Studies of agronomic performance of quinoa (Chenopodium quinoa Willd.) genotypes under arid conditions of northeast of the Algerian Sahara (Case of Oued righ)

Mabrouka Oustani[1]*, Mohammed Tahar Halilat[2] and Smail Mahda [3]

1, *2 .Laboratory of Saharan Bio-Resources: Preservation and Development, Faculty of Nature and Life Sciences and Sciences of Earth and Universe, University of Kasdi Merbah, 30000 Ouargla, Algeria*.
3. University of El Oued, Fac. Life and Natural Sciences, Department of Agronomy, El Oued (39 000), Algeria.

Abstract

The varietal behavior of six quinoa genotypes (Giza1, Sajama, Santa Maria, Q102, Q29, Q27 and Q18) was monitored under arid conditions of Oued righ region. The adopted experimental device is of random block type (with four blocks).Measurements included emergence rate, seed yield and thousand kernel weight. The obtained results showed that all the genotypes tested detected an adaptive potential to the extreme edapho-climatic conditions of the arid environment with a high germinating rate for all genotypes. The best yield was in favor of genotype Q102 (302.21g m^{-2}). While, the lowest yield was recorded by the Santa Maria genotype which recorded a yield of the order of (203.33 g m^{-2}). The obtained results show that quinoa holds great promise as a new crop in the agricultural production systems in south of Algeria adapts very well with the pedoclimatic conditions of Algeria.

Key words: Quinoa, Varietal Behavior, Adaptation, Arid Conditions.

INTRODUCTION

Quinoa (Chenopodium quinoa Willd.) is an annual grain plant native to the Andean region of South America. This plant adapts to different zones range from sea level up to 4000 m altitude with its rich genetic diversity [1].

Its main nutritional value is its balanced and complete composition of essential amino acids, comparable to that of milk and higher than that of wheat and other cereals [2]. Quinoa offers a mineral content (Ca, K, P, Mg, Fe and Zn) and vitamins (B1, B9, C and E), higher than that of conventional cereals [3].

In addition to having a very high nutritional value, quinoa is very resistant and grows where other varieties no longer produce. This plant is known by resistance to various abiotic stresses such as salinity, drought and high evapotranspiration rate [4, 6, 7, 8].

For these reasons, the benefits of quinoa offer opportunities for an alternative commercial crop, promising to be grown in arid and semi-arid environments that are prohibitive for other species and may therefore be able to use soil and high salinity waters in a sustainable and productive way. The introduction of quinoa cultivation in Algeria opens up great prospects for development, because of the adaptation of this plant associated with cereals to arid climates.

It is within this framework, that we proposed to study of the agronomic performance of different quinoa genotypes under arid conditions of northeast of the Algerian Sahara.

MATERIAL AND METHODS

Ecological context of study site

The trial was conducted in private farm's in the Oued righ area in the Northeast of the Algerian Sahara (32 ° 54 'to 39 ° 9' North and longitude 05 ° 50'to 05 °75 'East). The climate of the Oued-Righ region is arid with a monthly average temperature ranging from about 5 ° C in winter to 40 ° C in summer. The study site soil is characterized by a sandy texture, an alkaline pH, a high electrical conductivity ($CE_{1/5}$) and low percentage of C org and Nt % (Table 1). The water used for irrigation is characterized by an electrical conductivity of 7.65 dS m^{-1} and a pH of 8.6. According to the classification established by [9], the water used is inadequate for irrigation in ordinary conditions, but it can be used when soils are permeable with good drainage.

Table 1. Physical and chemical soil of experimental field

Sand (%)	Silt (%)	Clay (%)	pH (1.2.5)	$CE_{1/5}$ ($dS^{-1}m$)	C (%)	Nt %
73.50	23.28	5.15	8.37	4.27	0.32	0.027

Experimental design and trial conduct

The field experiment was conducted during the 2017-2018 cropping season in the private exploitation in Oued righ region. The trial protocol compares the production and early maturity potential of six quinoa genotypes (Giza 1, Sajama, Santa Maria, Q102, Q29, Q27 and Q18). The experimental design consisted in randomized blocks type (with four replicates). The trial includes 24 elementary plots. The area of each elementary parcel is 6 m^2 (3 × 2). The spacing between blok, row and seedlings is 1, 50 and 0.35 cm respectively. Sowing was carried manually out on 18 November 2018 by dibbling 6-7 seeds per pocket into the soil to a depth of 1 à 2 cm . A sowing density was 15 kg ha^{-1}.The irrigation supplied every two days using localized irrigation" as drop by drop irrigation. It was arrested a week before harvest which was carried on 14 March 2018. Weeding and phytosanitary treatments were done manually to keep the crop free of weeds throughout the growing season.

For the germination test, seeds were placed on filter paper in 9 cm diameter Petri dishes. The later were hermetically sealed with parafilm and kept in the growth chamber at a temperature of 25 ±1 °C (72 h) in the dark with a relative humidity of 70 %. The germination rate is expressed as the ratio of the number of sprouted seeds to the total number of sprouted seeds according to the following formula :

Germination rate = 100×NT /NG where

- NTG : Number of sprouted seeds

- NTGG : Number of total seeds

At harvest five plants of each genotype per elementary plot were selected at random to measure the weight 1000 seed (g) and seed yield.

STATICAL ANALYSIS

Obtained data were statistically analyzed by one-way analysis of variance using the programme R-commander (Rcmdr) (R Development Core Team, 2013).

RESULTS AND DISCUSSION

Germination and emergence rate of quinoa genotypes

Non significant results regarding germination among different genotypes were indicated in figure 1.In fact, high germination rates were recorded for all genotypes tested. The germination rate ranged from a low rate of 82% for Santa maria to a high rate of 100% for Q102, Q29, Q27. These results indicate that despite the importance of germination rate recorded for all the varieties studied; a lower emergence rate was observed per m² under field conditions, in particularly for Santa Maria and Q18, who recorded the lowest levee rates with 69.88 and 70.8 % respectively. This can be explained by the direct influence of medium conditions and genotype of quinoa on the emergence rate.

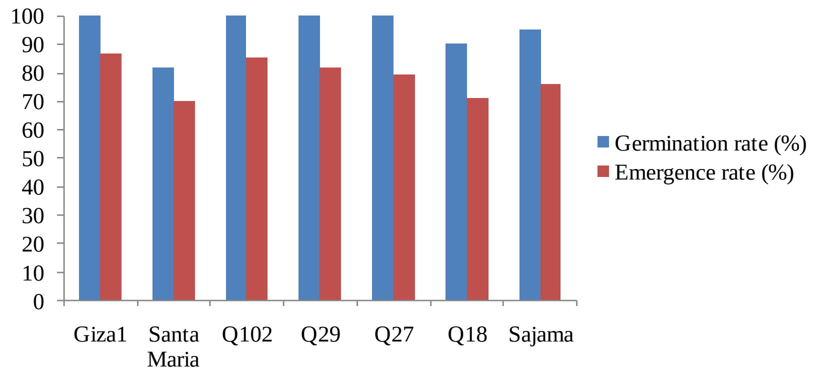

Figure1. Variation of germination test and emergence rate of quinoa genotypes

Seed yield (g m^{-2})

Statistically significant differences between quinoa genotypes were noted for seed yield (*P<0.01*) (Table 2). The highest yield was recorded by Q102 genotype with (302.21g m^{-2}). while, the lowest yield was recorded by the Santa maria with genotype (203.31 g m^{-2}), (203.31 g m^{-2}), with a reduction rate of 48, 42.9, 33.33 and 28.04 and 23.9% compared to Q102, Giza1, Sajama (Q29, Q27) and Q18 genotypes respectively.

These quinoa grain yields are comparable to those obtained by [10] for a similar sowing date in southern Morocco. Also addition, obtained results approached to those recorded by the results of the study carried out at Hassi Ben Abdellah (ITDAS,Ouargla, 2015) [11], who indicates that the Q102 genotype was ranked first with a maximum yield of 320 g m^{-2}. However, our results are not consistent with those reported by [12] in north of Algeria, who indicated that Q102 genotype is characterized by a weak performance compared to other genotypes.

The difference in yield between these field trials, particularly for genotype Q102, may be due to the date of sowing and / or soil and climate conditions in each region.

Weight of 1000 seeds

Statistical analysis on the weight of 1000 seeds detected significant differences between the seven quinoa genotypes tested (P <0.01) (Table 1). The best weight of 1000 seeds was recorded by Sajama genotype with a weight of 2.75g ; however the lowest weight was recorded by the Q29 and Q18 genotypes with 1.75 and 1.70g, respectively for the two genotypes.

The weights of 1000 grains recorded by this study are similar to those reported by Margarita *et al*. (2018) [13] but inferior to those obtained by [14].

A low thousand-grain weight may be the result of high seeding density, water deficit, or insufficient nitrogen fertilization at the time of accumulation of grain reserves.

According to [15], the weight of 1000 grains depends on mineral and water nutrition conditions, population density and climatic conditions.

Table 1. Yield parameters of quinoa genotypes (values are presented as means of four replicates and values in the parentheses represent the standard deviation (SD)

Genotype	Weight 1000 seed (g)	Seed yield (g m^{-2})
Giza1	2.15 ± (0.19) (b)	290.64 ± (20.25) (ab)
Santa Maria	2.70 ± (0.8) (a)	203.31 ± (19.64) (e)
Q102	2.20 ± (0.6) (b)	302.21± (23.22) (a)
Q29	1.75 ± (0.09) (d)	270.55 ± (30.01) (b)
Q27	2.05 ± (0.4) (c)	250.31 ± (25.63) (d)
Q18	1.70 ± (0.07) (d)	250.39 ± (19.33) (d)
Sajama	2.75 ± (0.38) (a)	260.23 ± (29. 16) (c)

CONCLUSION

The present study provides knowledge about the agronomic performance of seven genotypes of quinoa introduced to south of Algeria .The results from the field trial show that quinoa holds great promise as a new crop in the agricultural production systems in south of Algeria adapts very well with pedoclimatic conditions of south of Algeria. The seed yields obtained from the studied genotypes are considered medium compared to the yields reported from the more favorable growing environments. Results showed that Q102 genotype can be successfully grown under arid conditions of the south of Algeria because it has high grain yield and perform well in terms of the yield components examined.

REFERENCES

[1] Jacobsen S-E, Liu F, Jensen CR. 2009. Does root-sourced ABA play a role for regulation of stomata under drought in quinoa (Chenopodium quinoa Willd.). Scientia Horticulturae 122:281–287.

[2] Nowak V, Du J, Charrondière UR. 2016. Assessment of the nutritional composition of quinoa (*Chenopodium quinoa* Willd.). *Food Chemistry* 193:47–54 .

[3] Reguera M., Conesa CM., A Gil-Gómez **. A** , Haros **CM.** , Pérez-Casas MG **.**, Briones-Labarca V ., Bolaños L0, Bonilla I., Álvarez R**.** , Pinto k ., Mujica Á **. ,** Bascuñán-Godoy L ., 2018. The impact of different agroecological conditions on the nutritional composition of quinoa seeds. Peer J 6:e 44-42.

[4] Ruiz KB, Biondi S, Oses R, Acun ˜ a-Rodrı ´guez IS, Antognoni F,Martinez-Mosqueira EA, Coulibaly A, Canahua-Murillo A, Pinto M,Zurita-Silva A, Bazile D, Jacobsen S-E,

[5] Ruiz-Carrasco K, Antognoni F, Coulibaly AK, Lizardi S, Covarrubias A,Martı ´nez EA, Molina-Montenegro MA,

[6] Geerts, S., Raes, D., Garcia M., Condori, O., Mamani, J., Miranda, R., Cusicanqui, J., Taboada, C., Yucra, E.,Vacher, J., 2008. Could Deficit Irrigation Be a Sustainable Practice for Quinoa (*Chenopodium quinoa* Willd.) in The Southern Bolivian Altiplano? Agricultural Water Management 95, 909- 917.

[7] Sun Y, Liu F, Bendevis M, Shabala S, Jacobsen S-E. 2014. Sensitivity of two quinoa (Chenopodium quinoa Willd.) varieties to progressive drought stress. Journal of Agronomy and Crop Science 200:12–23.

[8] Khalil M. Saad-Allah1• Mohamed S. Youssef. 2018.Phytochemical and genetic characterization of five quinoa(Chenopodium quinoa Willd.) genotypes introduced to Egypt Physiol Mol Biol Plants.

[9] Durand, JH., 1983. Les sols irrigables. Paris : Presses universitaires de France, 322 p.

[10] Hirich1 A., R. Choukr-Allah1 R., Jacobsen S.-E. 2014. Effect of Sowing Dates on Development. Quinoa in Morocco – Effect of Sowing Dates on Development and Yield J Agro Crop Sci, ISSN 0931-2250.

[11] Institut Technique de Développement de l'Agronomie Saharienne .2015.

[12] Gasemi A., 2016. Introduction and assessment of Quinoa in Algeria: Field trial evaluation of eleven *Chenopodium quinoa* genotypes grown under Mediterranean conditions. (INRRA) (Algeria).

[13] Margarita Miranda, Antonio Vega-Gálvez, Enrique A. Martínez, Jéssica López, Rosa Marín, Mario Aranda, and Francisco Fuentes,2013). Influence of contrasting environments on seed compositionof two quinoa genotypes: nutritional Chilean journal of agricultural research 73(2).

[14] El-sadek Ashraf N. Multi-environmental evaluation for grain yield and its components of quinoa genotypes across the northwestern coast of Egypt (2017). Egyptian J. Desert Res., 67, No. 1, 65-82 (2017) Egyptian J. Desert Res., **67**, No. 1, 65-82 .

[15] Masle J. Meynard K. et Sebillotte M., 1981. Etude de l'hétérogéneité d'un peuplement de blé d'hiver. Notion de structure de peuplement. Rev. agricole, 107-116.