Article

Agronomic behavior of chickpea crop in the sector of El Limoncito, Ecuador

Ángel Bernardo Llerena Hidalgo§

Department of Agriculture-Faculty of Technical Education for Development-Catholic University of Santiago de Guayaquil. Guayaquil, Ecuador.

§Corresponding author: angel.llerena@cu.ucsg.edu.ec.

Abstract

In the present study, the agronomic behavior of the Peruvian tropicalized chickpea at different sowing distances was evaluated, under the edaphoclimatic conditions of the area of El Limoncito, province of Santa Elena, Ecuador. The experimental design applied was the completely randomized block design (DBCA), where five treatments with different sowing distances were studied, which were T1 (0.1 x 0.5 m), T2 (0.2 x 0.5 m), T3 (0.3 x 0.5 m), T4 (0.4 x 0.5 m) and T5 (0.5 x 0.5 m). In each treatment, the variables of plant height, number of flowers, number of branches, number of pods and yield were analyzed. The results obtained show that T2 with distance of 0.2 x 0.5 m gives optimal results in terms of plant height, number of flowers, number of branches, number of pods and yield.

Keywords: adaptability, edaphoclimatology, chickpea.

Reception date: May 2021
Acceptance date: July 2021

Introduction

Chickpea is the third largest food legume crop in the world (Heidarvand and Maali-Amiri, 2013). South Asia is the largest producer of chickpeas, contributing approximately three quarters of the world chickpea production. The world chickpea production in the period 2010-2018 had a growth of 3.9 million tonnes (Mt), which meant a considerable increase for that period (FAO, 2020). Commercially, two genotypes of chickpea, desi and kabuli, are produced. The kabuli genotype has larger, rounder, cream-colored seeds, while the desi genotype has relatively smaller, angular-shaped, dark-colored seeds (Nisa *et al*., 2020).

Chickpea is a grain of high nutritional power, the protein content for chickpeas desi and kabuli is 16.7 to 30.6% and 12.6 to 29% respectively (Wood and Grusak, 2007). The above indicates that chickpea cultivation is an integral part of the productive stabilization of grains rich in protein, as well as in other agricultural systems in general (Kazydub *et al*., 2019).

In addition to its nutritional importance, chickpea cultivation improves the fertility of agricultural soils, maintaining the productivity of cultivation systems due to its ability to fix atmospheric nitrogen (Sharma *et al*., 2018). On average, the estimated amounts of N fixed by chickpeas under conditions of regular precipitation and drought stress are 60 kg ha^{-1} and 19-24 kg ha^{-1}, respectively (Carranca *et al*., 1999; Abi-Ghanem *et al*., 2012).

Chickpea is quite resistant to drought, but it does not adapt to high humidity conditions. It can be grown rainfed in a cool and dry climate in semi-arid regions and, but with better yields, under irrigation (Saluzzo, 2010; Coirini and Nolasco, 2016). In addition to proper field preparation, the use of high-yield seeds, fertilization and other cultural practices, programming and irrigation are also important parameters in chickpea cultivation (Kirnak *et al*., 2017).

Over the past few decades, due to the increased demand for food, the growing world population is highly dependent on the conservation and use of the plant genetic resources remaining in the world (FAO, 1997; Sharma and Johnson, 2017). These should be studied and selected according to the phenotypic and genotypic variabilities of the agronomic characteristics expected from a crop of good production (Arora, 1991).

Therefore, it is necessary to constantly research different crop varieties in order to have knowledge of the most optimal varieties that can counteract or tolerate the different biotic and abiotic factors that limit crop production (Shagarodsky *et al*., 2001; Fierros *et al*., 2011).

Adaptability implies a property by which the capable organs of a plant survive and reproduce in fluctuating environments, so it is a genetic ability that results from stabilizing interactions with the environment, through genetic and physiological relationships of organisms (Anderson *et al*., 2011).

In Ecuador, chickpeas were formerly sown in the mountain range area belonging to the sector of Riobamba of the province of Chimborazo. Unfortunately, due to the vegetative cycle of six months of this crop, the plantations were affected by pests and diseases that practically decimated the profits of chickpea producers, as there was no alternative for the control of these pests, from the 90s, the sowing of chickpea stopped in these areas.

According to the informative bulletins of INIAP 1992, from this time, the chickpea consumed in the country is a chickpea imported from Peru, Mexico and Canada, for that reason it is necessary to investigate the agronomic behavior of the chickpea crop in the tropical zone of the country as a positive agroecological alternative. Therefore, it was proposed to determine the adaptability of the Peruvian tropicalized chickpea to the soil and temperature conditions of the area of Limoncito area, province of Santa Elena, which is part of the coastal area of Ecuador.

Materials and methods

Place of study

The study was conducted from 2018 to 2019 in El Limoncito, province of Santa Elena during rainy and dry season. The edaphoclimatic conditions are characteristic of a tropical zone, with latitude of 2°13’ 0” north latitude and longitude of 80°14’ 0” west longitude, with altitude 0 masl, with an average temperature of 28 °C and a precipitation of 700 mm.

Experimental design

The variety of chickpea (*Cicer arietinum* L.) used in the present research was of kabuli type of Peruvian origin. An experimental design of completely randomized block design (DBCA) was performed with five treatments and four repetitions. The trial was divided into plots and each one corresponded to an experimental block, the area of each plot was 5 x 5 m= 25 m^2 and each treatment corresponded to different sowing distances (Table 1).

Table 1. Chickpea sowing distances by treatment.

Treatment	Distance (between plants x between treatments, m)
T1	0.1 x 0.5
T2	0.2 x 0.5
T3	0.3 x 0.5
T4	0.4 x 0.5
T5	0.5 x 0.5

For the development of the trial, 5 treatments with 4 repetitions were determined. Each of them depending on their distance, the number of seeds varied per plot. In T1, it was sown with 500 seeds, in T2 with 250 seeds, in T3 with 250 seeds, in T4 with 250 seeds, while in T5 with the highest sowing distance with 100 seeds. To determine the adaptability, the agronomic characteristics of the crop were determined at 45 days, which were: plant height, number of flowers, number of branches, number of pods.

Chickpea yield

After the harvest, 100 grains of chickpea per plant were collected and weighed, to then determine the yield per plant in kg ha^{-1}.

Statistical analysis

For the statistical analysis, the InfoStat program was used. The data obtained were analyzed using an analysis of variance (Anova), then with a Duncan significance test, with a 5% probability of error.

Results and discussion

According to the analyses, the chickpea plants reached satisfactory growth and physiological development, evidenced by the agronomic characteristics observed.

Determination of plant height

The plant height was measured every 15 days until 45 days, with normal and satisfactory growth observed (Table 2).

Table 2. Average plant height at 45 days after sowing.

Treatments	Plant height	
T1	25.03	A B C
T2	26.48	B C
T3	25.85	C
T4	24.43	A B
T5	23.35	A

Means with different letters differ statistically (Duncan, $\alpha \leq 0.05$).

The plant height at 45 days is shown in Table 2, where the best result is observed in treatment T2 with a sowing distance of 0.2 x 0.5 m, which has a plant height of 26.48 cm.

In all treatments there was a significant difference in plant height, where treatment T1 measured 24.03 cm, T3 with 25.85 cm, T4 with 24.43 cm and T5 with the lowest height of 23.35 cm. Saluzzo (2010) indicates that at 60 days the chickpea has an average plant height of 60 cm.

Plant height is associated with growth, heliotropism, competitive vigor, reproductive size, plant fecundity, average longevity and crop adaptability (Pérez *et al.*, 2013). In Peru, chickpea seed varieties were studied under conditions of soil from alluvial origin, in flat terrain and with slope of 0 to 1.5%, soils with moderate drainage, where the sowing distance is 80 cm per row and 40 cm per plant, with optimal results (Chipana, 2015).

The sowing distances analyzed in investigations in Mexico in coastal areas determine as a recommendation that the distance of chickpea per row is 80 cm, this is a factor that will vary according to the climatic conditions, the type of soils, the topographical conditions and its appropriate fertilization to determine the yield and economic profitability (Apáez *et al*., 2016).

Number of flowers per plant

At 45 days after sowing, the number of flowers was counted (Table 3) and good results were observed in all treatments.

Table 3. Average number of flowers per plant made at 45 days.

Treatments	Number of flowers per plant
T1	92.25 A B
T2	93.5 B
T3	89.5 A
T4	105.25 A B
T5	102.5 C

Means with different letters differ statistically (Duncan, $\alpha \leq 0.05$).

According to the statistical analysis, there are significant differences between the treatments, evidencing that the sowing distance influences the development of the plant. Treatments T4 and T5 were the ones with the highest number of flowers with 105 and 102 respectively, while T3 is the one with the lowest number of flowers with 89 and treatments T1 and T2 with 92 and 93 respectively.

Number of branches per plant

The average number of branches per plant at 45 days of all treatments is 4, unlike T2 which had five branches, noting that there were no significant differences, according to the statistical analysis.

Number of pods per plant

In the number of pods per plant at 45 days (Table 4), likewise, there were no significant differences, with an average of 40 pods in treatments T1, T2, T3, while 39 pods were observed in T4 and T5.

Table 4. Average number of pods per plant at 45 days.

Treatments	Number of pods per plant
T1	40
T2	40
T3	40
T4	39
T5	39

Determination of the weight of 100 chickpea grains

After three months of harvest, 100 chickpea grains were collected and weighed. In the results of the statistical analyses, it can be seen that there is a significant difference between the tests carried out (Table 5). It was noted that treatments T1 and T2, with an average of 48.46 g and 49.83 g respectively, were the heaviest. Kabuli-type chickpea had a weight of 100 seeds greater than 25 grams, while 100 seeds of the Desi type weigh less than 25 grams (Vizgarra *et al*., 2017).

Table 5. Weight of 100 grains of chickpea.

Treatment	Weight (g)	
T1	48.46	A
T2	49.83	A
T3	34.22	B
T4	33.16	B
T5	29.48	C

Means with different letters differ statistically (Duncan, α≤ 0.05).

Yield

According to the averages obtained regarding the yield variable expressed in kg ha^{-1} (Table 6), it was observed that the best sowing distance corresponds to treatment T2 with an average of 1 814.14 kg ha^{-1} and the one with the lowest treatment of 986.03 kg ha^{-1}, which is consistent with the results of trials carried out in Mexico City (Moral *et al*., 1994).

Table 6. Average yield in kg ha^{-1}.

Treatments	Yield (kg ha^{-1})	
T1	1766.53	A
T2	1814.14	A
T3	1106.48	B
T4	1088.3	B
T5	986.03	C

Means with different letters differ statistically (Duncan, α≤ 0.05).

From the different yields in the different sowing distances evaluated (Figure 1), in the present trial, it can be concluded that the treatment that had the best agronomic behavior was treatment T2 (0.2 x 0.5 m) with 1 814.14 kg ha^{-1} and the treatment that had the lowest yield was treatment T5 with 986.03 kg ha^{-1}, which shows that for the edaphoclimatic conditions of Limoncito, the distance of 0.2 x 0.5 m is the treatment with the highest yield.

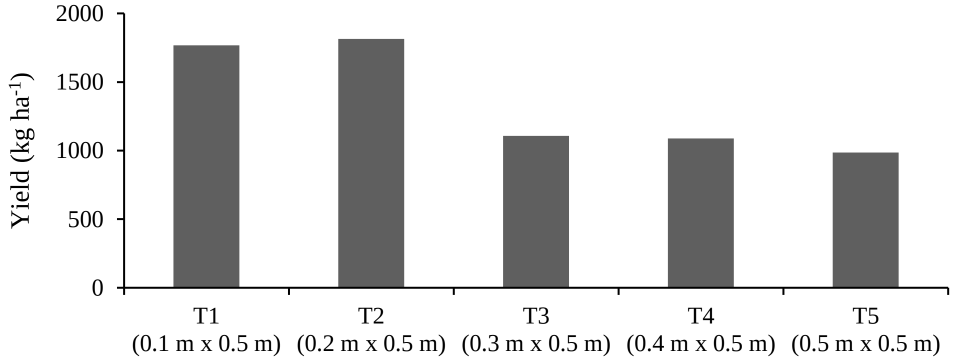

Figure 1. Graphical representation in bars of chickpea yield.

Conclusions

The present research shows that the adaptability of the Peruvian tropicalized chickpea, kabuli type, in the edaphoclimatic conditions of El Limoncito, Ecuador is very favorable, noting that T2 with a sowing distance of 0.2 x 0.5 m is the one with the best agronomic development of the plant in terms of plant height, number of flowers, number of branches, number of pods. This presents a good option for the farmer of tropical areas as a crop production alternative.

Acknowledgements

The authors thank the Institute of Research and Innovation (SINDE) of the Catholic University of Santiago de Guayaquil (UCSG), for the financing of the project: 'Adaptation of chickpea (*Cicer arietinum*) to the edaphoclimatic conditions of Limoncito, province of Santa Elena', which is part of this paper.

Cited literature

Abi-Ghanem, R.; Carpenter-Boggs, L.; Smith, J.; Vandemark, G. 2012. Nitrogen fixation by US and middle eastern chickpeas with commercial and wild middle eastern inocula. ISRN Soil Science.1-5 pp.

Anderson, J. T.; Willis, J. H. and Mitchell-Olds, T. 2011. Evolutionary genetics of plant adaptation. Trends in genetics: TIG. 27(7):258-266.

Apáez, B. M.; Escalante, E. J. A. S.; Rodríguez, G. M. T.; Sosa, M. E. y Apáez, B. P. 2016. Distancia entre hileras, nitrógeno y producción de garbanzo en humedad residual. Rev. Mex. Cienc. Agríc. 7(2):223-234.

Carranca, C. de V. A. and Rolston, D. 1999. Biological nitrogen fixation by fababean, pea and chickpea, under field conditions, estimated by the isotope dilution technique. European Journal of Agronomy. 10(1):49-56.

Chipana, C. 2015. Ensayo de treinta variedades de garbanzo (*Cicer arietinum* L.) sembrado en invierno para condiciones de costa central (Tesis de grado). UNA La Molina Lima, Perú.

Coirini, A. y Nolasco, M. 2016. El cultivo de garbanzo en Córdoba: análisis con imágenes satelitales. CAI, 8º Congreso de AgroInformática. 67-80 pp.

FAO. Organización de las Naciones Unidas para la Alimentación y la Agricultura. 1997. The state of the world's plant genetic resources for food and agriculture. FAO: Roma. Obtenido de: http://www.fao.org/3/a-w7324e.pdf)%D8%9B.

FAO. Organización de las Naciones Unidas para la Alimentación y la Agricultura. 2020. FAOSTAT. Obtenido de: http://www.fao.org/faostat/en/#data/QC.

Fierros, G.; Ortega, P.; Acosta, J.; Padilla, I.; Valenzuela, V.; Jiménez, Y. y López, J. 2011. Respuesta del rendimiento de genotipos de garbanzo blanco a la sequía terminal. Rev. Mex. Cienc. Agríc. 8(5):1143-1154.

Heidarvand, L. and Maali-Amiri, R. 2013. Physio-biochemical and proteome analysis of chickpea in early phases of cold stress. J. PlantPhysiol. 170:459-469.

Kazydub, N.; Kuzmina, S. and Chernenko, S. 2017. Adaptability of chickpea collection samples in the southern forest-steppe of western Siberia. Bulgarian Journal of Agricultural Science. 23(5):743-749.

Kirnak, H.; Varol, I.; Irik, H. and Ozaktan, H. 2017. Effects of Irrigation Applied at Different Growth Stages on Chickpea Yield. Agronomy Research. 15(5):1928-1933.

Moral, J.; Mejias, A. y López, M. 1994. El cultivo del garbanzo: diseño para una agricultura sostenible. Madrid Ministerio de Agricultura Pesca y Alimentación, Secretaria General Técnica. Hojas divulgadoras. España. Ministerio de Agricultura, Pesca y Alimentación. 12-94 pp.

Nisa, Z.; Arif, A. and Waheed, M. Q. *et al*. 2020. A comparative metabolomic study on desi and kabuli chickpea (*Cicer arietinum* L.) genotypes under rainfed and irrigated field conditions. Sci. Rep. 10:13919.

Pérez, N.; Díaz, S.; Garnier, E.; Lavorel, S.; Poorter, H.; Jaureguiberry, P.; Bret-Harte, M.; Cornwell, W.; Craine, J.; Gurvich, D.; Urcelay, C.; Veneklaas, E.; Reich, P.; Poorter, L.; Wright, I.; Ray, P.; Enrico, L.; Pausas, J.; de Vos, A.; Buchmann, N.; Funes, G.; Quétier, F.; Hodgson, J.; Thompson, K.; Morgan, H. D.; Ter Steege, H.; Van der Heijden, M.; Sack, L.; Blonder, B.; Poschlod, P.; Vaieretti, M.; Conti, G.; Staver, A.; Aquino, S. and Cornelissen, J. 2013. New handbook for standardised measurement of plant functional traits worldwide. Australian Journal of Botany. 61:167-234.

Saluzzo, A. 2010. Adaptación del cultivo de garbanzo en función de la variabilidad ambiental. 3ª Jornada Nacional de Garbanzo, INTA EEA Salta.

Shagarodsky, T.; Chiang, M. y López, Y. 2001. Evaluación de cultivares de garbanzo (*Cicer arietinum* l.) en Cuba. Agronomía Mesoamericana. 12(1):95-98.

Sharma, R. and Johnson, P. 2017. Genotype x environment interaction and stability analysis for yield traits in chickpea (*Cicer arietinum* L.). Electronic Journal of Plant Breeding. 8(3):865-869.

Sharma, R.; Abraham, S.; Bhagat, R.; Mishra, T. and Prakash, O. 2018. Evaluation of chickpea varieties treated with bio inoculants for yield performance, disease resistance and adaptability to climatic conditions of Gariyaband district in Chhattisgarh. Legume Research. 41(1):57-59.

Vizgarra, O.; Espeche, C.; Silvana, Y.; Mamaní, G. y Daniel, P. L. 2017. TUC 403 y TUC 464, dos nuevas variedades de garbanzo tipo Kabuli para el noroeste argentino. Rev. Ind. y Agríc. de Tucumán. 94(1):41-47.

Wood, J. and Grusak, M. 2007. Nutritional Value of Chickpea. In Chickpea Breeding and Management. CAB International. 101-142 pp.