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Relationship among some seed characters, laboratory germination and field emergence in chickpea (*Cicer arietinum* L.) genotypes differing in testa colour

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ABSTRACT

Field emergence (FE) of 22 genotypes of chickpea, all having laboratory germination (LG) of more than 89%, ranged between 39-87%, indicating seed vigour differences between genotypes. Seed of the genotypes having white or beige testa had poor emergence (39-69%) than with brown or black testa (64-87%). Significant correlation of FE with water uptake (-0.438*), electrical conductivity of seed leachate (-0.870), 100-seed weight (-0.865**) and proportion of seed coat (0.904**) indicated that seeds of genotypes/cultivar with low vigour and possibly poor FE could be identified prior to sowing. In general poor vigour seeds imbibed water rapidly (white/beige coloured seeds). Kabuli cultivars imbibed water to its maximum capacity within 4-8 hours while desi cultivars reached its maximum water imbibing capacity only after 16 hour of imbibition. For the initial first hour of imbibition the percent increase in water uptake of coloured desi genotypes ranged between 1.56 % to 38.25% while in kabuli genotypes it ranged from 40.17% to 71.84 %. Electrical conductivity (EC) showed the similar trend as of water absorption in kabuli and desi genotypes. Significant negative association was found between EC and FE in kabuli genotypes but this relationship was not significant in desi genotypes suggesting usefulness of EC in predicting FE of kabuli genotypes.**

Key words: Chickpea, Testa colour, Water uptake, Germination, Field emergence

Chickpea (*Cicer arietinum* L.) is an important cool season food legumes, grown in about 50 countries and consumed in more than 120 countries. India is the leader in terms of chickpea production with 68% share in global chickpea production (FAO 2014). Two types of chickpea i.e. desi and kabuli are well recognized. Desi types are small seeded, with pigmented seed coat while kabuli type are unpigmented/beige colour and are large seeded. Rapid establishment and uniform plant stands under different climatic conditions are required for high yielding and successful chickpea production, for which requires high vigour seeds, i.e. seeds that: germinate quickly and completely producing normal and vigorous seedlings which shows little or no sensitivity to external factors, enabling them to establish in a wide range of climatic conditions (Corbineau and Come 2006; Mohammadi *et al*. 2011). Wide range of variability exists for seed weight, testa colour, plant height, duration of flowering etc in chickpea. Seed coat pigmentation is found to be associated with vigour differences in peas (Powell 1989), french beans (Dickson and Petzoldt 1988), fababean (Kantar *et al*. 1996), flax (Saeidi 2008), cowpea (Peksen *et al*. 2004). Low seed vigour in these legumes are often linked with cotyledon and seed coat cracking, open hilum/ micropyle, imbibitional damage resulting from rapid entry of water to the seeds causing increased amount of solute leakage from the seeds. Yadav and Sharma (2001) reported that owing to delicate seed coat, kabuli types suffer from poor plant establishment due to above factors. Therefore, present experiment was carried to understand the relationship of some physical and physiological seed traits with FE in 22 chickpea genotypes differing in testa colour.

MATERIALS AND METHODS

Twenty two chickpea genotypes (11 each in desi and kabuli) from ICRISAT, Hyderabad and IISS, Mau, were used as an experimental material in this study. The detail information including name of chickpea genotypes, type, sources, testa colour and initial moisture content is given in Table 1.

Testa was removed from cotyledons carefully by hand after soaking in distilled water for 4 to 5 h which was dried at 80°C for 24 h in an electric oven. Dried testa and cotyledons were weighed separately to determine proportion of testa. The proportion of testa was than calculated using the formula

$$\frac{\text{weight of testa}}{\text{weight of testa and cotyledon}} \times 100$$

For determining rate of water imbibition, 50 weighed seeds of each lot in three replicates were soaked in 250 ml de-ionized water at 20°C. Seeds were re-weighed at 1, 4, 8, 12, 16 and 24 hours. The seeds were removed, blotted dry, weighed and immediately placed back in water. Than the percent increase in water uptake was calculated. After 24 h, EC of the steep water was measured by conductivity meter and expressed in µS/cm/g of seed.

Germination was tested in three replications of 100 seeds each in between-paper at 25 °C (Anon 2011). Field emergence was tested by hand-sowing seeds in 10 m rows (100 seeds per row) in three randomized rows. The number

Table 1. Detail information of the genotypes used in the study

Genotype	Type	Source	Testa colour	Initial seed moisture content (%)
G-118	Desi	ICRISAT*	Dark Brown	11.32
G-7	Desi	ICRISAT	Blackish Brown	12.01
G-50	Desi	ICRISAT	Green	13.13
G-229	Desi	ICRISAT	Brown	12.50
G-39	Desi	ICRISAT	Light Brown	13.00
G-95	Desi	ICRISAT	Brown	11.91
G-53	Desi	ICRISAT	Dark Brown	13.20
G-66	Desi	ICRISAT	Yellowish Brown	13.00
G-18	Desi	ICRISAT	Black	11.26
G-56	Desi	ICRISAT	Black	10.87
G-148	Desi	ICRISAT	Brown	12.35
G-71	Kabuli	ICRISAT	Yellowish Beige	12.65
G-227	Kabuli	ICRISAT	Brownish Yellow	12.56
G-149	Kabuli	ICRISAT	Brownish Yellow	12.43
G-232	Kabuli	ICRISAT	Yellowish Beige	13.04
G-225	Kabuli	ICRISAT	Brownish Yellow	13.19
G-137	Kabuli	ICRISAT	Yellowish White	12.60
G-233	Kabuli	ICRISAT	Whitish Yellow	12.57
G-144	Kabuli	ICRISAT	Whitish Yellow	13.32
CSJK-21	Kabuli	IISS, Mau**	Yellowish Beige	13.03
BG-1105	Kabuli	IISS, Mau	Whitish Yellow	12.88
BG-1088	Kabuli	IISS, Mau	Yellowish Beige	12.75

ICRISAT- International Crop Research Institute for Semi Arid Tropics, Hyderabad
IISS- Indian Institute of Seed Science, Mau, Uttar Pradesh

of seedlings emerged were counted after three weeks and computed as field emergence percent.

RESULTS AND DISCUSSION

100-seed weight and proportion of seed coat

Significant variation was observed among chickpea genotypes in 100-seed weight and proportion of seed coat. In general, the 100-seed weight of coloured genotypes (shown in the separate group in the right side of Fig 1) was lower than the white/beige coloured genotypes. 100-seed weight of unpigmented kabuli genotypes ranged between 15.89g (G-71) to 30.82g (G-223) while in desi genotypes it varied from 8.16g (G-148) to 22.17 g (G-229). However, the proportion of seed coat was almost three times higher in coloured desi genotypes. Coloured genotype G-50 recorded

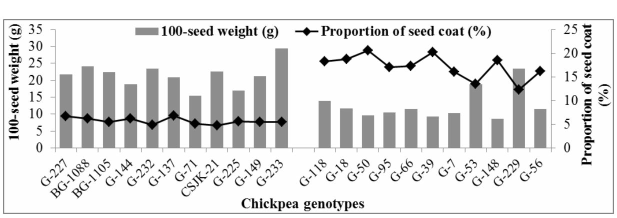

Fig. 1 100-seed weight and proportion of seed coat of 22 chickpea genotypes. Genotypes on the left side are kabuli type and on the right side are desi
CD value for 100-seed weight and proportion of seed coat was 1.17 and 1.67 respectively.

maximum seed coat to seed ratio (20.58%) while minimum (4.76%) was recorded in beige coloured CSJK-21 (Fig 1).

Laboratory germination (LG) and field emergence (FE)

LG of seeds exceeded 88% (Fig 2). In spite of high LG, FE was low for seeds of kabuli type (= 69%). Kabuli genotype CSJK-21 recorded FE of only 39%. All desi genotypes had high emergence percentage (= 80%) except for G-229 (64%). In general, coloured desi types showed better emergence than unpigmented/beige kabuli types indicating difference in seed vigour. Similar findings was also reported in fababean (Kantar *et al*. 1996) and cowpea (Peksen *et al*. 2004), where white seeds had poor FE than coloured seeds.

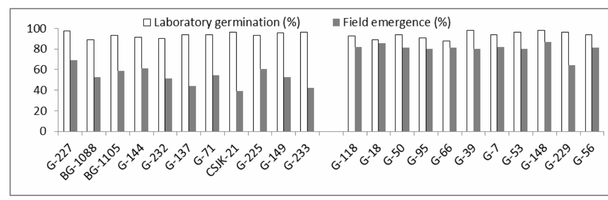

Fig. 2 Laboratory germination (%) and Field emergence (%) of 22 chickpea genotypes. Genotypes on the left side are of kabuli type and Genotypes on the right side are desi

Water imbibition rate (WIR) and Electrical conductivity (EC)

The seed moisture contents of chickpea genotypes ranged from 10.87% to 13.32% (Table 1). WIR of coloured genotypes varied between 109.81% (G-118) and 128.98% (G-39) while in kabuli types it ranged from 111.86% (G-232) to 145.09% (BG-1088) at the end of 24 hour. Significant differences were observed between white/beige and coloured chickpea seeds in terms of WIR depending on imbibition time. For the initial first hour of imbibition, the coloured desi types imbibied water slowly with a percent increase of = 40% with genotypes G-118 and G-229 imbibing less than 5%. While the kabuli type imbibed rapidly > 40% water with some genotypes G-137, G-144, CSJK-21 and BG-1088 imbibing more than 60%. Kabuli genotypes reached its maximum water imbibing ability between 4-8 hours whereas desi genotypes continued to imbibe water even up to 16 h of imbibition (Fig 3, 4 and 5). There was a significant difference in EC values of the steep water between and within the desi and kabuli genotypes (Table 2). Solute leakage when the seeds were soaked in water for 24 hours was generally greater from the seeds of kabuli genotypes showing poor field emergence. The majority of kabuli genotypes had leachate conductivities > 100 µS/cm/g seed, while maximum seed leachate conductivity in desi genotype (G-53) was 80.33 µS/cm/g seed. In average EC of kabuli genotypes was approximately 2.5 times higher than desi genotypes. Such high leakage of solutes from seeds during imbibition resulted from the death of the tissue due to rapid uptake of water (Powell and Matthews 1978).

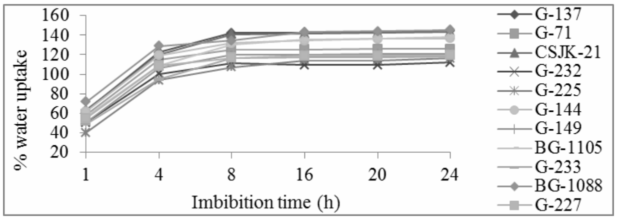

Fig. 3 Water imbibition pattern of chickpea genotypes having white/beige testa

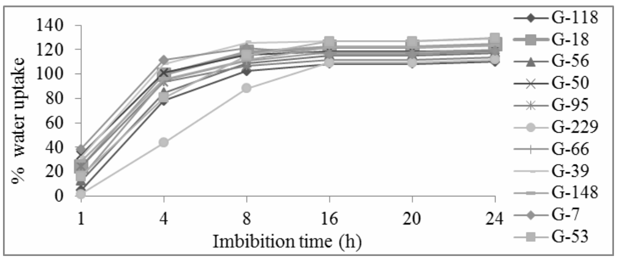

Fig. 4 Water imbibition pattern of chickpea genotypes having coloured testa

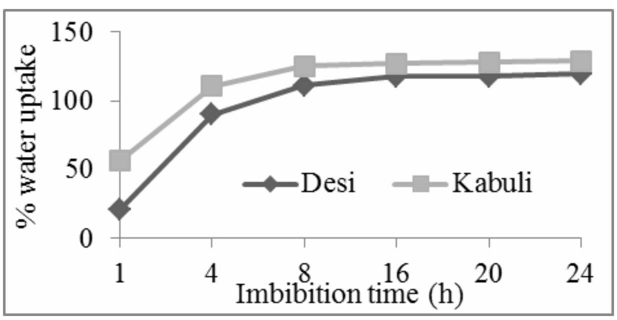

Fig. 5 Average changes in per cent water uptake of chickpea genotypes with white/beige testa (kabuli) and coloured testa (desi)

Table 2. EC of steep water after 24 hours for kabuli and desi genotypes

Kabuli genotypes	EC (µS/cm/g)	Desi Genotypes	EC (µS/cm/g)
G-227	65.67^{abcde}	G-118	36.33^{a}
BG-1088	140.00^{gh}	G-18	43.00^{ab}
BG-1105	123.33^{fgh}	G-50	37.33^{ab}
G-144	101.33^{cdefg}	G-95	27.33^{a}
G-232	107.33^{defg}	G-66	43.00^{ab}
G-137	172.00^{h}	G-39	36.00^{a}
G-71	$76.33^{abcdefg}$	G-7	64.33^{abcd}
CSJK-21	147.00^{gh}	G-53	80.33^{abcdef}
G-225	49.00^{abc}	G-148	43.00^{ab}
G-149	116.33^{defg}	G-229	64.00^{abcd}
G-233	120.00^{efgh}	G-56	46.33^{abc}
Average	**110.76**		**47.36**

Similar alphabets indicate non-significant differences between the values, following DMRT (duncan multiple range test).

Rapid imbibition was observed in beige coloured kabuli genotypes than coloured desi genotypes. Permeability of the testa, presence of cracks in testa, micropyle-hilum status, degree of the adherence of the testa to cotyledons, chemical composition of the seed coat are some of the characters that regulates the entry of water into the seed (Legesse and Powell 1992). Similar results were also reported by Peksen *et al*. (2004), whereby white coloured cowpea genotypes imbibed water rapidly than coloured genotypes. Slow water uptake by coloured desi genotypes may be attributed to the coloured seed coat which remain tightly adhere to the cotyledon as compared to kabuli genotypes whereby there was a large air space present between testa and cotyledon (Dickson and Petzoldt 1988).

In general, seedling emergence was lower from the seeds of kabuli than desi types with former recording rapid water uptake and higher solute leakage from the seeds. Yadav and Sharma (2001) correlate seed coat cracking with poor FE in kabuli chickpea. Such cracks result into imbibitional damage (Rowland and Custa 1977) and transverse cracking of the cotyledons (Roos and Manalo 1976), which reduces respiration and translocation rates of reserves from cotyledons to the growing axis of the seeds (Freeman 1995) and ultimately damages the embryo affecting field emergence.

The white seeded kabuli genotypes having high EC value had low FE. Table 3 depicts negative and significant association (r=-0.725*) between EC and FE in kabuli genotypes, but this relationship was not significant in coloured desi genotypes. Overall, EC showed a negative and highly significant correlation with FE (r= -0.870**). Similar reports have been proposed by Peksen *et al*., (2004) and Farghaly(1991). Table 4 depicts significant association of FE with water uptake (-0.438*), electrical conductivity of seed leachate (-0.870**), 100-seed weight (-0.865**) and proportion of seed coat (0.904**) indicated that seeds of genotypes/cultivar with low vigour and possibly poor FE could be identified prior to sowing.

Accelerated ageing test for soybean and electrical conductivity test for pea are the two vigour testing methods recognized by International Seed Testing Association. Besides, ISTA has also recently added radical emergence test for maize and control deterioration test for *Brassica species*. There are no vigour testing method in chickpea therefore, laboratory germination are mostly used to predict the field emergence of the chickpea seed lots. General

Table 3. Correlations among water absorption rate (WAR), electrical conductivity (EC), seed coat ratio, 100 seed weight, laboratory germination and field emergence in both seed groups

Chickpea type		Seed coat ratio (%)	100-seed weight (g)	Laboratory germination (%)	Field emergence (%)
Kabuli	EC	0.090	0.502	0.169	-0.725*
	WAR	0.303	-0.063	0.242	-0.288
Desi	EC	-0.774**	0.644*	0.272	-0.424
	WAR	0.199	-0.223	0.221	0.348
Overall	EC	-0.782**	0.797**	0.064	-0.870**
	WAR	-0.379	0.278	0.015	-0.438*

*, **: Correlation is significant at 0.01 and 0.05 level

Table 4. Correlation coefficients between different seed parameters in 22 chickpea genotype

Parameter	Electrical conductivity	100-seed weight	Proportion of seed coat	Field emergence	Water absorption rate
Electrical conductivity	1.00				
100-seed weight	.797**	1.00			
Proportion of seed coat	-.782**	-.847**	1.00		
Field emergence	-.870**	-.865**	.904**	1.00	
Water absorption rate	.697**	.278	-.379	-.438*	1.00

*, **: Correlation is significant at 0.01 and 0.05 level

assumption is better the LG and vigour indices, better is the vigour. However, results of this study suggest unsuitability of using LG as a vigour testing procedure in chickpea. EC is negatively related to seed quality. Higher the value of EC lower is the seed quality. Negative and significant correlation (r=-0.725*) between EC and FE in kabuli genotypes suggest that EC should be used to predict the field emergence potential. Poor FE is a serious problem in kabuli chickpea. Imbibitional damage could be the major reason for poor FE in kabuli chickpea. Rapid water uptake by kabuli seeds results in higher amount of solute leakage from the seeds to soil which might act as a point of fungal infection. For this reason, the seeds must be treated with fungicide before sowing in case of kabuli chickpea. Significant association of FE with rate of water uptake, seed weight, seed coat ratio, EC was observed which provides an opportunity to identify seeds of genotypes/cultivar with low vigour and possibly poor FE prior to sowing.

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