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Effect of Salinity on Growth of *Chenopodium Quiona* Wild

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ABSTRACT

Salinity is today one of the most alarming threat in the irrigated agriculture. Further it is an abiotic stress that affects germination as well as plant growth and productivity. Quiona (*Chenopodium quiona* Wild) is an ancient Andean crop that tolerates to salinity provides with high potential in the world where increased salinization is an important cause of crop failure. It is traditionally called the mother of grains having the potential to habitat under high saline environment. It contains high protein contents and produces high quality protein with a balanced amino acid profile in embryonic tissues. The aim of the present work plan was to evaluate the germination of quinoa seed under different salinity levels. Saline solutions were artificially prepared from 0 to16 dSm^{-1}. Quinoa seeds were soaked with different saline solution in Petri dishes using randomized complete block design with three replicates. Seeds were germinated in petri dishes. The experiment results revealed that germination percentage was ranged 100 to 90 % up to 14dSm^{-1} and drastically reduced to 65% at 16dSm^{-1}. These results showed the salt tolerance of quiona against high salinity considering seed germination. Quinoa plant height, fresh weight, dry weight after two weeks were significantly affected by different artificially salinity levels. The maximum plant height (2.77cm) was attained at (4.00dSm^{-1}) followed by 2.40 cm in (6.00dSm^{-1}). Maximum fresh weight (7.85 mg $plant^{-1}$**)** was registered by (6.00dSm^{-1}) and it was statistically at par with (7.8 mg $plant^{-1}$) in (4.00dSm^{-1}). Similarly the maximum dry weight (3.67 mg $plant^{-1}$) was recorded in (6.00dSm^{-1}) followed by (3.65 mg $plant^{-1}$) in (4.00dSm^{-1}) that was statistically at par with each other

Keywords: Salinity, Electrical conductivity, halophyte, Salt tolerance and germination.

INTRODUCTION

Soil salinity is the worldwide problem and it is reported that salinity affects 900 million ha of the total area of the world that is the major threat to the crop production (Munns, 2002) because the majority of the crops do not favor such conditions having high salinity. Salinity causes the malfunctioning in physiological features of the plants like ion accumulation upto toxic levels, membrane rupture, abnormal plant growth, higher transpiration rate, and unavailability of nutrients, membrane permeability and reduced photosynthetic activity (Munns, 2002).

(Munns, 2009) reported that the salt tolerant species have the concentration of Na^+ ions in root cortex 10 times less than that of sensitive species. Higher concentration of salts in the shoots affects the activity of enzymes and metabolic functioning like photosynthesis and synthesis of proteins (Munns, 2005).

Quinoa (*Chenopodium quinoa* Wild.) has garnered much attention in recent years because it is an excellent source of plant-based protein and is highly tolerance of soil salinity. Because soil salinity affects between 20 and 50% of irrigated arable land worldwide (Pitman and Läuchli, 2002).Quinoa shows exceptional adaptation to harsh environments such as drought and salinity (González *et al.*, 2015). Soil salinity reduces crop Yield sand is a worldwide problem. In the United States, approximately2.2million hectares of crop landin48States were occupied by saline soils, while another 30.8 million hectares are at risk of becoming saline (United States Department of Agriculture [USDA], 2011). The salinity issue leads producers to grow more salt-tolerant crops, such as quinoa.

One promising species that has a high potential to become a cash crop is *Chenopodium quiona* Wild (Chenopodeaceae). Quinoa has been an important food source in the Andean region for thousands of years (Jacobsen et al., 2009; Koyro and Eisa, 2008; Hariadi et al., 2011). Recently, it gains worldwide

attention because of its extraordinary tolerance to various environmental stress conditions like soil salinity, acidity, drought, frost, etc. (Maughan et al., 2009; Hariadi et al., 2011). Apart from this, its grains is a rich source of a wide range of minerals (Ca, P, Mg, Fe and Zn), vitamins (B1, B9, C and E), oil containing large amounts of linoleate, linolenate and natural antioxidants and high quality protein containing ample amounts of essential amino acids such as lysine and methionine (Koyro and Eisa, 2008; Abugoch et al., 2009). The nutrition value of quinoa seeds is reported to meet and surpass that recommended by the World Health Organization (WHO) (Hirose et al., 2010). Furthermore, its leaves are widely used as food for human and livestock (Aufhammer, 2000). Due to its high nutritional value, quinoa attracted the attention as alternative crop worldwide and has been chosen by the Food and Agriculture Organization as one of the crops destined for food security in this century (Mujica et al., 2001).

Deeper understanding of individual physiological, biochemical and structural mechanisms that determine salt tolerance in *C. quinoa* is a prerequisite for its sustainable utilization as non-conventional crop using alternative water sources on marginal lands (Koyro, 2006). As well known, salt tolerance comprises an array of interconnected morphological, physiological and biochemical mechanisms on whole plant, tissue, and cellular/molecular levels (Ashraf and Harris, 2004; Tammam *et al.*, 2008; Geissler *et al*., 2009a). These mechanisms are related to the four major constraints of salinity on plant growth, i.e., osmotic effects, restriction of CO_2 gas exchange, ion toxicity, and nutritional imbalance (Koyro, 2006; Geissler et al., 2009a). To withstand osmotic constraints, plants have to be more restrictive with water loss by a sensitive stomata closure response.

Regarding the other two constraints mentioned above, high NaCl concentrations adversely affect the acquisition of essential nutrients as Na+ competitively inhibits K+ and Ca2+ uptake, whilst Cl- restricts anions uptake (Tester and Davenport, 2003; Liu et al., 2006; Tammam et al., 2008), disturbing ion homeostasis within the plant. Moreover, salinity may create specific ion toxicity as disproportionate presence of Na+ and Cl- in cellular and intracellular compartments inhibits many enzymatic systems, altering a wide range of important metabolic processes that plant growth is crucially depending on (Blaha *et al*., 2000; Munns, 2005). Adaptation mechanisms should therefore contribute to mre-establish the homeostatic conditions needed for inward net flux of water and ion uptake. One major aspect of plant adaptation to saline environments is the utilization of massive accumulation of inorganic ions (mainly Na+ and Cl-) to adjust osmotically (Ottow *et al.*, 2005). Osmotic adjustment (OA) in terms of salt accumulation is energetically efficient, but strategies that act in concert to avert ion toxicity and imbalance (Munns 2005; Wang *et al.*, 2007; Koyro *et al*., 2011).

In consideration of this background, the present study aimed mainly at monitoring salt-tolerance responses of *C. quinoa* at precise salinity level

MATERIAL AND METHODS

The study was carried at NARC Islamabad to investigate the impact of salinity on growth of quinoa crop. A lab experiment was designed to study the germination of quinoa by using saline water with filter paper in Petri dishes. Artificially saline water developed by using NaCl 0.58g, 0.87g, 1.16g, 1.45g, 1.74g, 2.03g and 2.32g into 250ml of distilled water to make 40 mm, 60mm, 80mm, 100mm, 120mm, 140mm and 160mm sodium concentration in 250ml of water. Quinoa seeds were sown in the Petri dishes having different concentrations of saline water. Germination checked regularly 3 days after sowing date.

RESULTS AND DISCUSSION

Non- significant results regarding germination among different salinity levels was noted in table- However germination percentage was reduced to 65 % by 16 (dSm^{-1}). In other words Quinoa seeds were germinated up to 14 dSm^{-1}. Lodging problem of quinoa seedlings was also noted. The lodging might be due to very thick and weak stem of quinoa seedlings.

Results in table-1 confirmed that Quinoa plant height, fresh weight, dry weight after two weeks were significantly affected by different artificially salinity levels. The maximum plant height (2.77cm) was attained at (4.00dSm^{-1}) followed by 2.40 cm in (6.00dSm^{-1}). Maximum fresh weight (7.85 mg $plant^{-1}$**)** was registered by (6.00dSm^{-1}) and it was statistically at par with (7.8 mg $plant^{-1}$) in (4.00dSm^{-1}). Similarly the maximum dry weight (3.67 mg $plant^{-1}$) was recorded in (6.00dSm^{-1}) followed by (3.65 mg $plant^{-1}$) in (4.00dSm^{-1}) that was statistically at par with each other. High concentration of salts in

the soil solution causes reduction in plant growth by reducing soil water osmotic potential and consequently decreasing the growth rate (Munns 2009). In addition, excessive amounts of salt entering the plant will eventually reach toxic levels in the older transpiring leaves, causing premature senescence and reducing the assimilation, and consequently the growth (Munns 2002, 2009).

Table1. *Quinoa growth under different artificially salinity levels (dSm^{-1}) after two weeks*

Salinity levels (dSm^{-1})	Germination (%)	Plant Height(cm)	Fresh Weight (mg $plant^{-1}$)	Dry Weight (mg $plant^{-1}$)
4	90^{NS}	2.77 a	7.80 a	3.65 a
6	90	2.40 b	7.85 a	3.67a
8	100	2.25 b	5.50 b	3.09 a
10	95	2.12c	4.60 c	2.35 b
12	90	2.03d	3.40 d	1.82
14	95	1.92d	3.18de	1.52 bc
16	65	1.33 e	2.92e	1.44 c
LSD	NS	0.20	0.35	0.25

Table2. *Na: K and nutrient concentration in Quinoa plant tissues under different artificially salinity levels (dSm^{-1}) after two weeks*

Salinity levels (dSm^{-1})	Na (ppm)	K (ppm)	N a / K	Z n (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
4	12.1 e	83.5 a	0.14c	8.6 a	0.35	60.1 a	2.9
6	13.2 d	85.1 a	0.15 c	6.9 b	0.32	58.0 a	2.5
8	14.5cd	82.5ab	0.17 c	5.7bc	0.39	56.5 ab	2.3
10	16.1 c	79.3c d	0.20 b	4.9cd	0.37	54.6 bc	2.0
12	17.2 b	75.5 d	0.23 a	4.6d	0.36	52.5 cd	2.2
14	18.7a	74.3de	0.25a	3.9de	0.34	49.9cd	2.4
16	18.9a	72.0e	0.26a	3.7e	0.35	46.7de	2.6
LSD	1.09	1.60	0.04	0.92	NS	2.1	NS

Results in table-2 showed significant Na, K, Na/K, Zn and Fe concentration while Cu and Mn concentrations indicated non-significant behaviour in Quinoa plant tissues after two weeks. Maximum Na (18.9 ppm) was recorded at 16 dSm^{-1} and the lowest (12.1 ppm) by 04 dSm^{-1}. Na/K was maximum (0.26) at 16 dSm^{-1} and the least 0.14 by. Fe was maximum (60.1 ppm) at 04 dSm^{-1} while Cu and Mn showed non- significant results.

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