Mineral profile and resilience to low water provision of white and black chickpea varieties (*Cicer arietinum*)

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INTRODUCTION

Legumes are of great importance for agriculture and the environment due to their ability to fix atmospheric nitrogen, providing important amounts of minerals, and vitamins, being are an excellent option for a balanced diet (Geraldo *et al*., 2022). Among the most consumed legumes worldwide, chickpeas (*Cicer arietinum*) have gained evidence in these past decades, through increased individual production, intercropping with other crops, and formulation of food products, thus improving the resilience of agroecosystems at lower environmental costs (Saget *et al*., 2020). However, the exploitation of traditional chickpea varieties, such as the black chickpea, has been overlooked, and the recovery of under-exploited traditional varieties could contribute to foster biodiversity, promote environmental sustainability and diversify diets. However, current knowledge on the nutritional profile of commercial and traditional chickpea varieties and their resilience to environmental stresses, such as water scarcity, is very limited, being the focus of this work.

METHODS

Seeds of a commercial white chickpea and a traditional black chickpea variety were analysed for their mineral and protein content as described by Nunes da Silva *et al*. (2022). Antioxidant capacity was determined spectrophotometrically as in Marinova *et al*. (2005). Seeds were then germinated and grown under distinct water provision conditions. Water was provided three times a week, in variable amounts corresponding to 90%, 50% or 25% of the field capacity (N = 15). At pod filling, plants were analyzed for root and shoot fresh weight and number of pods per plant.

RESULTS AND DISCUSSION

Both chickpea varieties had significant amounts of several macro- and micro-nutrients important for human nutrition, such as potassium (which averaged (≈) 2 $mg.g^{-1}$), magnesium (≈ 600 $µ.g^{-1}$), zinc (≈ 17 $µg.g^{-1}$) and iron (≈ 23 $µg.g^{-1}$) (Table 1). The white chickpea was richer in boron (by 30%), while the black chickpea had a higher content of antioxidant compounds (by 32%), which comprise bioactive non-nutrients important for human health (Geraldo *et al*., 2021). These results support the inclusion of chickpea in novel food formulations, including, e.g., pasta (Saget *et al*., 2020).

Table 1. Nutritional profile of white and black chickpeas. Values represent the mean ± sem and letters indicate statistically different means at *p* < 0.05.

	White chickpea	Black chickpea	*P* value
Magnesium ($mg.g^{-1}$)	0.62 ± 0.01	0.71 ± 0.04	0.064
Iron ($µg.g^{-1}$)	21.1 ± 0.25	24.2 ± 1.35	0.088
Zinc ($µg.g^{-1}$)	16.5 ± 0.64	17.8 ± 0.78	0.271
Boron ($µg.g^{-1}$)	3.13 ± 0.15 ^{a}	2.35 ± 0.20 ^{b}	**0.036**
Protein (%)	15.8 ± 0.05	16.0 ± 0.23	0.584
Antioxidants (%)	0.64 ± 0.01 ^{b}	0.85 ± 0.02 ^{a}	**0.002**

Low water provision (25% field capacity) resulted in significant decreases in root and shoot biomasses and number of pods per plant (from 33 up to 56%), compared with optimal water supply (90% field capacity). In the black chickpea, higher root biomass and lower shoot biomass were observed at lower water supplies (by 65% and 24%, respectively), probably as a strategy for coping with the lower water availability (Martin-Vertedor and Dodd, 2011).

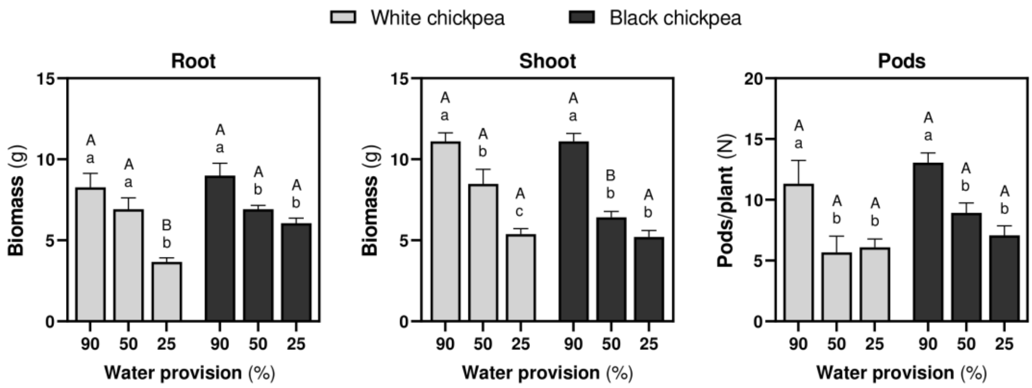

Fig. 1. Root and shoot biomass (fresh weight) and number of pods per plant of white and black chickpeas grown under distinct water supplies. Values represent the mean ± sem. Upper case letters indicate statistically different means between varieties subjected to the same water provision, while lower case letters indicate statistical differences between water provisions within each variety ($p < 0.05$).

CONCLUSIONS

While the white chickpea variety showed higher boron concentration, the black one was richer in antioxidants, highlighting that the intraspecific differences in chickpea nutritional profile could provide sufficient genotypic variability for crop improvement programs. In the black chickpea, low water supplies propelled biomass allocation to roots, which could provide an adaptative strategy in cases of drought events resulting from climate change.

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REFERENCES

Geraldo, R., Santos, C. S., Pinto, E., and Vasconcelos, M. W. (2022) Widening the perspectives for legume consumption: the case of bioactive non-nutrients. *Front. Plant Sci*. 56: doi: 10.3389/fpls.2022.772054

Marinova, D., Ribarova, F., and Atanassova, M. (2005) Total phenolics and total flavonoids in bulgarian fruits and vegetables. *J. Chem. Tech. Metal*. 40: 255-260

Martin-Vertedor, A.I. and Dodd, I.C. (2011) Root-to-shoot signalling when soil moisture is heterogeneous: increasing the proportion of root biomass in drying soil inhibits leaf growth and increases leaf abscisic acid concentration. *Plant Cell Environ*. 34: 1164-1175

Nunes da Silva, M., Fernandes, A.P.G., Vasconcelos, M.V., Valente, L.M.P. and Carvalho, S.M.P. (2022) Influence of the nitrogen source on the tolerance of *Actinidia chinensis* to *Pseudomonas syringae* pv. *actinidiae*. *Acta Hortic*. 1332: 103-110

Saget, S., Costa, M., Barilli, E., de Vasconcelos, M. W., Santos, C. S., Styles, D., and Williams, M. (2020) Substituting wheat with chickpea flour in pasta production delivers more nutrition at a lower environmental cost. *Sustain. Prod. Consum*. 24: 26-38