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GRAIN DENSITY AS SELECTION CRITERION IN CHICKPEA AND WHEAT

M. C. KHARKWAL AND H. B. CHAUDHARY

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Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012

ABSTRACT

The present work using 177 chickpea genotypes consisting of 97 desi, 55 kabuli and 25 green seeded and 50 wheat genotypes showed that grain density is an important indicator for post-anthesis source-sink relationship determining the grain weight component of yield. The results showed that a wide range of variability existed for grain weight, volume and density in both chickpea and wheat. Among the chickpea genotypes, kabuli types exhibited highest range and mean for grain weight and density. The study on wheat under two environments shows that the grain density could be increased with simultaneous increase in grain weight and yield even under abiotic stress environments. It is therefore suggested that the grain density could be used as a selection criterion as well as a parameter for identifying tolerence during grain filling particularly under adverse abiotic conditions like late planting, high/ low temperature and moisture stress.

Key Words : Chickpea, wheat, grain density, grain weight, grain yield, stress susceptibility index, correlations

Grain weight is an important yield parameter and a higher grain weight is a highly desirable character in pulses and cereals [1-5]. This parameter becomes all the more important under abiotic stressed cultivation, since the other major yield parameters, viz., number of pods/ spikes per plant, number of grains per pod/ spike and tiller number per unit area are adversely affected. However, it would be much more desirable to increase both the grain density and grain weight to increase the grain yield. Is it possible to do so? If yes, then how far can one go for increasing grain density and weight, and how should one proceed. The first logical step in this direction would be to understand the interrelationship between density and various other grain characters like grain weight, volume and yield which ultimately determine the yielding ability of a genotype.

MATERIALS AND METHODS

The experimental material for this investigation consisted of 177 chickpea (*Cicer arietinum* L.) genotypes including 97 desi, 55 kabuli and 25 green seeded types and

50 wheat genotypes drawn from important areas of chickpea and wheat cultivation in India representing a broad spectrum of available genetic and geographic variability for diffrent grain characters and yield potential under a wide spectrum of environments. Besides wide genetic variability, the genotypes studied also included a number of popular high yielding released/ identified varieties with wide adaptability to varying abiotic stress conditions. Grain weight, volume and density observations in case of chickpea were recorded for each variety using six replications. Grain volume was determined by using Hexane (liquid) displacement. Grain density was worked out by dividing the weight of the grain by its volume. Grain samples of wheat for 100 grain weight, volume and density were drawn from individual plot yields of a trial of 50 genotypes conducted under normal as well as abiotic stress (late planting) condition with three replications sown on 19th Nov. 1996 and 6th Jan. 1997, respectively. Range, mean, standard error and ANOVA for grain weight, grain volume, grain density and grain yield and correlation matrix was worked out. In case of wheat genotypes, the values of stress susceptibility index (S) were also calculated following Fischer and Maurer [6] as given below.

$$S = (1\text{-}Ylp/Ynp)/Di$$

Where Ylp is grain yield in stress (late planting) environment, Ynp is grain yield in normal planting environment and Di is stress intensity index calculated as:

$$Di = 1 - Xlp/Xnp$$

where Xlp and Xnp are the average grain yield values over all entries under stress (late planting) and normal planting environments.

RESULTS AND DISCUSSION

Highly significant differences in mean, and variance parameters were observed in all the three types of chickpea as well as wheat genotypes for all the characters studied (Table 1-2). In case of chickpea, widest range and highest mean were seen in kabuli types for all the characters except grain density. Desi types also showed a wide range. In wheat, the widest range and highest means were observed under normal planting condition. The analysis of variance (Table 3 & 4) revealed ample genetic variability for all the characters studied. The estimates of correlation coefficients among different grain characters (Table 5 & 6) indicated that grain density was positively correlated with grain volume and grain weight in chickpea. In case of wheat also, grain density showed highly significant positive correlation with grain volume, significantly positive correlation with grain yield and positive correlation with grain weight. Stress susceptibility index (S) values indicating variable response of genotypes to stress environment as well as absence of correlation between S

Table 1. Range, mean and coefficient of variation for grain characters in chickpea

Character	Range	Mean	CV%
100 Grain weight (g)			
desi types (582)	10.520 - 36.200	17.098 ± 0.280	5.65
kabuli types (330)	13.160 - 50.000	24.561 ± 0.369	4.22
green types (150)	12.440 - 29.120	17.154 ± 0.326	4.26
Pooled (1062)	10.520 - 50.000	19.425 ± 0.224	4.93
Grain density (g/cc)			
desi types (582)	1.063 - 1.575	1.326 ± 0.003	3.70
kabuli types (330)	1.186 - 1.642	1.339 ± 0.003	3.38
green types (150)	1.212 - 1.491	1.315 ± 0.003	2.76
Pooled (1082)	1.063 - 1.642	1.328 ± 0.002	3.50
100 Grain volume (cc)			
desi types (582)	8.000 - 27.800	12.801 ± 0.194	5.27
kabuli types (330)	9.400 - 36.800	18.349 ± 0.273	3.84
green types (150)	8.800 - 22.200	13.049 ± 0.248	4.21
Pooled (1062)	8.000 - 36.800	14.560 ± 0.161	4.57

Number within bracket indicate frequency of given type in chickpea sample.

Table 2. Range, mean and coefficient of variation for grain characters, yield and stress susceptibility index in wheat

Character	Range	Mean	CV%
100 Grain weight (g)			
Normalsown (150)	3.190 - 6.410	4.565 ± 0.052	4.82
Late sown (150)	2.570 - 5.500	4.002 ± 0.047	7.55
Pooled (300)	2.570 - 6.410	4.284 ± 0.039	6.52
Grain density (g/cc)			
Normal sown (150)	1.238 - 1.404	1.341 ± 0.002	1.43
Late sown (150)	1.013 - 1.381	1.331 ± 0.003	2.41
Pooled (300)	1.013 - 1.404	1.336 ± 0.002	1.98
100 Grain volume (cc)			
Normal sown (150)	2.420 - 4.820	3.405 ± 0.039	4.75
Late sown (150)	1.950 - 4.100	3.008 ± 0.035	7.88
Pooled (300)	1.950 - 4.820	3.206 ± 0.028	6.72
Grain yield (g)			
Normal sown (150)	1000 - 2700	1689 ± 30.98	19.59
Late sown (150)	510 - 2040	1182 ± 23.72	17.76
Pooled (300)	510 - 2700	1436 ± 24.38	19.23
Stress Index	0.021 - 2.274	0.966 ± 0.046	41.87

Numbers within brackets indicate frequency of given type in wheat sample

Table 3. **Analysis of variance (MSS) for grain weight, grain density and volume in chickpea**

Source	df	Mean squares		
		grain weight	grain density	grain volume
desi types				
Replications	5	2.378*	0.004	0.685
Genotypes	96	270.986**	0.017**	130.020**
Error	480	0.934	0.002	0.456
kabuli types				
Replications	5	1.121	0.004	0.084
Genotypes	54	268.722**	0.005**	147.606**
Error	270	1.076	0.002	0.496
green types				
Replications	5	0.472	0.002	0.279
Genotypes	24	96.432**	0.004**	55.532**
Error	120	0.535	0.001	0.301
Pooled analysis				
Replications	5	3.091**	0.004	0.905
Genotypes	176	315.175**	0.011**	162.878**
Error	880	0.917	0.002	0.442

*, ** Significant at 5% and 1% levels, respectively

Table 4. **Analysis of variance (MSS) for grain weight, density, volume, grain yield wheat**

Source	df	Mean squares			
		grain weight	grain density	grain volume	grain yield
Normal Planting					
Replications	2	1.574**	0.000	0.796**	116524
Genotypes	49	1.083**	0.001**	0.610**	213663**
Error	98	0.048	0.000	0.026	109636
Late Planting					
Replications	2	0.062	0.003	0.056	18388
Genotypes	49	0.810**	0.002**	0.436**	167700**
Error	98	0.091	0.001	0.056	44083
Pooled Analysis					
Replications	2	0.760	0.002	0.284	113297
Genotypes	49	1.711	0.002	0.954	253757**
Environment	1	23.750	0.008	11.797	19309107**
G X E	49	0.182	0.001	0.092	127605**
Error	198	0.078	0.001	0.046	76301

*, **Significant at 5% and 1% levels, respectively

Table 5. Correlation matrix for grain density, grain volume and grain weight of 177 chickpea genotypes

	Grain volume	Grain weight
Grain density	0.263**	0.364**
Grain volume		0.994**

Pooled observation (error = 880, n = 1062)

*, ** significant at P = 0.05 & P = 0.01, respectively

Table 6. Correlation matrix for grain density, grain weight, grain volume and grain yield of 50 wheat genotypes

	Grain density	Grain volume	Grain yield
Grain weight	0.183	0.987**	0.223*
Grain density		0.027	0.106
Grain volume			0.209*

Pooled observation (error = 198, n = 300)

* **Significant at P = 0.5, P = 0.01, respectively

values and grain density (r = 0.043), grain volume (r = 0.124) and grain weight (r= 0.130) were observed. This observation indicates that, the grain weight can be increased with increase in grain volume along with increase or minimal adverse influence on grain density even under stress conditions. Since, high grain density is also highly desirable for sound seed quality and better keeping quality of seed, the selection for increased grain density would be highly useful besides its contribution to high seed yield. Thus, the strategy should be to increase the grain weight and volume further with an increase or without corresponding loss in grain density by improving the grain filling rather than by increaseing the grain volume only. A more recent study [7] showed that the sharp decline rate of post-anthesis flag leaf photosynthesis could largely explain the decrease in grain density inspite of an increase in grain weight in such genotypes. Thus, screening of chickpea and wheat genotypes based on both grain density and grain weight may provide more information to the breeders on assimilate source-grain sink relationship during the post-anthesis period [8,9]. This approach will obviate the need of the breeders for actual measurements of post-anthesis photosynthesis and contribution from stem reserves. The genotypic variation in grain weight results from the interaction between potential storage capacity / volume and realisation of this potential [10] which depends on rates and duration of grain filling [11,12]. It has been reported that to increase the grain weight, both structural and synthetic components of the grain must improve simultaneously in a complementary manner [7, 13].

In fact, an increase or no loss in grain density with corresponding increase in grain weight would indicate that, physiologically, a highly efficient and improved source - sink relationship with the synchronous development of a strong assimilate

Table 7. Chickpea genotypes showing high grain density, high grain weight and high volume combinations

	Type & Variety	100 Grain density (g/cc)	100 Grain weight (g)	100 Grain volume (cc)
	Desi type	≥ 1.334[@]	≥ 17.819[@]	≥ 13.301[@]
1.	G 40	1.435	26.240	18.300
2.	GNG 469*	1.415	24.527	17.333
3.	E 100 Y	1.408	31.207	22.167
4.	Jyothi*	1.399	23.700	16.933
5.	Type 3*	1.396	33.660	22.667
6.	Gaurav*	1.395	28.687	20.567
7.	Annigeri*	1.395	22.327	16.000
8.	ICC 4958	1.394	32.553	23.347
9.	Phule G5*	1.392	27.093	19.467
10.	BG 256*	1.391	26.333	18.933
11.	ICC 5136	1.391	32.780	23.567
12.	KTP 1	1.389	31.340	22.567
13.	K 850*	1.388	26.220	18.300
14.	E 100 YM	1.385	33.780	24.400
15.	Radhey*	1.385	24.727	17.867
16.	ICC 1581	1.379	34.407	24.967
17.	ICC 5166	1.351	35.033	25.933
	GM	1.326	17.098	12.801
	CD at 1% level	0.073	1.437	1.004
	Kabuli type	≥ 1.347[@]	25.511[@]	≥ 19.052[@]
1.	HK 89-96	1.371	36.500	26.633
2.	ICC 11295	1.363	47.973	35.200
3.	BG 1025	1.347	30.400	22.567

(*Table cont. to next page*)

	GM	1.339	24.561	18.349
	CD at 1% level	0.061	1.542	1.047
	Green type	≥ 1.323@	≥ 17.994@	≥ 13.688@
1.	Green Bold	1.356	21.000	15.567
2.	BGM 464	1.336	19.207	14.367
3.	FM 93	1.333	20.500	15.400
4.	FM 58	1.333	20.393	15.300
5.	FM 157	1.333	20.207	15.167
	GM	1.315	17.154	13.049
	CD at 1% level	0.054	1.087	0.816

* High yielding varieties released through Central Variety Release Committee of Govt. of India

@ Selection Criterion = GM + SE x t value at P = 0.01 %

Table 8. Wheat genotypes combining high grain density and grain yield/plot with other desirable attributes and low stress index (Pooled basis)

S.No. Variety	Grain Density (g/cc)	Grain Yield/Plot (g)	100 Grain Weight (g)	100 Grain Volume (cc)	Stress Index
	≥ 1.341@	≥ 1499@			
1. HD-2285*	1.374	1527	4.22	3.07	0.995
2. HD-2329*	1.356	1618	4.45	3.28	0.801
3. PBW-226*	1.352	1570	4.12	3.05	0.023
4. DL-788-2*	1.352	1640	4.17	3.09	1.263
5. Sonalika*	1.346	1597	4.46	3.31	0.899
6. DL-153-2*	1.341	1770	5.31	3.96	1.030
7. DL-976-2	1.341	1855	4.55	3.39	0.507
8. PBW-175*	1.341	1638	4.56	3.40	1.205
GM	1.336	1436	4.28	3.21	0.966
(1) at 1% level	0.039	410	0.41	0.32	0.864

*High yielding varieties released through Central Variety Release Committee of Govt. of India.

@Selection criterion : GM + SE x t value at P=0.01%

source has developed during grain development [13]. When grain weight increases only due to increased grain sink capacity, grain density is expected to decrease sharply. However, it can be seen that even on the basis of a rigid selection criterion (GM + SE x t value at P=0.01%) of high grain density, weight and volume combination, it is possible to find a fairly large proportion of genotypes combining all the three characters (Table 7). A closer look of the pooled yield performance of the wheat genotypes (Table 8) combining high grain density, high grain yield, grain weight and large volume along with low stress susceptibility index indicates that under normal as well as stress environment e.g. late planting conditions, most of these genotypes are high yielding, very stable, widely adaptable and time tested varieties released for commercial cultivation after going through a rigourous testing of All India Coordinated Trials. High values of grain density and yield with low values of stress susceptibility index (S) in these genotypes also indicate that through breeding efforts varieties could be developed by intensifying selection pressure for these characters along with increased seed weight and yield components. Thus, the findings of the present study strengthen the proposed hypothesis that density should be used as a regular selection criterion by the breeders, particularly in advance generations to ensure the establishment of a good post-anthesis source-sink relationship under normal as well as under abiotic stress environments. This observation is also evident from the fact that the majority of the genotypes exhibiting high grain density, high grain yield and grain weight and smaller stress susceptibility index (S) values (Table 8) belong to released varieties included in this study. Thus, the selection criteria based on grain density should enable the selection of genotypes with high grain yield potential as well as tolerance to stress conditions. The present study on chickpea and wheat for grain density and its interreationship with other grain characters and yield can serve as paradigm for corresponding grain characters in other pulses and cereal crops.

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