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Influence of Genotypes and Environments on Protein Content in Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted to evaluate a set of chickpea genotypes for yield and protein content at four different locations during 2019-20. The results showed the differential response of chickpea genotypes and environment with respect to protein content. In general, the genotypes with low seed yield and small seed size (<20gm/100 seed) had higher protein content (>20%) as compared to those with high yield and bold seed size (>25gm/100 seed). Similarly, the protein content of all the five genotypes was observed higher (20.65, 23.06, 20.30, 20.65 and 20.76 percent, respectively) in Kota than the respective mean values (19.37, 21.03, 19.31, 19.87, 18.35 percent) while it was lower (16.35, 20.59, 17.53, 19.41, 16.32 percent) than mean values (19.37, 21.03, 19.31, 19.87, 18.35 percent) in Aklera as compared to other locations. This might be due to contrasting climatic conditions in Kota and Aklera indicating that the genotypes grown under irrigated conditions showed

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better quality over those grown in rainfed area. The genotypes RKG 13-515-1 and GNG 2144 showed consistent performance in terms of yield and protein content (20.65, 20.53, 19.96, 16.35, 19.37 percent and 23.06, 20.19, 20.30, 20.59, 21.03 percent, respectively) and can be used as parents in hybridization programme to develop transgressive segregants having high yield and protein content with early maturity.

Keywords: chickpea; yield; protein; seed weight; environment.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.), is the most important pulse crop cultivated across the world. India is the world's largest producer and consumer of chickpea where it is cultivated in 10.91 m. ha. area yielding production of 13.75 m. tons with productivity of 1260 kg/ha during 2021-22 [1]. The major chickpea growing states in the country are Madhya Pradesh, Maharashtra, Rajasthan and Gujarat. In Rajasthan, it is cultivated in 2.30 m. ha. area yielding production of 2.68 m. tons with productivity of 1166 kg/ha (2021-22). The south eastern humid plain zone (Zone V) though cultivates chickpea in only 0.153 m. ha. area with the production of 0.281 m. tons, yet the productivity of 1842 kg/ha is quite higher than the state and the national average due to high soil fertility and available moisture. Chickpea is one of the major sources of dietary protein for predominantly vegetarian Indian population. Besides food security, with an increasing awareness of the nutritive value and health benefits, emphasis is now focussed on nutritional security as well.

The genotypes perform differently in different environments with respect to yield and quality. The presence of G x E interactions deviate the correlation between phenotype and genotype, and makes it difficult to judge the true genetic potential of the genotypes. Stability of a cultivar refers to its consistency in performance across environments and is affected by the presence of G x E interactions [2]. Bouri et al. [3] reported the effect of genotype environment interaction on plant height, number of pods per plant, number of seeds per pod and seed size. Fatih et al. [4] also observed significant effects of genotypes, locations, years and their interactions on seed yield. The cultivation environment, the cultivation year and the genotypes, as well as their interactions significantly affect the functional properties and nutritional composition of chickpea. Even within the same variety, nutritional composition of chickpea varies depending on developmental stages, growing regions, and agricultural practices [5]. The growing environment of a plant is made up of many factors. Some of these are soil, fertilizer treatments, altitude, climate, rainfall, length of growing season, light intensity, length of day, and temperature. These operate in different, but interrelated, ways to change the composition of plants [6] The genotypes showing stable performance in terms of yield and quality are highly desired. Increasing seed yield and quality (protein content) of pulses is one of the major breeding objectives. Information on inheritance pattern and relationships of protein content with other traits would help in identifying suitable breeding strategies for developing chickpea cultivars with enhanced yield and protein content with preferred seed size.

Soybean is the major *kharif* crop in Kota region and soybean-chickpea is one of the common cropping sequences prevalent in the zone. Occurrence of occasional rainfall during maturity stage due to retreating monsoon sometimes delays the harvesting of the *kharif* crop (soybean) as well as the sowing of the subsequent *Rabi* crop (chickpea). Therefore, besides timely sowing, the genotypes/varieties suitable for late sowing of chickpea during first fortnight of December are also required. Besides this, chickpea also encounter yield loss due to high temperature stress during seed filling and maturity stage. Therefore, this experiment was conducted to identify a stable genotype in terms of yield, yield attributes and quality with respect to varying environments (locations) under late sowing.

2. MATERIALS AND METHODS

The experimental material comprised of five diverse chickpea genotypes from different agroclimatic zones including a test genotype along with four checks showing variability for yield and yield contributing traits. All the checks are recommended for late sowing conditions except GNG 1958 which is recommended for timely sowing but is a popular variety under cultivation in the zone. The source of material is provided under Table 1. The experiment was

Table 1. Source of experimental material used in the experiment

S.No.	Entries	Pedigree	Recommended Ecology	Source
1.	RKG 13-515-1	GNG 469 X IPC 2729	Late sown	ARS, Kota (Zone V-South Eastern Humid Plain Zone), Rajasthan
2.	GNG 2144 (C)	CSJD 901 X CSG 8962	Late sown	ARS, Ganganagar (Zone IB-Irrrigated North Western Plain Zone), Rajasthan
3.	RVG 202 (C)	(JAKI 9226 X DCP 20) X JG 412	Late sown	RVSKVV, Gwalior (Zone-Vindhya Plateau), Madhya Pradesh
4.	RVG 203(C)	(ICCV 91902 X ICCV 10) X ICCV 89230	Late sown	RVSKVV, Gwalior (Zone-Vindhya Plateau), Madhya Pradesh
5.	GNG 1958 (C)	GNG 1365 X SAKI 9516	Timely sown	ARS, Ganganagar (Zone IB-Irrrigated North Western Plain Zone), Rajasthan

conducted in randomized block design with four replications at four different locations of three districts under South Eastern Humid Plain Zone (Zone V) of Rajasthan *viz*., Kota, Bundi, Aklera and Khanpur (both under district Jhalawar) under late sown conditions during *Rabi*, 2019-20 following all the recommended package of practices. The trials at all the locations were sown during late November to first week of December to ensure late sowing. Each genotype was accommodated in eight rows of 4m length with the crop geometry of 30x10cm. Protein content in seed samples from each location was estimated in Central Laboratory, ARS, Kota following Lowry et.al., 1951.

Statistical analysis for seed yield has been provided in Table 3.

3. RESULTS AND DISCUSSION

The data on yield and yield contributing characters is provided in Tables 2 to 5. The highest seed yield of 3027 kg/ha was observed in the genotype RKG 13-515-1 which was 14 to 18 percent higher than the checks GNG 1958 and GNG 2144, respectively. The lowest seed yield was observed in the varieties RVG 202 and RVG 203. The days to 50 percent flowering ranged from 67 to 77 days. The earliest flowering was seen in the variety RVG 203 and RVG 202 while GNG 1958 and GNG 2144 were the most late in flowering. Similarly, the check varieties RVG 203 and RVG 202 were the earliest to mature, while GNG 1958 and GNG 2144 were most late to mature. The seed index was highest in the variety GNG 1958 followed by RKG 13-515-1. The lowest seed index was observed in the variety GNG 2144 followed by RVG 202 and RVG 203. With respect to quality, the highest protein content was observed in the check variety GNG 2144 followed by RVG 203, RKG 13-515-1 and RVG 202 while the lowest protein content was observed in GNG 1958.

In general, the genotypes like GNG 2144 and RVG 203 with small seed size and lower 100-seed weight had higher protein content as compared to those with bold seed size and higher seed weight *viz*., GNG 1958 and RVG 202 suggesting negative correlation between seed weight and protein content. GNG 2144 and GNG 1958 are contrasting varieties with respect to seed weight as one is small seeded and the latter bold seeded. GNG 2144 had higher protein content while GNG 1958 had lower protein content at most of the locations. Falco *et. al*. [7] also observed negative correlation between protein content and 100-seed weight. Saxena *et. al.* [8] also reported significant negative correlation between seed size and protein content in pigeonpea. However, breeding lines combining high protein content with medium seed size were successfully developed. A negative relationship between seed size and protein content implies that as seed increases in size, there is an increased amount of starch deposition altering the starch/protein ratio [9]. Protein content and starch content have been found to be negatively correlated in chickpea [10,11]. Sarika *et. al*. [12] stated that the negative correlation between protein content and 100-seed weight; positive correlation between seed weight and sugars including RFOs indicate that bolder seed types are greater in causing flatulence while the smaller to medium size one had greater protein per cent.

While Kulwal and Mhase [13] and Geethanjali et al*.* [14] reported positive correlation between 100-seed weight and protein content. It might be due to difference in the genotypes used and the environmental conditions to conduct the study. Similarly, the negative association was also seen between seed yield and quality. The genotypes viz., RKG 13-515-1 and GNG 1958 having high yield had comparatively lower protein content than the others. Frimpong et al. [10] and Meena et. al. [15] also recorded negative correlation between grain yield and protein content in chickpea. Geethanjali et. al. [14] also suggested that in general, quality and quantity are the two traits that act in opposite directions. Gaur et. al. [16] also observed protein content to be negatively correlated with seed size(r =-0.40) and grain yield per plant (r =-0.18). He indicated that an increment in protein content is expected to have a negative effect on seed size and grain yield. However, careful selection of transgressive segregants with high protein content along with moderate seed size and utilizing diverse sources of high protein content will be useful in developing chickpea cultivars with high protein content and high grain yield.

Besides seed yield and seed size, the protein content was also observed to be influenced by the locations and environments. The protein and carbohydrate content of chickpea has been shown to vary widely depending on genotype, growing conditions during grain maturation, cultural practices and sowing time (autumn or spring) [17,18,19,20]. Tayyar et. al. [20] reported higher protein content in chickpea from spring than autumn plantings and attributed this higher protein concentration to the shorter period for pod filling and less starch accumulation under spring sowing. In the present study, the experiment was conducted at four different locations *viz.*, Kota, Bundi, Aklera, Khanpur of three districts (Kota, Bundi, Jhalawar), the protein content of all the genotypes was observed higher than the mean in Kota while it was lower than mean in Aklera as compared to other locations. This might be due to contrasting climatic conditions in Kota and Aklera as Kota is covered under irrigated area while Aklera is covered under dryland area. Although chickpea is said to be a rainfed crop but it responds well to fertilizers and irrigation. The maximum protein content with increasing frequency of irrigation in chickpea was also reported by Dixit et. al. [21], Patel et. al. [22] also reported that the protein content and protein yield were significantly higher with 0.8 IW/CPE ratio as compared to 0.4 IW/ CPE ratio. This indicates the influence of moisture or irrigation on protein content [23].

Table 2. Mean values of 100-seed weight (g) of chickpea genotypes at different locations

S. No.	Entries	Locations				Mean
		ARS, Kota	ATC, Bundi	ARSS, Khanpur	ARSS, Aklera	
1.	RKG 13-515-1	21.15	24.65	22.50	23.25	22.88
2.	GNG 2144 (C)	15.40	17.10	16.85	20.00	17.33
3.	RVG 202 (C)	20.30	22.69	21.46	23.50	21.98
4.	RVG 203(C)	20.75	21.10	21.78	23.75	21.84
5.	GNG 1958 (C)	26.50	27.10	25.60	25.25	26.11

Table 3. Mean values of seed yield (kg/ha) of chickpea genotypes at different locations

S. No.	Entries	Locations				Mean
		ARS, Kota	ATC, Bundi	ARSS, Khanpur	ARSS, Aklera	
1.	RKG 13-515-1	2622	3411	2615	3458	3027
2.	GNG 2144 (C)	2127	3146	2129	2843	2561
3.	RVG 202 (C)	2164	2719	1708	2865	2364
4.	RVG 203(C)	2392	2542	1857	3064	2464
5.	GNG 1958 (C)	2339	3023	2144	3086	2648
	CD (5%)	278.08	276	465.27	366.23	

Table 4. Mean values of protein content (%) of chickpea genotypes at different locations

S. No.	Entries	Locations				Mean
		ARS, Kota	ATC, Bundi	ARSS, Khanpur	ARSS, Aklera	
1.	RKG 13-515-1	20.65	20.53	19.96	16.35	19.37
2.	GNG 2144 (C)	23.06	20.19	20.30	20.59	21.03
3.	RVG 202 (C)	20.30	20.15	19.27	17.53	19.31
4.	RVG 203 (C)	20.65	19.38	20.07	19.41	19.87
5.	GNG 1958 (C)	20.76	17.65	18.69	16.32	18.35

Table 5. Overall mean values of yield and attributing traits across the locations

S. No.	Entries	Characters				
		Days to 50% flowering	**Days to maturity**	**100-seed weight (g)**	**Seed yield (kg/ha)**	**Protein (%)**
1.	RKG 13-515-1	70	120	22.88	**3027**	19.37
2.	GNG 2144 (C)	74	124	**17.33**	2561	**21.03**
3.	RVG 202 (C)	68	117	21.98	2364	19.31
4.	RVG 203(C)	**67**	**114**	21.84	2464	19.87
5.	GNG 1958 (C)	77	125	26.11	2648	18.35

4. CONCLUSION

The genotypes RKG 13-515-1 and GNG 2144 showed consistent performance in terms of seed yield and protein content, respectively at most of the test locations. The genotypes RKG 13-515-1, RVG 203 and GNG 2144 seemed promising for the desirable traits like high yield, early flowering and maturity, small seed size and protein content. These genotypes can be used as parents in hybridization programme to develop transgressive segregants having high yield and protein content with early maturity.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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