Evaluation of Quinoa varieties for crop diversification in the Rhamna region

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ABSTRACT

Quinoa is recognized as a crop of great value in terms of tolerance to abiotic stresses and there is growing interest to introduce it in marginal agricultural production systems, such as Rhamna region. In this context, Quinoa has been given special attention as drought tolerant crops and a cash crops to increase the revenue of the poor farmers. It was considered as a versatile agro-industrial crop, rich in nutrients and able to thrive in extreme climatic and soil conditions.

The main objective of this work is to evaluate growth, productivity and adaptation of several quinoa including those developed at ICBA in UAE and two Danish varieties compared to the mixture of lines locally cultivated in Morocco. The trial was carried out in the experimental farm of Mohamed VI Polytechnic University in a completely randomized bloc design.

The ICBA lines had maximum heights at maturity. Puno and Titicaca recorded minimum values for stem diameter, length and diameter of the inflorescence. Q2 line recorded the highest yield (34.03 qx / ha) with a relatively low harvest index (0.19) which makes this line suitable for both fodder and seed production. Puno is a variety that has recorded low values in terms of yield only in terms of harvest index.
Titicaca variety has shown satisfactory harvest index values with acceptable grain yields (19 qx / ha). It's grain yields would therefore make it well adapted to local production conditions and can therefore be used as a seed for quinoa production.
The morphological traits that were recorded in the same environment, show that the genotype influence the variation between characters.
Regarding qualitative traits, no effect of genotype on color of inflorescence and pericarp was observed. Thus, the dominance of the orange color for the inflorescence and the cream for the pericarp (any genotype combined).

Key words: *Chenopodium quinoa*, Qualitative traits, Quantitative traits, adaptation, Characterization.

STUDY ZONE

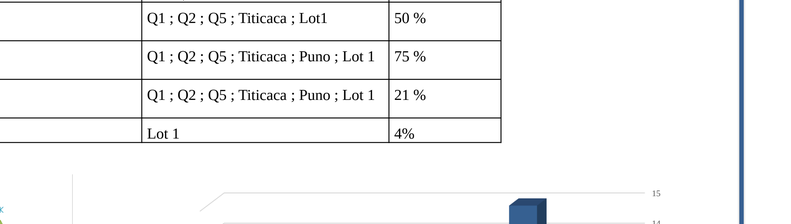
Map 1: map: province and prefecture of the marrakech safi region

STUDY CONTEXT

Problem related to this study: Rhamna is a region subject to several climatic constraints:

- ✓ Soils with low production potential
- ✓ Saline and degraded soils
- ✓ Irregularity inter and intra annual precipitation
- ✓ Semi-arid climate (annual rainfall <200 mm)
- ✓ Water is scarce and difficult to exploit
- ✓ Low diversity crops: dominance of cereals

Diversification of crops by introducing new alternative species such as Quinoa (*Chenopodium quinoa*)



OBJECTIVES

- The development of varieties combining high yield potential, tolerance, resistance and adaptation to the different agro-climatic conditions of the Rhamna region
- The production of grain of adequate quality for food and industry.

METHODOLOGIE

This experiment was conducted in the experimental station of Mohammed VI Polytechnic University of Benguerir, the plant material is composed of five lines of quinoa from the ICBA selection program (Q1, Q2, Q3, Q4, Q5), 2 varieties registered in the official catalog of Denmark (Titicaca and Puno) and a lot which is a mixture of 2 lines (L119 and L143). The experimental protocol is in complete random blocks with four repetitions. Each block consists of 8 elementary plots (PE) with a surface area of 100 m2. The trial was conducted on February 21, 2018. Each variety (or line) was sown in rows 10 meters long and 0.5 meters apart.

Table 1: technical conduct of quinoa

Soil preparation	Seed bed	Irrigation	Fertilization	Planting date	Seeding method	Harvest date
Deep plowing with disks	**Preparation by disc harrow**	**Hourly flow per experimental unit: 1600 l / hr Distance between ramps: 50 cm Distance between ramps: 50 cm**	**No fertilizer input**	**16-02-2018**	**Sowing in poquet**	**25-06-2018**

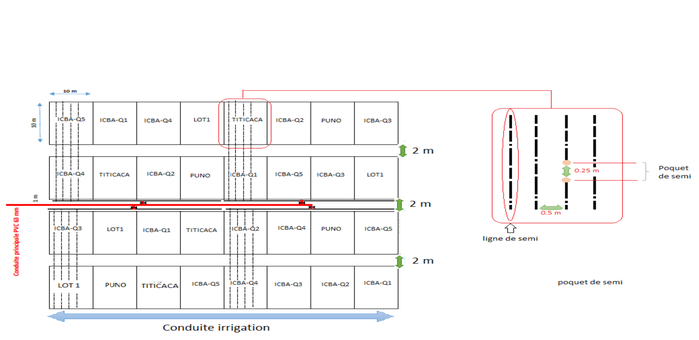


Fig 1: diagram of the technical conduct

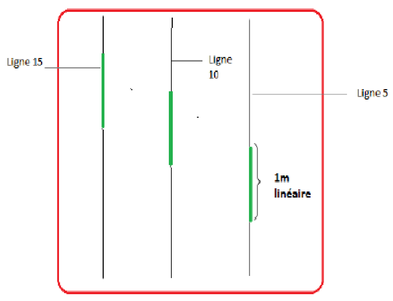
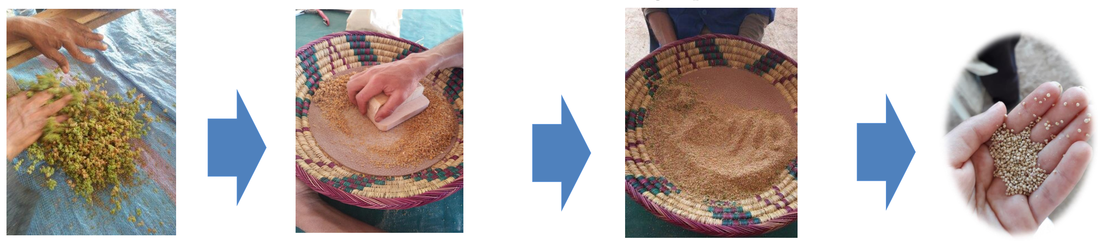


Fig 2: plan of observations at the field level



Cutting the panicle — Separation of seeds from the panicle — Seeds obtained

Fig 3 : post-harvest processing steps

Laboratory soil analysis

The analysis of the soil before sowing was carried out using samples collected over the entire area of the territory (experimental station), the observation of the spatial variability determined the number of samples to be taken. The choice of depths (0-30, 30-50 cm) is dictated by the nature of the root system of the plant.

RESULTS

Physicochemical characterization of the experimentation soil

Table 2 : soil test results before and after sowing

Parameter	Sampling date	
	Before sowing	56 days after sowing
Texture	Silty clay	-
pH	8,4	8,5
EC	0,11	0,39
Total limestone	0,2	5,51
Carbonates CaO	3156	11521
Potash K_2O (mg/Kg)	351	324
N-NO3 mg / Kg	7,9	5,9
Organic Material	2,09	1,99
P2O5 assimilable (mg/Kg)	43	14,1
CEC (méq/100g)	21	18,47

Fig 4: mixing soil samples

Morphological characters

The results of the qualitative characteristics obtained clearly show the absence of a genotype effect on the color variability of the inflorescence and the seeds. The growth pattern in quinoa is rapid between 48 and 60 days after sowing, then becomes slow for Puno and Titicaca varieties.
At maturity, the average size of the root was 1.58 cm, the root size of the genotypes studied was between 10.25 cm and 15.33 cm in the two lines Q1 and Q5 respectively. While Puno and Q2 have developed roots of similar sizes (14 cm). Regarding the length of the inflorescence, there is also a wide range of variation.
The dry weight of the aerial part ranges from 66.15 g at Titicaca to 264.43 g at Q2. This parameter allowed us to calculate the harvest index to judge the genotype in terms of yield and total biomass production.

Table 3 : Qualitative characteristics studied in the 6 studied genotypes of quinoa

Qualitative character	Phenotype	Variety / line	Percentage
Color of the inflorescence	Jaune	Q1 ; Q2 ; Q5 ; Titicaca ; Puno ; Lot1	25 %
	Pourpre	Q1 ; Q5 ; Puno ; Lot1	21 %
	Mélange	Puno ; Lot 1	4 %
	Orange	Q1 ; Q2 ; Q5 ; Titicaca ; Lot1	50 %
Color of the pericarp	Crème	Q1 ; Q2 ; Q5 ; Titicaca ; Puno ; Lot 1	75 %
	Jaune	Q1 ; Q2 ; Q5 ; Titicaca ; Puno ; Lot 1	21 %
	Pourpre	Lot 1	4%

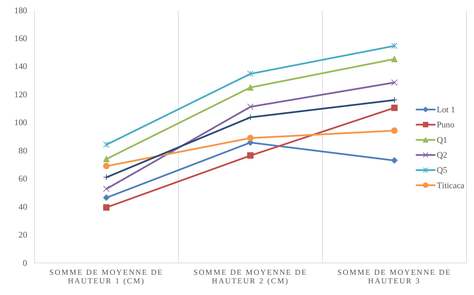


Fig 4 : Quinoa genotype growth curve (cm)

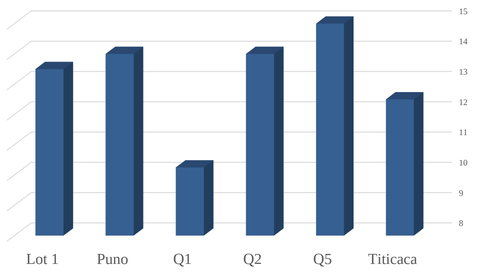


Fig 5 : root size of quinoa genotypes (cm)

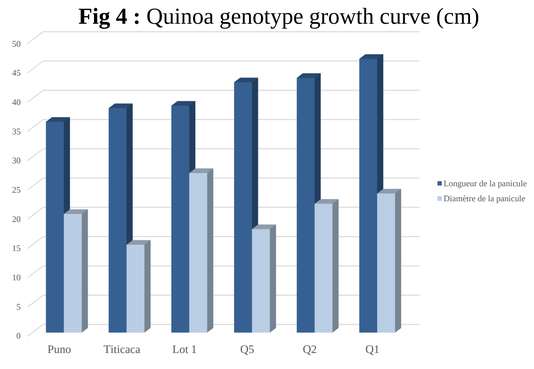


Fig 6 : length and diameter of the inflorescence (cm)

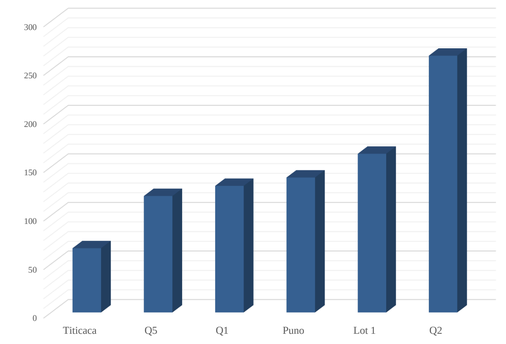


Fig 7 : dry biomass of the aerial part (g)

Agronomic parameters

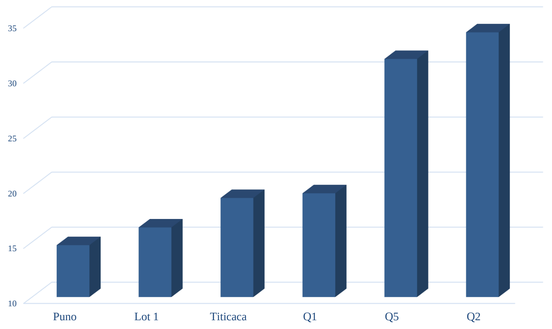


Fig 8 : grain yield of quinoa genotypes (qx / ha)

The effect of the genotype on the yield is very remarkable, considerable variations were recorded between the genotypes studied. The best yield was observed in line Q2, followed by line Q5 which differs slightly from the last one (31.61 q / ha). Q1 and Titicaca have reached almost similar values.

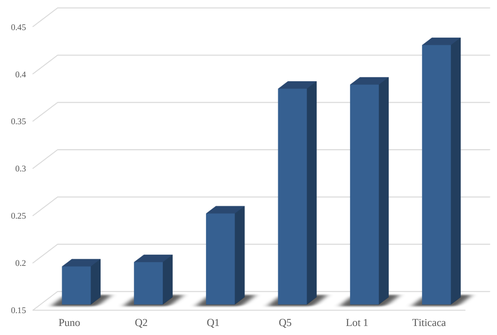


Fig 9 : harvest index of quinoa genotypes

The results of harvest indices allowed us to distinguish 2 classes. The first class or this index is practically high. This class included the Q5, Lot1 and Titicaca genotypes where the values ranged from 0.37 to 0.42. 2nd class included genotypes Q1, Q2 and Puno.

CONCLUSION

- The yield potential of quinoa lines ranged from 14.71 to 34.03 qx / ha under supplemental irrigation conditions at Benguerir.
- The evaluation of the productivity of the selected quinoa lines clearly showed the dual potential of the Q2 lineage for biomass and grain production.
- The provision of supplemental irrigation would therefore be an advantage to the development of quinoa and would make the region of Rhamna a region of its culture.
- The Titicaca and Puno varieties have had a relatively short growing season and could be described as early.
- The Q2 line showed good vegetative development, but a lower harvest index; its grain yield was however maximum.
- The Titicaca variety showed the highest harvest index (0.42) and an average grain yield of 19 qx / ha. It would therefore adapt well to the conditions of production of Rhamna region.

RECOMMANDATIONS

- Undertake a yield comparison test with different organic amendment doses or irrigation to evaluate the response of the genotypes studied to these factors.
- Under burdock conditions, perform supplemental irrigation tests to determine the critical stage in quinoa. Determine which stages are least sensitive to lack of water to optimize its use during the quinoa cycle.
- Determine the impact of seeding techniques on yield (in-line seeding, broadcast seeding, seedling).
- To study the influence of quinoa culture (introduced in rotational systems) on soil moisture and nitrogen conditions.
- Identify the constraints linked to the lifting of the quinoa culture and propose adapted installation techniques (good preparation of seedbed) in order to obtain a homogeneous and synchronized lifting.
- Perform saponin analyzes for advanced lines in selection to determine their levels of this anti-nutrient substance.