ISSN 1479-2621
Plant Genetic Resources: Characterization and Utilization (2019) **17**(5); 464–467
doi:10.1017/S147926211900025X

Short Communication

Characterization of chickpea gene pools for nutrient concentrations under agro-climatic conditions of North-Western Himalayas

Humara Fayaz[1,2], Irshad Ahmad Rather[2], Aijaz A. Wani[1], Sandhya Tyagi[2], Renu Pandey[3] and Reyazul Rouf Mir[2]*

[1]*Cytogenetics and Reproductive Biology Laboratory, Department of Botany, University of Kashmir, Srinagar, India,* [2]*Division of Genetics and Plant Breeding, Faculty of Agriculture, SKAUST-K Wadura Sopore, Kashmir, India and* [3]*Mineral Nutrition Laboratory, Division of Plant Physiology, ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India*

Received 28 May 2019; Accepted 10 July 2019 – First published online 10 September 2019

Abstract

Chickpea is one of the most important nutritious grain legume crops in the world. There is limited information available on micro- and macro-nutrients in chickpea. Therefore, an effort was made to evaluate a set of 40 chickpea genotypes belonging to all the gene pools including cultivated (*Cicer arietinum*) as well as wild, *Cicer reticulatum* from the primary gene pool, *Cicer echinospermum* from the secondary gene pool and *Cicer microphyllum* from the tertiary gene pools. Concentration in the seed of the micro- (Zn, Fe, Cu and Mn) and macro-nutrients (Ca, Mg and K) was studied. Substantial variation was observed among different gene pools for the concentration of all the nutrients. The cultivated chickpea exhibited higher seed Cu, Mn, Mg and Ca than wilds indicating positive domestication effect, whereas wild crop relatives were found to have higher levels than cultivated chickpeas for seed Zn, Fe and K concentrations. While comparing *desi*-type chickpeas with *Kabulis*, it was revealed that *desi* types possessed more Zn, Cu, Ca and Mg than *Kabulis* but reverse was true for seed Fe, Mn and K. Among different *desi* types (*desi* brown, *desi* green and *desi* black), *desi* brown types were generally associated with higher mineral nutrient levels. The present study led to the identification of most promising genotypes for different seed micro- and macro-nutrients. These promising lines may serve as genetic resources useful in gene discovery programmes and for alleviating malnutrition or hidden hunger in the developing world.

Keywords: chickpea, different gene pools, mineral composition, promising nutrient-dense genotypes

Introduction

Chickpea is the world's most important grain legume crop. Micro-nutrient malnutrition has several ill-effects on human health and high healthcare costs all over the world (Welch and Graham, 2002). Chickpea is a good source of minerals;

*Corresponding author. E-mail: imrouf2006@gmail.com, rrmir@skuastkashmir.ac.in

it has the potential to contribute to daily Fe and Zn intake and can help to alleviate hidden hunger (Jukanti *et al.*, 2012). A few studies conducted earlier using different market classes of chickpea confirmed that chickpea possess higher seed Fe and Zn content as compared to staple cereals (Jukanti *et al.*, 2012). Different market classes like *desi* versus *Kabuli* types have been evaluated for nutrient concentrations in earlier studies (Aliu *et al.*, 2016). Recently, a study has also evaluated a set of wild relatives including lines from primary gene pool species and a few lines from secondary gene pool species for seed nutrient content (Von Wettberg *et al.*, 2018). However, reports on all gene pools of chickpea for comparative nutrient densities are meagre (Kahraman *et al.*, 2017). In addition, there is hardly any report available where nutrient concentrations in chickpea have been evaluated from North-Western Himalayas of the state Jammu and Kashmir, India despite the fact that the state high hills of Jammu and Kashmir are the natural habitat for tertiary gene pool species of chickpea. Therefore, there is an urgent need to evaluate chickpea genotypes belonging to all gene pools to fill the gaps in the available literature. We evaluated a set of 40 chickpea genotypes including members of both cultivated chickpea as well as wild chickpea from all gene pools for key micro- and macro-nutrients. Most promising genotypes with high micro-nutrient concentration have been identified for chickpea breeding programmes, transcriptomics, applied genomics and crop biotechnology programmes.

Experimental details

A set of 40 Chickpea genotypes including *desi* chickpea, *desi* stay green, *Kabuli* chickpea and wild relatives belonging to different gene pools were evaluated for nutrient concentrations (online Supplementary Table S1). The wild relatives included *Cicer reticulatum*, *Cicer echinospermum* and *Cicer microphyllum*. The seed material of tertiary gene pool species *C. microphyllum* was collected from its wild natural habitat in Leh Ladakh region of the state of Jammu and Kashmir, India. All standard agronomic practices were followed in order to raise a good crop.

The micro-nutrient concentrations in a set of 40 genotypes were estimated and involved following procedure briefly.

(i) Seeds of 5–10 representative plants were selected and surface cleaned with 70% ethanol to remove soil and dust and further oven dried at 55–60°C. (ii) Random sample of 20 seeds from each genotype was finely ground to flour. (iii) Ground seed samples (500 mg) were digested using 9:4 diacid mixture (HNO_3:$HClO_4$) (Dutta *et al.*, 2016). The aliquot was used to quantify micro- (Zn, Fe, Cu, Mn) and macro- (Mg, Ca, K) nutrients by atomic absorption spectrophotometer against standard solutions of known concentration. (iv) Data were statistically analysed using MS-Excel 2007.

Discussion

Chickpea is one of the most important legume crops inherently loaded with micro- and macro-nutrients for nutritional security in the world. Our results revealed significant variation for seed Zn and Fe concentrations among different genotypes including cultivated and wild genotypes. The wild genotypes possessed higher seed Zn, Fe and K concentration than cultivated chickpeas (Table 1). Among the cultivated gene pool, *desi* chickpeas possessed significantly higher Zn concentration as compared to *Kabuli* types while the reverse was true for Fe concentration (Table 1). These findings got support from some earlier studies (Ibáñez *et al.*, 1998; Wang *et al.*, 2010). Our results indicated that black-seeded chickpea are best for alleviating seed Zn deficiency. The pea-shaped chickpea possess highest seed Zn concentration than both *desi* and *Kabuli* types indicating transgressive segregation for seed Zn content in pea-shaped chickpeas.

Similarly, for seed Fe concentration within *desi* types indicated that *desi* brown types are best for alleviating Fe deficiency. The pea shaped was found to possess intermediate seed Fe concentration (between *desi* and *Kabuli* types) (Table 1).

The cultivated chickpeas have Cu concentration much higher than wild types (Table 1). Seed Cu concentration in *desi* chickpeas was found to be more than *Kabuli* chickpeas. Similar results were also reported in some earlier studies (Chavan *et al.*, 1986).

Seed Mn concentration revealed that the average Mn concentration in *desi* chickpeas was less than *Kabuli* chickpeas (Table 1). The variation in results in different studies may be attributed to different germplasm used under different environmental conditions and different estimation procedures.

The analysis of the macro-nutrients between cultivated and wild gene pools indicated that wild chickpeas possess more K than cultivated but the other two macro-nutrients such as seed Ca and Mg showed a reverse trend (Table 1). The results indicated positive domestication effects on seed Ca and seed Mg concentration while as negative domestication effects on seed K concentration and this also indicates that K could be improved by involving wild gene pools in crossing programmes with cultivated chickpeas.

The nutrient analysis among wild relatives revealed some important facts such as *C. microphyllum* is inferior in terms of nutrient availability (Zn, Fe, Cu, Mn K, Ca and Mg) than both *C. reticulatum* and *C. echinospermum* (Table 2). However, more efforts need to be made in future

https://doi.org/10.1017/S147926211900025X Published online by Cambridge University Press

Table 1. Variation for micro- and macro-nutrients in different cultivated versus wild gene pools and among different cultivated chickpea types/colour classes

Genotypes	Value	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
Cultivated	Min	26.95	82.6	1.3	1630	7671	1370	13,203
	Max	46.89	143.5	10.2	3780	15,000	1449	33,264
	Avg	37.60	104.9	4.7	2674	11,539	3665	19,736
Wild	Min	32.45	100.8	2.1	1570	12,400	1130	1847
	Max	41.18	128.4	3.7	2590	15,000	4860	23,904
	Avg	38.19	114.9	2.98	2046	11,784	2698	15,457
Variation for micro- and macro-nutrients in different cultivated chickpea seed types/seed colours								
Desi	Min	26.95	82.6	1.3	1630	7671	1430	15,103
	Max	46.89	143.5	10.2	3780	14,979	8740	33,264
	Avg	38.05	103.95	4.9	2674	11,321	3935	20,189
Kabuli	Min	29.6	95.5	1.8	2350	10,019	1610	16,138
	Max	38.44	124.5	5.6	3290	15,000	5650	20,063
	Avg	33.7	112.8	3.6	2950	12,120	2904	17,702
Desi brown	Min	29.61	93	1.3	1800	7671	1590	15,241
	Max	42.75	117.5	10.2	3730	13,470	8740	25,262
	Avg	36.25	103.9	5.6	2745	11,919	4612	21,228
Desi green	Min	26.95	82.6	1.4	1800	10,654	1370	15,103
	Max	46.89	131.8	10.2	3780	13,470	14,490	26,594
	Avg	37.89	101.54	5.02	2637	10,949	3810	19,745
Desi black	Min	37.24	97.4	3.9	1980	11,894	2440	16,976
	Max	42.29	102.3	9.2	2610	14,979	5190	17,437
	Avg	39.76	99.85	6.55	2295	13,436	3815	17,206
Pea shaped	Min	30.54	87	2.5	1630	8557.5	2950	13,203
	Max	45.69	120.4	3.7	3390	10,894	4700	33,264
	Avg	39.49	107.1	3.2	2773	9910	3900	21,471

Table 2. Variation for micro- and macro-nutrients in different wild chickpea gene pools

Gene pool	Value	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
Primary	Min	39.79	113.39	2.1	1920	14,399	1130	16,675
(*C. reticulatum*)	Max	41.18	119	3.7	2040	15,000	1890	19,366
	Avg	40.48	116.19	2.9	1980	14,699	1510	18,020
Secondary	Min	39.3	113.3	2.2	2110	12,761	2010	22,239
(*C. echinospermum*)	Max	39.85	128.4	3.6	2590	14,549	4860	23,904
	Avg	39.575	120.85	2.9	2350	13,655	3435	23,071
Tertiary (*C. microphyllum*)	Mean	32.45	100.8	2.3	1570	12,400	2950	1847

to collect more accessions of *C. microphyllum* from their natural habitat to test their nutrient status. *Cicer echinospermum* was found to possess more seed Fe, Mn, Ca and Mg than *C. reticulatum*; *C. reticulatum* was found to possess more seed Zn and K. For seed Cu concentration, the two species did not show any difference (Table 2). The results of seed K and Zn content got support from an earlier study involving the same material from UC-Davis (von Wettberg *et al.*, 2018).

In summary, cultivated chickpea was found much superior to wild chickpeas in terms of nutrient density indicating positive domestication effect. Among cultivated types, *desi*

https://doi.org/10.1017/S147926211900025X Published online by Cambridge University Press

chickpea genotypes were found superior to *Kabuli* types and these findings got support from some earlier studies (Veenakumari *et al*., 2017).

The best genotypes identified from our study (online Supplementary Table S2) can be selected as potential donors for targeted micro-/macro-nutrient bio-fortification programmes in future. However, it is advised to evaluate these genotypes for micro and macro-nutrients again under the range of environments before their use in future breeding or genomics programmes.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S147926211900025X

References

Aliu S, Kaul HP, Rusinovci I, Shala-Mayrhofer V, Fetahu S and Zeka D (2016) Genetic diversity for some nutritive traits of chickpea (*Cicer arietinum* L.) from different regions in Kosova. *Turish Journal of Field Crops* 21: 156–161.

Chavan JK, Kadam SS, Salunkhe DK and Beuchat LR (1986) Biochemistry and technology of chickpea (*Cicer arietinum* L.) seeds. *Critical Reviews in Food Science and Nutrition* 25: 107–158.

Dutta SK, Chatterjee D, Sarkar D, Singh SB, Boopathi T, Kuotsu R, Vikramjeet K, Akoijam RS, Saha S, Vanlalhmangaiha, Malsawmzuali, Chowdhury S and Lungmuana (2016) Common bean (*Phaseolus vulgaris* L., Fabaceae), landraces of Lushai hills in India: nutrients and antioxidants source for the farmers. *Indian Journal of Traditional Knowledge* 15: 313–320.

Ibáñez MV, Rincón F, Amaro M and Martínez B (1998) Intrinsic variability of mineral composition of chickpea (*Cicer arietinum* L.). *Food chemistry* 63: 55–60.

Jukanti AK, Gaur PM, Gowda CLL and Chibbar RN (2012) Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): a review. *British Journal of Nutrition* 108: S11–S26.

Kahraman A, Pandey A and Khan MK (2017) Nutritional diversity assessment in chickpea – a prospect for nutrient deprived world. *Harran Tarım ve Gıda Bilimleri Dergisi* 21: 357–363.

Veenakumari VN, Kasturiba B and Vijaykumar AG (2017) Mineral composition and sugars content in chickpea (*Cicer arietinum* L.) varieties. *International Journal of Current Research* 12: 62144–62147.

Von Wettberg EJ, Chang PL, Başdemir F, Carrasquila-Garcia N, Korbu LB, Moenga SM and Cordeiro MA (2018) Ecology and genomics of an important crop wild relative as a prelude to agricultural innovation. *Nature Communications* 9: 649.

Wang N, Hatcher DW, Tyler RT, Toews R and Gawalko EJ (2010) Effect of cooking on the composition of beans (*Phaseolus vulgaris* L.) and chickpeas (*Cicer arietinum* L.). *Food Research International* 43: 589–594.

Welch MR and Graham DR (2002) Breeding crops for enhanced micronutrient content. *Plant and Soil* 245: 205–214.