Conference Managing Water Scarcity in River Basins

Quinoa (*Chenopodium quinoa*) yield potential in the semi arid region of Rhamna, Morocco under rainfed and irrigated conditions

Filali Kaoutar Choukr-Allah Redouane ***

***Corresponding author. Tel.: 00212(0) 618 94 78 53; E-mail: k.filali87@gmail.com*

**Agronomic and Veterinary medicine Hassan II Institute, CHA Agadir, Morocco.*

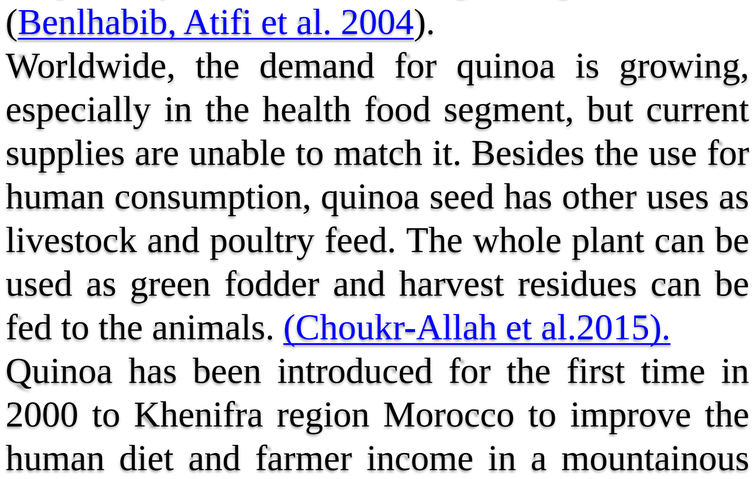
INTRODUCTION

Quinoa has been recognized as a climate resilient crop of great value and there is an increasing effort to introduce it in different marginal agriculture production systems of the world. Various quinoa cultivars have been screened for tolerance to abiotic stresses, especially salinity, drought, and frost and the positive attributes of the crop have created wider global interest in its cultivation (Jacobsen,2003; Jacobsen et al., 2003) Quinoa is also considered as strategic food security crop by FAO due to its high nutritional value and to its adaptability to unfavorable growing conditions (Benlhabib, Atifi et al. 2004).

Worldwide, the demand for quinoa is growing, especially in the health food segment, but current supplies are unable to match it. Besides the use for human consumption, quinoa seed has other uses as livestock and poultry feed. The whole plant can be used as green fodder and harvest residues can be fed to the animals. (Choukr-Allah et al.2015).

Quinoa has been introduced for the first time in 2000 to Khenifra region Morocco to improve the human diet and farmer income in a mountainous region. Selection efforts have been deployed to adapt quinoa genotypes to local environments (Jacobsen and Stolen 1993).

Rhamna area's minimal temperatures ranged from 4.3 to 5.1 °C, and maximal temperatures from 37.5 to 39.3°C. Its average annual rainfall is 250mm/year. Therefore, the present study was conducted with the following objective: characterize five selected varieties from ICBA through phenologic, morphologic and agronomic traits and evaluate their potential of productivity under several experimental plots under rainfed and irrigated conditions.



MATERIALS AND METHODS

The experiment was carried out between 18 February and 30 June 2018, in seven trials at Bouchane community, Morocco, five were conducted in rainfed and two with irrigation, once a week.

The half of the two trials conducted with irrigation, had been supplied by organic matter at a dose of 40kg/ha at the sowing,

Fives quinoa varieties developed at the ICBA Dubai breeding program were used : Q1, Q2, Q3, Q4 and Q5 more the control which is the local variety of the region Rhamna,

Experimental units (4.5 m²) were organized in a complete randomized block with six replicates. Elementary plots consisted of 3 rows of 5 meter at 0.5m row-spacing.

The weed control in the parcels is done by hand cutting and picking. Harvests by hand in the end of June were done at physiological maturity, The maturation period, plant height and seed yield were determined for the cultivars that came to harvest stage. Collected data were subjected to analysis of variance; means comparisons were handled using the LSD test at 0.05 significance. Statistical data processing was achieved by the software SPSS, version 12.

RESULTS

1.Seed yield

The analysis of the variance showed significant variation among trials for seed yield (Fig1).

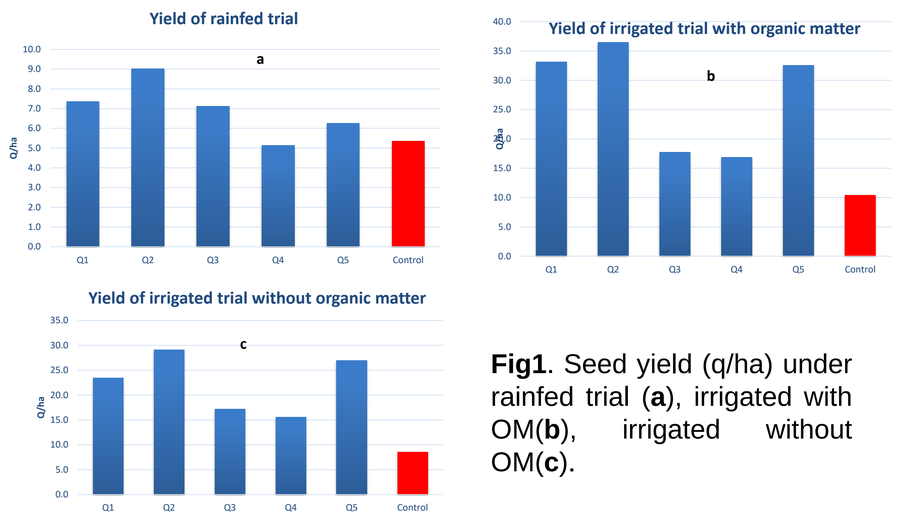


Fig1. Seed yield (q/ha) under rainfed trial (**a**), irrigated with OM(**b**), irrigated without OM(**c**).

Q2 recorded high values of seed yield under the three trials (9q/ha) on rainfed, (36q/ha) with irrigation with OM and (29q/ha) with irrigation without OM. However, Q4 was the lowest yielding under the three fields too (5,1q/ha)(16,9q/ha) and (15,5q/ha).

The control variety, used by the farmers since five years ago, gave also the lowest yield in rainfed and irrigated conditions in comparative with the tested varieties (8,5q/ha, 10,4 q/ha and 5,4q/ha),

The results obtained indicated that irrigation combined with organic matter at a dose of 40kg/ha at the sowing, increased seed yield by 500% for Q4, by 400% for Q1 and Q2, by 180% for the control in comparison with the rainfed conditions.

Also, the irrigation without organic matter improved the seed yield of all varieties by 322%, 241%, 302%, 431% and 159% for Q2, Q3, Q4, Q5, and the control respectively in comparison with the rainfed conditions.

According to statistical analysis, differences are significatives for the three effects :varieties, irrigation and organic matter.

2.Pheno-morphological characterization

There was 27 days difference in the maturity between the quinoa varieties on rainfed conditions, and 35 days difference under irrigated conditions with organic matter. Also, variations were revealed for the plant height, which varied significantly from 52cm to 131cm for Q2 under rainfed and irrigated conditions with organic matter and from 42cm to 79 cm for the control under rainfed and irrigated conditions.

Grain yield fluctuated between 2,89 and 6 GPlant-1 in Q4 and the local variety respectively under rainfed; and ranged from 10 GPlant-1 in the control to 19,21 in Q2 under irrigated conditions.

Tab. 2 Quinoa varieties phenologic-agronomic traits (means)

Characters	Varieties								
	Q1			Q2			Q3		
	rainfed	Irrg1	Irrg0	rainfed	Irrg1	Irrg0	rainfed	Irrg1	Irrg0
Days to emergence	6	6	5	5	6	7	5	6	5
Days to flowering	84	88	89	84	89	89	88	89	90
Days to maturity	120	126	126	120	126	124	115	120	123
Number of nods*	14,5	14,75	13,5	13,5	16,08	17,5	14,94	13,91	15,33
Plant height (cm)*	50,83	115,66	109,25	52,16	127,5	131,9	52,83	107,58	121,75
Grain yield (g)*	4,35	15,62	18,4	5,33	17,14	19,21	4,78	13,24	13,66

Characters	Varieties								
	Q4			Q5			control		
	rainfed	Irrg1	Irrg0	rainfed	Irrg1	Irrg0	rainfed	Irrg1	Irrg0
Days to emergence	6	6	5	5	6	7	5	6	7
Days to flowering	91	95	97	79	81	80	82	85	84
Days to maturity	132	145	145	105	110	110	115	119	121
Number of nods*	14,71	17,16	17,33	13,72	15,33	15,75	11,05	14,16	12,65
Plant height (cm)*	46,05	137,5	122,75	46,77	87,66	92,91	42,83	70,85	79,75
Grain yield (g)*	2,85	12,95	13	3,91	16,87	18,11	6	10,67	10,41

* Significant at P < 0.05, ** Significant at P < 0.01, *** Significant at P < 0.001

Fig3: Differents colors of the local quinoa of Rhamna (right) in comparaison with varieties from ICBA (left)

DISCUSSION

Quinoa is a crop adapted to diverse habitats with tremendous potential for diversification of agricultural systems in mountainous regions of the developing world (Jacobsen 2001) and (Mujica, Jacobsen et al. 2001).

The present study gave some interesting results with reference to yield and morphologic characters. A large amount of variation was found with respect to yield potential. Earlier, (Prakash, Nath et al. 1993) have reported significant differences within quinoa germplasm and suggested their use in breeding of nutritionally superior lines.

Our results show that quinoa could serve as an alternative crop for Rhamna region and other regions having similar agro-climatic and edaphic conditions. A thorough assessment of yield potential of the varieties under this study clearly shows that Q2 and Q5 varieties were high yielding. This reflects greater adaptability of those lines to agro climatic conditions in the region of Rhamna, especially Q2. However, Q4 was the lowest yielding and also was the last to mature.

This variation in seed yield and witnessed in Q4, and Q2 could be due to genetic factors and points towards wide genetic diversity among the varieties.

Our study confirms that the five varieties are more suited for agricultural diversification in countries like Morocco that have cold winters and hot summers.

The Pheno-morphological characterization of the showed a difference in the maturity period between the varieties among the three conditions.

Q4 reached the maturity after 145 days under irrigation conditions with OM and can be qualified of late variety, while Q5 needed only 105 days to mature under rainfed conditions, it's could be a early variety.

CONCLUSION

The data analysis highlighted significant yield variation among the tested varieties and trials. The best accession Q2 presented the highest yield at the three locations; it has reached 9q/ha in rainfed condition, and 36q/ha in irrigation with OM. Q5 recorded also the highest yield (32q/ha), Both Q1 and Q2 accessions were intermediate in both their yields. Q4 accession was the least in terms of yield. Highest yield of all accessions confounded was obtained with irrigation with Organic matter, which improves yield potential. Q2 is the best variety to introduce to Rhamna region

REFERENCES

Benlhabib, O., M. Atifi, et al. (2004). "The introduction of a new peruvian crop quinoa to a rural community in Morocco." In: Proceedings of the VIIIth European Society of Agronomy Meeting Copenhagen, Denmark **11-15**: 881-882.

Choukr-allah et al. (2016). "Quinoa for Marginal Environments:Toward Future Food and Nutritional Security in MENA and Central Asia Regions. Research and Innovation Division, International Center for Biosaline Agriculture, Dubai, UAE (2-3).

Jacobsen, S.-E. (1998). "Developmental stability of quinoa under European conditions." Industrial Crops and Products **7**(2–3): 169-174.

Jacobsen, S.-E. (2003). "The Worldwide Potential for Quinoa (Chenopodium quinoaWilld.)." Food Reviews International **19**(1-2): 167-177.

Jacobsen, S. E. (2001). "El potencial de la quinua para Europa In: Jacobsen, S.E., Portillo, Z. (Eds.), Memorias, Primer taller Internacional sobre Quinua-Recursos Geneticos y Sistemas de Produccion. Lima, Peru, UNALM." J **May 10-14, 199**: 355-366.

Jacobsen, S. E., A. Mujica, et al. (2003). "The Resistance of Quinoa (Chenopodium quinoaWilld.) to Adverse Abiotic Factors." Food Reviews International **19**(1-2): 99-109.

Jacobsen, S. E. and O. Stolen (1993). "Quinoa- morphology, phenology and prospects for its production as a new crop in Europe." Eur. J. Agron **2**: 19-29.

Mujica, A., S. E. Jacobsen, et al. (2001). "Quinua (Chenopodium quinoa Willd.)-Ancestral Cultivo Andino, Alimento del presente y futuro." FAO,.

R. Repo-Carrasco, C. Espinoza, et al. (2003). "Nutritional value and use of the Andean crops quinoa (Chenopodium quinoa) and kañiwa (Chenopodium pallidicaule)." Food Reviews International **19**(1-2): 179-189.

Acknowledgements: This research was supported by ICBA institute and UM6P university, the authors thank them for providing seed and for assistance.