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Quinoa and its potential to grow under water scarcity and salt stress conditions: Promising research findings.

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INTRODUCTION

- Global food security faces the challenges of rapid population growth and shortage of water resources in the coming decades. Drought and climate change further threaten the stability of land and water resources and deteriorate the conditions of crop growth. Nowadays, a huge area of our planet is threatened by water shortage and soil salinization.
- To keep pace with increasing population, food production must be increased by adopting different management approaches like root zone irrigation (ARD), deficit irrigation (DI) and tolerant crops like quinoa.
- Quinoa’s high genetic diversity offers a way to address the situation by adapting to different ecological environments where those limiting factors are present.

What is the challenge?

For most of arid and semi arid countries in the Mediterranean and Arab world, the key challenge is how to expand quinoa production reliably and sustainably and to bring reasonable answers to the following questions: can we have satisfactory production with less water and/or with saline water and drought conditions? and is quinoa the appropriate solution to meet sustainable food and nutrition security challenge in those countries?

Here comes the important role of research in answering the above mentioned questions. Research has focused mainly on agronomic, biological and nutritional aspects of quinoa in order to understand the potential input of quinoa on arid and semi arid agro ecosystems.

Quinoa and drought tolerance

- This subject received the attention of many researchers (Jensen *et al*., 2000; Jacobsen *et al*., 2003, 2009; Garcia *et al*., 2007). Those authors stated clearly that Quinoa has a high tolerance to drought.
- The research findings in this field proved that water stress during the pre-flowering, flowering and grain filling period of quinoa should be avoided. Through minor water applications we can increase yield significantly and stabilize yields in years of precipitation deficits (Garcia, 2003; Guarcia *et al*., 2003). High yields and water use efficiencies can be obtained with water stress in the initial vegetative stages.

Quinoa and drought tolerance

- Drought stress during the vegetative growth leads to deep root development that allowes the plant to be able to optimize its photosynthesis and carbon translocation.
- The reaction of quinoa plants to drought are based on drought avoidance mechanisms: reduced transpiration and sustained water uptake. Transpiration is reduced due to decrease of stomatal conductance and leaf area development.

Quinoa and salinity tolerance

- The other part of research which received the attention of many researchers on quinoa is its tolerance to salinity.
- El-Youssefi *et al*. (2012) showed that the threshold value is to be 6dS/m. However, this threshold value was not the same but varied greatly from one researcher to another.
- The farm trials carried out by Rao (2016) showed that seed yields were maximum despite irrigation with highly saline water (15-18dS/m). The experimental work conducted in Turkey (Yazar *et al*., 2015) indicated that salinity stress up to 40dS/m did not interfere significantly with seeds and biomass yields. Razzaghi *et al*. (2011), showed a yield reduction of 50% with saline water of 40dS/m compared with fresh water.

Quinoa and salinity tolerance

- Experimentally in Agadir, Morocco Hirich *et al*. (2014) showed that irrigation with water of 10dS/m salinity has not affected seed yield significantly and yield reduction was only 9% compared to fresh water (1dS/m). and added that increasing salinity to 20dS/m and 30dS/m seed yield was reduced by 24 and 34%, respectively, compared to the control. Similar data were obtained by Jacobsen *et al.* (2013) indicating that the yield of quinoa was the highest under moderately saline conditions (10-20dS/m).

The Analysis of experimental data

- The analysis of such findings related to quinoa response to salinity are indeed not quantified and not identifying clearly the water salinity threshold value for safe use and what will be the effect on the crop yield parameters. There was no agreement among the researchers on defining the salinity level that promotes growth and production of quinoa and the threshold salinity value above which growth and productivity are negatively affected.

Quinoa and irrigation with saline water: the raised questions

- Under irrigation with salinity level above the determined threshold values, What will be the rate of change in yield parameter?
- Will the changes in growth and yield parameters for the investigated quinoa varieties be the same under the threshold values and/or the exceeding ones?
- Those are important issues still seeking for answers. Indeed, the available research findings regarding quinoa response to salinity level of irrigation water is only providing limited knowledge to identify the salinity level that could be safely used without any significant effect on the yield and crop production.

Research needed

The numerous researches carried out by many researchers and research institutions in the Mediterranean as well as in several European countries, all fully agreed on the potential of quinoa as an alternative crop for marginal environments. However, the prospect of a wider scale adoption requires an intensive research programme covering different issues:

- To fully exploit quinoa's potential as a stress-tolerant and climate resilient crop; a part of the research should be directed towards the identification of new and high yielding quinoa genotypes with good local adaptation and high nutritional quality.

Research needed

- The knowledge about the relationship between the growth conditions and the nutrition profile of quinoa is still limited. Additional research should be carried out to characterize and evaluate the effects of extreme growing conditions on quinoa nutritional quality. This will greatly help in the selection of nutritionally high and stable cultivars, avoid failure and to achieve the maximum profitability of growing quinoa in marginal environmental conditions.

Research needed

- Research should be extended to evaluate the potential of quinoa as an alternative food and feed crop in several selected countries particularly those seriously affected by salinity and water scarcity in the Mediterranean and MENA regions.
- Further research should look at the economic sustainability of quinoa under marginal environmental conditions and how it should be technically managed to bring the possible maximum profit. This implies having in hands appropriate integrated crop-water-soil management.
- It is of paramount importance to strengthen research networks to continue generating and sharing information on quinoa making research findings available and accessible to all stakeholders involved.

Concluding remarks and recommendations.

- Research and the new knowledge it produces must be disseminated or at least made accessible to all stakeholders involved in quinoa production.
- The need of a holistic vision of quinoa in each individual country, taking into account the wide range of stakeholders involved in research, production, sale and conservation.
- Considering quinoa an appropriate crop to address hunger, malnutrition and poverty challenges, it is needed to have appropriate supporting tools including improving capacity development, strengthening competencies, fostering knowledge transfer, smoothing exchange of experiences and awareness among the various stakeholders involved in the process.

Concluding remarks and recommendations.

- It is needed to design appropriate educational program to full fill the gap in farmers' knowledge to ensure sustainable cultivation. It is also crucial to build necessary technical capacity and upgrade the skills of farmers and extension services using enhanced demonstration extension capacities.

Thank You