessions (ICC 11745, 15428, 15574 and 15744) were observed with test weight >40 g in this study and considering other quality parameters, these accessions could be of value for further utilization in research.

The seed coats of *desi* are thicker than *kabuli* type chickpea in tested accessions. The lowest seed coat content (4.0%) was observed in ICC 11745, a *kabuli* type accession with smooth seed surface and having highest 100-seed weight and other physical dimensions. Six accessions had seed coat content <5%. The seed coat content was highest (16.2%) in ICC 16868, a small seeded *desi* accession with angular shape, rough seed surface and having lowest sphericity and seed shape aspect. Singh *et al*. (1980) have also reported higher seed coat contents in *desi* types (14.2%) than in *kabuli* types (4.9%). Seed coats of *desi* types were 2.72 times thicker than *kabulis* with normal testa and 3-25 times thicker than *kabulis* with cracked testa (Yadav and Sharma, 2000). Wood *et al*. (2011) reported differences in the processing of *desi* and *kabuli* chickpea seed types on the basis of morphology and composition of seed coats.

Certain factors such as seed hardness, small seed size, absence of anti-nutritional factors, and presence of toxic substances, may affect bruchid damage to legume seeds (Southgate, 1979), and rough (wrinkled) and thick seed coat might be responsible for resistance to bruchids. He recommended ICC 4969 (a chickpea germplasm accession with thick green coloured seed coat) for use in future breeding programs for bruchid resistance. ICC 4969 deserves further studies as it is also reported to be free from damage by the seed beetle (Erle *et al*., 2009). There is growing evidence of seed coat characteristics to specific seed problems like susceptibility to mechanical damage, seed longevity and tolerance to field weathering (Shahid *et al*., 2011). The seed coat performs a vital function in protecting the seed prior to germination and allows the seed to remain dormant or withstand mechanical damage (Dave *et al*., 2010). Seed coat thickness exhibits monogenic inheritance, with the thin *kabuli* seed coat being the recessive character. No relationship was found between seed coat thickness and seed size (Gil and Cubero, 1993).

Observations on physical dimensions of chickpea seeds showed significant differences among accessions. Four accessions (ICC 2296, 4948 16220 and 16960) were smallest and four accessions (ICC 11745, 15428, 15574 and 15744) were the largest for various seed size measurements. Seed volume and GMD are relative measures of length, width and thickness and among the tested accessions ICC 4948 and ICC 2296 had seed volume less than 200 mm^3 and ICC 11745 and ICC 15574 had volume more than 800 mm^3. The GMD of seeds ranged between 5.5 and 10 mm and 23 accessions had a GMD more than 7.5 mm. The trade recognizes three groups in chickpea based on seed diameter in Europe and Australia: large seeded (>9 mm), medium seeded (8-9 mm), and small seeded (7-8 mm). *Kabuli* type chickpea seeds more than 7 mm receive a premium of US $50 per ton for each additional mm of diameter (Biçer, 2009) and the seed lot must contain a large proportion of such seeds to get the extra price (Barker, 2007).

Seed surface area, sphericity and seed shape aspect are important physical parameters contributing to the seed shape of chickpea. The smallest seed surface area was recorded in ICC 4849 followed by ICC 2296, 16220 and 16960 while ICC 11745 had highest seed surface area followed by ICC 15574, 15428 and 15744. It is important to evaluate the sphericity of the germplasm accessions especially for the pea shaped accessions. Such accessions are of interest to breeders attempting to satisfy diverse marketing needs. Nelson and Wang (1989) proposed a visual scoring system to describe a broad variation of seed shape. Based on the measurements the accessions were classified into six groups for seed surface area and five groups for sphericity and shape aspect.

The sphericity among tested accessions ranged from 70.7 to 95.5%. The sphericity was highest in ICC 15428 followed by ICC 15744, 16395 and 15833 with pea shaped intermediate types. Nine accessions had sphericity between 90 to 95% having a perfect pea shape followed by 28 accessions with sphericity between 85 to 90%. Dutta *et al*. (2004) reported a sphericity (74%) and roundness (70%) at 10•9% moisture content in chickpea. Higher sphericity of chickpea seeds allows more sliding and rolling during seed processing (Konak *et al*., 2002). Ghadge *et al*., (2008) studied the physical properties of chickpea split (‘dhal’) and identified the importance of sphericity and aspect ratio of the seeds in determining the shape of the splits (‘dhal’). The seed shape aspect of chickpea accessions ranged from 58.0 to 96.1% with a mean of 81.6%. Ten accessions had seed shape aspect between 85 and 90% including one accession (ICC 15428) with seed shape aspect >95%. Sphericity and seed shape aspect of chickpea seeds were significantly correlated ($r = 0.993$). The 100-seed weight, emc and other physical dimensions significantly contributed to the sphericity and seed shape aspect of chickpea. However, these traits were negatively correlated to the seed coat content. The basic seed shapes of chickpea germplasm such as angular, owl’s head and pea were recorded following the Descriptors for Chickpea (IBPGR/ICRISAT/ICARDA, 1993). However, further classification/grading these shapes of large germplasm collections offers much needed diversity for seed shape trait for utilization in research.

True seed density in chickpea is related to physical seed dimensions, the sphericity and seed shape aspect. The intermediate types have greater true seed densities compared to *desi* and *kabuli* types. Seed density is a component of grain yield that is positively correlated with seed protein concentration and selection for increased density could provide an efficient way to improve protein concentration without affecting seed yield. Also, the measurement of seed density and seed weight is relatively inexpensive hence a low-cost way to identify promising accessions (Hongxia and Joseph, 2002).

Along with dietary value, importance of chickpea is also judged by physiochemical and cooking quality traits (Patane, 2006). New varieties are accepted as fully valuable raw material for the production of foodstuffs based on evaluation of their physical, chemical and nutritive properties. Efforts are needed to identify variation for these traits for use in breeding programmes. Lopez and Fuentes (1990) and Badshah *et al*. (2003) observed relationships among water absorption and seed coat contents which depend on cultivar, size and rugosity of the seed affecting the cooking quality. Ozer *et al*. (2010) emphasized the importance of physical, physiochemical and cooking properties of chickpea in identification of chickpea landraces for developing high quality chickpea cultivars.

Seed weight and volume are important attributes determining the consumer preference and cooking quality of chickpea cultivars. *Kabuli* type chickpea genotypes had high values of seed weight, hydration and swelling capacity than *desi* types, indicating seed coat differences affecting the seed quality traits. Mehla *et al*. (2001) identified seed weight, seed volume, swelling capacity and hydration capacity as important quality traits in chickpea. Agbola *et al*. (2002) and Shahid *et al*., (2011) emphasized the need to improve the physical quality characteristics and selections based on these traits for improvement of quality traits in chickpea. Singh *et al*. (2003) and Lokare *et al*. (2007) observed little influence of environment on seed physiochemical traits in chickpea. Hossain *et al*. (2010) observed low genotype x environment interaction and high magnitude of heritability suggesting the environmental stability of the chickpea seed shape trait (roundness index). Selection for variation in the physical seed characters of chickpea will enable breeding of varieties with the potential to attract premium prices.

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