OPEN ACCESS
Freely Available Online

OpenAccessPub

JOURNAL OF AGRONOMY RESEARCH
ISSN NO: 2639-3166

Research Article

DOI: 10.14302/issn.2639-3166.jar-19-2237

Effect of Saline Irrigation on Agro-Physiological and Biochemical of Some Quinoa Cultivars Under Field Conditions

Moatz A. Mohamed[1], M.H. Mubarak[1], Salah.A. Okasha[2,*]

[1]Plant Prod. Dept., Fac. of Envi. Agricultural Sci., Arish Univ., North Sinai, Egypt.

[2]Agronomy. Dept, Fac. of Agri., Suez Canal Univ., Ismailia, Egypt.

Abstract

In regions where irrigation water supplies are limited, drainage or water with salinity can be used to supplement them. Field experiments were carried out during the quinoa growing season of 2015/2016 and 2016/2017 at North Sinai in order to evaluate six quinoa genotypes (Chenopodium quinoa Willd.) under saline irrigation (5400 ppm) on growth, yield, its component, seeds chemical composition under field conditions. For plot 50% heading and maturity, the most earliness averages were 47.25 and 92.50 day, respectively for genotype Q-Q37-1, while the least earliness averages were 55.75 and 96.25 for genotypes KVLSRA 2 and KVLSRA 1, respectively. The highest averages was recorded for number of panicles/plant, plant fresh weight, plant yield weight, harvest index, 1000 seeds weight index and yield / fed-1 (ton) were 12.27, 82.32 gm, 17.83 gm, 28.89 %, 2.97 gm and 1.84 ton fed-1) for genotypes Q-Q37-1, Q-Q37-1, Q-Q37-1, Q-Q37-1, Q52 and Q-Q37-1, respectively. While, the lowest values were recorded for genotypes KVLSRA1, KVLSRA1, KVLSRA1, Regeolona, KVLSRA1 and KVLSRA1 with averages 8.72, 23.73gm, 5.52 gm, 22.76 %, 2.43 gm and 1.23 ton fed-1, respectively. For protein and carbohydrates total content, values ranged from 14.75 to 10.59 and from 58.13 to 54.64 % for genotypes Q52 and Regeolona, respectively. While in moisture content, values ranged from 11.66 to 10.83 for genotypes KVLSR1 and Q-Q37-1 , respectively. Also, fats content ranged from 10.44 to 7.14 % for genotypes Q52 and Regeolona, respectively. While values of saponin ranged from 0.56 to 0.37% for genotypes KVLSR1 and Regeolona, respectively.

Corresponding author: Salah.A. Okasha, Agronomy. Dept, Fac. of Agri., Suez Canal Univ., Ismailia, Egypt

Citation: Moatz A. Mohamed, M.H. Mubarak, Salah.A. Okasha (2019) Effect of Saline Irrigation on Agro-Physiological and Biochemical of Some Quinoa Cultivars Under Field Conditions. Journal of Agronomy Research - 1(4):1-9. https://doi.org/10.14302/issn.2639-3166.jar-19-2237

Keywords: Quinoa, irrigation, salinity, yield, chemical composition

Received: Feb 07, 2019 **Accepted:** Feb 27, 2019 **Published:** Mar 07, 2019

Editor: Abubaker Haroun Mohamed Adam, Department of Crop Science (Agronomy), College of Agriculture, Bahri University-Alkadaru- Khartoum -Sudan, Sudan.

Introduction

Salinity is considered as main major problem in agriculture, particularly because saline soils are found primarily in arid regions where draught, extreme temperatures, and nutrient deficiency go hand in hand, and where scarce precipitation and high evaporation hinder a leaching out of the salts that accumulate in the upper soil layers. It is estimated that between 340 and as much as 950 billion squares kilometers, equivalent to about 20% of the arid and semiarid soils of the world, or 6% of the world land area, are saline. There is an increase in salinization due to irrigation, which is estimated to affect 50% of irrigated land [1],[2]. There are only few crops can be grown under marginal and extreme saline, dry and cold areas; quinoa is one of them [3].

Quinoa (*Chenopodium quinoa Willd.*) is a member of the Goosefoot Family (Chenopodiaceae), which includes such plants as sugar beets, Swiss chard *(beta sp.*), spinach (*Spinacia oleraceae*) and Lamb's quarters (*Chenpodium album*). The later has been a nuisance weed to farmers in many regions of the United States.

Quinoa derived from the Spanish spelling of the Quechua name kinwa or occasionally "Qin-wah", a species of goosefoot (*Chenopodium*). Quinoa is a dicotyledonous, annual plant usually ranges in height from 60-120 cm, depending on the eco-type. The root system is extensive; it consists of many branches from a central tap root which may extend 30 cm in a field environment. The woody central stem is either branched or unbranched depending on the variety and may be green, red or purple. Leaves normally arranged alternately, the upper leaves are lanceolate while the lower leaves are more rhomboidal. The upper and lower surfaces of the leaves are covered with small glands.

The panicles arise either from the top of the plant or from axils on the stem. The panicles have a central axis from which a secondary axis emerges either with flowers (amaranthiform), or bearing a tertiary axis carrying the flowers (glomeruliform). The green, hypogenous flowers have a simple perianth and are generally bisexual and self-fertilizing. The seeds are achenes about 2-3 mm in diameter and are found in a large array of pigments. From white to red, purple, and black, which are probably associated with "eco-type" and vary from region to region.

Quinoa originated in the Andean region of Ecuador, Bolivia, Colombia and Peru, where it was successfully domesticated 3,000 to 4,000 years ago for human consumption, though archeological evidence shows a non-domesticated association with pastoral herding some 5,200 to 7,000 years ago.

Quinoa seeds are utilized to make flour for biscuits and cakes, added directly into soups, eaten as breakfast- type cereal, the fresh leaves and tender shoots of the plant are eaten raw in salads, or cooked and eaten as a vegetable. The young sprouts can also be added to salads or eaten plain [4].

It is seen to be as an alternative to cereals in human diet and animal feeds, cultivation and processing are thus necessary to exploit the potential of this crop on a wider geographic basis than hitherto [5].

Also, It has been selected by FAO as one of the crops destined to offer food security in this century. The genetic variability of quinoas huge, with cultivars being adapted to growth from sea level to 4000 masl, from 40 degrees S to 2 degrees N, and from cold, highland climates to tropical conditions. It was described as a likely candidate crop for NASA's Controlled Ecological Life port System [6].

In Europe, quinoa was suggested to be as a break crop between cereal crops and after potato crops. When grown in areas to which it is best adapted, it should be able to compete with cereals in both human diets and animal rations [7]. So far, the results regarding quinoa as a drought resistant crop of high nutritive quality, which can be grown on poor, infertile soils, seem promising [8].

It was suggested to be an important new crop for Pakistan agriculture, providing highly nutritive and versatile food products for the population and a new raw material for the industry. In particular, it could be cultivated in many of the marginal environments afflicted by drought or salinity stress, which currently suffer from very low productivity [9].

Environmental extreme conditions of Southern America , Pakistan and Egypt deserts tend to participate similar features (both of them face draught and salinity

problems side by side) , so that, quinoa could be suggested as an attractive alternative crop for the arid and semiarid regions, where water deficiency and salinity have been recognized as major agricultural problems [10]. The principal aims of this study, i) Describe some selected Quinoa genotypes ii) Evaluate seedling germination and growth of the selected genotypes under invitro salinity and drought stress, iii) Evaluate growth, yield and its components and seeds chemical compositions for the selected genotypes under In vivo dominant stress, iv) Select the best genotypes under invitro stress and In vivo stress conditions of North Sinai region.

Materials And Methods

This study was carried out at the experimental farm of Environmental Agricultural Sciences Faculty, El- Arish, North Sinai, during 2015/2016 and 2016 /2017 seasons. The name and origin of the studied quinoa un branched- genotypes (*Chenopodium quinoa* W.) are shown in Table 1.

In Vivo Dominant Stress

Two seasons field experiments were carried out at Faculty of Agricultural and Environmental Sciences' Farm, during two seasons (2015/16 and 2016/17), to evaluate plant growth, yield, yield components and chemical composition of six quinoa genotypes.

Description of in Vivo Dominant Stress

The meteorological data of average temperature, relative humidity and rainfall during seasons are shown in Table (2), mean physical and chemical properties of the soil and analyzed irrigation water are shown in (Table 3).

Experimental Design

The field experiment was conducted at the 3rd week of December by using randomized complete block design (RCBD) with four replicates. Each plot area was 12 m^2 consisted of 4 rows with 5 m length, and the spacing was 0.6m between rows, and both sides of row were cultivated and sowing rate was 3 gm per 5m equal about 75 plant m^{-2} (4.2 kg fed^{-1}, feddan = 4200 m^2) and a sowing depth of 2 cm.

Organic and Calcium super phosphate (15.5% of P2O5). Fertilizers were applied fully prior to planting at the rate of 150 kg fed^{-1}. Urea (46.5% N) was added at the rate of 150 kg fed^{-1} and was divided into 6 weekly portions which the first portion was after 7 days from planting. Potassium Sulphate (50% K2o) was added at the rate of 150 kg fed^{-1} and was divided into 4 semi monthly portions which the first portion was after 14 days from planting [11], [12] and Irrigation was applied every 3 days for 2h day^{-1} by GR drippers 4 L hr^{-1}.

Collected Data

Earliness Parameters

Five random plants per plot were labeled and the following phonological data were recorded at intervals of 5 day [13]. Heading and maturity date 50% were computed as number of days from sowing until 50% of heading and maturity, respectively.

Growth Parameters:

At harvest time a random sample of ten guarded plants were taken from each plot to measure the following characters.

Plant Height (cm)

was measured for individual plants from the soil surface to stem apex of individual, and the mean was computed.

Root Length (cm)

was measured for individual plants from the soil surface to root apex of individuals, and the mean was computed.

Stem Diameter (cm)

was measured for the last node of main stem to the base of main stem spike.

Number of Leaves/ Plant

was measured as number of mature leaves per plant.

Yield, its Components and Harvest Index

At harvest time a random sample of ten guarded plants were taken from each plot to measure the following characters:

Number of Panicles / Plant

Plant Fresh Weight (gm)

was measured as the total fresh weight of plant after manual threshed.

Plant Yield Weight (gm)

Table 1. Name/ Cross and origin of the six quinoa -un branched - genotypes used.

No.	Name/ Cross	Origin
1	KVLSRA 1	Denmark
2	KVLSRA 2	Denmark
3	KVLSRA 3	Denmark
4	Q-52	Chile
5	Q-Q 37	Chile
6	REGEOLONA	Chile

Table 2. Temperatures and humidity distribution during 2015/2016-2016-2017 seasons

Month	2015/2016 season			2016/2017 season		
	Max. Temp. (C°)	Min. Temp. (C°)	Humidity (%)	Max. Temp. (C°)	Min. Tempe. (C°)	Humidity (%)
October	30.3	20.0	77.9	30.3	16.9	68.2
November	26.6	14.7	76.7	26.7	13.2	58.2
December	21.1	8.2	78.1	20.9	9.0	56.8
January	18.6	7.1	78.8	18.8	5.8	62.9
February	22.6	8.8	81.4	18.68	6.50	73.14
March	24.4	11.3	73.6	23.2	9.5	67.0
April	28.7	13.7	69.3	25.5	12.1	63.1
May	30.4	16.4	59.3	29.5	15.5	61.6

Source: Central laboratory for agricultural climate, Agric. Res. Center, Giza, Egypt

Table 3. Means of Physical and chemical properties of the soil sites and the analysis of irrigation water at the two used experimental sites.

Soil depth cm	Organic matter (%)	PH.	Particle size distribution %			Irrigation water		
			Sand	Silt	Clay	PH	EC	ppm
0-15	2.70	9.1	83.00	12	5	7.5	7.1	5400
15-30	2.90	9.3	83.00	12	5			

were determined as average weight of all seeds of the ten plants.

Harvest Index HI (%)

was calculated as the percentage of plant yield weight per plant fresh weight [14].

1000 Seed Weight (Seed Index) (gm)

were computed by weighting hundred grains, then multiplying by ten.

Yield (Ton Fed^{-1})

were computed by weighting plot seeds yield, then multiplying by 350.

Statistic Analysis

The experiments were grown in a randomized complete block design (RCBD) with four replicates and data were statistically analyzed according to steel et al [15]. Mean separations were exposed to statistical analysis were done by using a Computer program Costat software (version 6.311).

Results and Discussions

Effect of the Salinity Irrigation on the six Genotypes Earliness

Data in table (4) indicated that there were significant differences between the six studied genotypes at earliness at both seasons for plot 50% heading and maturity. The most earliness cultivars for 50% heading and 50 % maturity were recorded by Q-Q37-1 and Regeolona with average 47.25 , 92.50 and 47.50, 92.25 day and 36.33 , 79.33 and 37.33 , 79.66 day in both seasons, respectively, while the latest earliness averages were recorded by KVLSRA 1 and KVLSRA 2 genotypes, respectively.

Effect of Salinity Irrigation on Growth

Concerning to season 2015/16 the data in table (5) indicated that significant differences between studied genotypes in growth parameters. The highest recorded averages for plant height, root length, stem diameter and leaves number were 86.45, 15.17, 1.63cm and 93.27, respectively for genotype Q-Q37-1, While the lowest values were recorded by KVLSRA 1 genotype with 62.72, 12.88, 0.95 and 65.92, respectively. For season 2016/17, the results indicated significant differences between studied genotypes in growth parameters. The highest recorded averages for plant height, root length, stem diameter and leaves number were 70.86, 9.93, 1.39 and 88.13, respectively for genotype Q-Q37-1. While the lowest recorded averages were 48.83, 7.22, 0.91 and 48.08, respectively for genotype KVLSRA 1.

Effect of Salinity Irrigation on the Six Genotypes' Yield, Yield Components and Harvest Index:-

Data in table (6) indicated significant differences between studied genotypes for yield, its component and harvest indexes. The cultivars Q-Q 37-1 and Regeolona recorded the high values for no. of panicles plant^{-1}, plant fresh weight, yield weight plant^{-1}, harvest index, 1000- seed weight and yield fed^{-1} (ton) in both seasons. While the cultivars KVLSRA1, KVLSRA2 showed lower mean values the majority of traits.

Table 4. means of earliness of the six quinoa genotypes under salinity irrigation in 2015/16-2016/17 seasons

Genotypes	Plot 50% heading (days)		Plot 50% maturity (days)	
	2015/16	2016/17	2015/16	2016/17
KVLSRA 1	55.80 ±2.17^{b}	45.66 ±2.60^{d}	96.25±1.41^{ab}	92.66 ±1.76^{d}
KVLSRA 2	55.50 ±2.28^{b}	44.00 ±3.0^{c}	94.50 ±0.50^{a}	86.00 ±0.57^{b}
KVLSRA 3	48.00 ±0.40^{a}	39.33 ±0.57^{b}	92.75±0.85^{a}	81.66 ±0.66^{b}
Q-52	50.75 ±0.25^{a}	39.33 ±0.33^{b}	92.75±0.47^{a}	80.33 ±0.88^{b}
Q-Q 37-1	47.25 ±0.25^{a}	36.33 ±0.33^{a}	92.25±0.83^{a}	79.33 ±0.33^{a}
Regeolona	47.50 ±0.25^{a}	37.33 ±0.33^{b}	92.50 ±0.28^{a}	79.66 ±0.66^{b}

Table 5. means of growth of the six quinoa genotypes under salinity irrigation in 2015/16-2016/17 seasons

Genotypes	Plant height (cm)	Root length (cm)	Stem diameter (cm)	No. of Leaves plant^{-1}
Season 2015/2016				
KVLSRA 1	62.72±1.24^{de}	12.88±0.24^{b}	0.95±0.10^{c}	65.92±6.35^{c}
KVLSRA 2	68.42±1.49^{d}	12.95±0.29^{b}	1.02±0.11^{bc}	72.17±.10^{bc}
KVLSRA 3	77.30±1.85^{b}	15.1±0.50^{a}	1.37±0.12^{ab}	88.70±6.43^{b}
Q-52	83.32±0.54^{a}	14.99±0.30^{a}	1.57±0.07^{a}	83.00±11.34^{bc}
Q-Q 37-1	86.45±2.94^{a}	15.17±0.38^{a}	1.63±0.11^{a}	93.27±3.31^{a}
Regeolona	81.52±4.31^{a}	13.51±0.67^{ab}	1.33±0.10^{ab}	87.60±1.53^{bc}
Season 2016/2017				
KVLSRA 1	48.83 ^{c} ±1.54	7.22 ^{c}±0.17	0.91 ^{c} ±0.13	48.08 ^{c}±0.08
KVLSRA 2	53.16 ^{c} ±2.08	8.51 ^{b}±0.21	0.99 ^{b} 0.13	42.03 ^{c}±4.35
KVLSRA 3	64.53 ^{b} 0.32	8.66 ^{b}±0.47	1.30 ^{ab} 0.08	60.02 ^{bc} ±1.39
Q-52	68.73 ^{a} ±1.92	9.04 ^{ab} ±0.11	1.38 ^{a} 0.07	80.71 ^{bc} ±6.89
Q-Q 37-1	70.86 ^{a} ±2.62	9.93 ^{a}±0.23	1.39 ^{a} 0.08	88.13 ^{a}±3.00
Regeolona	66.16 ^{ab} 1.62	8.17 ^{bc} ±0.59	1.36 ^{a} 0.12	77.63 ^{b}±5.14

Table 6. means of yield and its component of the six quinoa genotypes under salinity irrigation in 2015/16-2016/17 seasons.

Genotypes	No. of Panicles/plant		Plant fresh Weight (gm)		Yield Weight/plant (gm)	
	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17
KVLSRA 1	8.72 ^{b}±0.31	7.59 ^{c} ±0.16	56.95 ^{c}±4.68	46.94 ^{d}±0.05	6.39 ^{c}±0.24	6.35 ^{c}±0.15
KVLSRA 2	8.53 ^{b}±0.13	8.54 ^{bc}±0.15	57.43 ^{c}±1.49	50.95 ^{c}±1.32	10.58 ^{c} ±0.16	7.79 ^{b}±0.12
KVLSRA 3	11.72 ^{ab}± 0.31	9.93 ^{b}±0.39	68.71 ^{bc}±2.14	60.57 ^{b}±1.62	13.93 ^{b}±0.18	8.98 ^{b}±0.13
Q-52	11.9 ^{ab}±0.96	9.89 ^{b}±0.77	75.12 ^{b}±4.18	62.66 ^{b}±3.46	14.29 ^{b}±0.14	9.19 ^{a}±0.45
Q-Q 37-1	12.27 ^{a}±0.24	12.1 ^{a}±0.16	82.32 ^{a}±0.81	72.26 ^{a}±1.83	17.83 ^{a}±0.28	9.79 ^{a}±0.10
Regeolona	12.1 ^{a}±0.53	11.9 ^{a}±0.06	81.6 ^{a} ±2.76	70.48 ^{a}±0.95	15.13 ^{ab}±0.16	11.35 ^{a}±0.02
Genotypes	Harvest Index (HI) %		1000 -seeds weight Index (gm)		Yield (ton fed^{-1})	
	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17
KVLSRA 1	23.26 ^{b}±0.040	18.14^{c}±1.06	2.43 ^{ab}±.04	2.33 ^{b}±0.04	1.23 ^{b}±0.44	0.77 ^{b}±0.32
KVLSRA 2	22.76 ^{c}±0.17	16.99 ±2.93	2.76 ^{a}±0.08	1.72 ^{bc}±0.10	1.65 ^{ab}±0.77	0.76 ^{b}±0.13
KVLSRA 3	27.73 ^{a}±0.11	21.55^{b}±2.10	2.77 ^{a}±.09	2.75 ^{a}±0.12	1.74 ^{a}±0.43	1.04 ^{a}±0.09
Q-52	24.56 ^{b}±0.013	20.39^{b}±1.23	2.97 ^{a}±0.13	2.68 ^{a}±0.18	1.70 ^{a}±0.73	1.02 ^{a}±0.01
Q-Q 37-1	28.89 ^{a}±0.10	18.29^{c}±0.31	3.03 ^{a}±0.17	2.79 ^{a}±0.23	1.84 ^{a}±0.38	1.06 ^{a}±0.09
Regeolona	26.86 ^{ab}±0.15	24.16^{a}±4.2	2.93 ^{a}±0.15	2.88 ^{a}±0.17	1.75 ^{a}±0.03	1.05 ^{a}±0.13

Effect of Salinity Irrigation on Seeds Chemical Composition on First Season

Data in table (7) indicated that chemical component (%) varied significantly between the six studied genotypes. For protein and carbohydrates total content, values ranged from 14.75 to 10.59 and from 58.13 to 54.64 % for genotypes Q_{52} and Regeolona, respectively. While in moisture content, values ranged from 11.66 to 10.83 for genotypes KVLSR1 and Q-Q_{37-1}, respectively. Also, fats content ranged from 10.44 to 7.14 % for genotypes Q_{52} and Regeolona, respectively. While values of saponin ranged from 0.56 to 0.37% for genotypes KVLSR1 and Regeolona, respectively.

Discussions

Salt tolerance is a complex trait and attributed to a raise of interrelated with morphological, biochemical and physiological mechanisms. In this situation, the selection and screening of quinoa genotypes for salt tolerant is an important step to persue their adaptation under marginal and poor nutrient sandy soils. Quinoa genotypes were slightly increased after 20% seawater salinity [16]. Selection of a particular policy depends upon of soil type, water quality, the agro-climatic conditions and crops to be irrigated. Many researchers reported that quinoa cultivars have good tolerance to high salinity levels [17], [18], [19]. Salinity irrigation caused significant variation between cultivars for all studied traits. Similar results were reported by other colleagues [20], [21], [22], [23].

Salt-induced growth reduction is presumably due to low photosynthetic supply as a consequence of impaired photosynthetic capacity. Also, they confirmed that all growth traits of quinoa plant affected by the high levels of salinity where, this achieves depend on the kind and quantity of salt. Our results showed that salinity irrigation reduced morphological yield and its component traits for all cultivars at 2016/17 season than 2015/2016. This finding was confirmed that the salt concentrations in irrigated water and soil were much higher in second season than the first season. Our findings also, are in agreement with [24] that a decreased in no of leaves plant^{-1} was found when salt levels increased in irrigated water. Salt concentrations in irrigated water affected on seed germination and early seedling growth of quinoa, where saline stress reduced growth abilities of quninoa cultivars in contrast with growing in pure water conditions [25]. [26], [27],[28], also found the same result in significant reductions in grain yield, no- of seeds and 1000-seed weight of quinoa in the presence of salinity. Previous study confirmed that, quinoa plant showed good resistance to water and salt stress through osmotic adjustments and stomatal responses that played an important role in the preservation of a leaf turgor favorable to plant growth and preserved crop yield [29].

Conclusion

From the data presented in this study, it could be concluded that the genotype Q-Q37-1 was earliness genotypes for 50% heading and maturity, the genotypes Q-Q37-1, Q-Q37-1, Q-Q37-1, Q-Q37-1, Q52 and

Table 7. means of chemical composition of the six quinoa genotypes under salinity irrigation in the first season (2015/16).

Genotypes	Protein (%)	Carbo- hydrates (%)	Moisture (%)	Fat (%)	Saponin (%)
KVLSRA 1	11.77 ^{c} ± 0.10	56.75 ^{b} ± 0.34	11.66 ^{a} ± 0.19	7.91 ^{a} ± 1.22	0.56 ^{a} ± 0.33
KVLSRA 2	11.61 ^{c} ±0 .06	58.00 ^{a} ± 0.05	11.16 ^{bcd} ± 0.09	10.01 ^{a} ± 1.62	0.43 ^{bc} ± 0.19
KVLSRA 3	12.35 ^{b} ± 0.11	57.66 ^{ab} ± 0.30	11.49 ^{ab} ± 0.09	8.89 ^{a} ± 1.37	0.39 ^{c} ± 0.14
Q-52	14.75 ^{a} ±0 .05	58.31 ^{a} ± 0.10	10.99 ^{cd} ± 0.19	10.44 ^{a} ± 1.18	0.43 ^{bc} ± 0.17
Q-Q 37-1	14.44 ^{a} ± 0.05	58.17 ^{a} ± 0.02	10.83 ^{d} ± 0.98	9.18 ^{a} ± 0.32	0.50 ^{ab} ± 0.15
REGEOLONA	10.59 ^{d} ± 0.19	54.64 ^{c} ± 0.19	11.33 ^{abc} ± 0.01	7.14 ^{a} ± 0.53	0.37 ^{c} ± 0.28

Q-Q37-1 gave the high averages for number of panicles/ plant, plant fresh weight, plant yield weight, harvest index, 1000 seeds weight index and yield in (ton fed-1) the genotype Q52 and Regeolona were the best genotypes for protein and carbohydrates total content. Future experiments are in progress to pinpoint the factors related to improvement of quinoa genotypes for yield and chemical composition under salinity and drought stress conditions.

References

1. Jacobsen, S. E.; Quispe, H. and Mujica, A. (2000) . Quinoa: an alternating crop for saline soils in the Andes , CIP Program Report (1999-2000), Peru.
2. Geissler, N., Hussin, S., Koyro, H.W., (2010). Elevated atmospheric CO2 concentration enhances salinity tolerance in Aster tripolium L. Planta 231, 583–594.
3. Jacobsen, S. E. and Mujica, A. (2001). Quinoa response to a biotic stress factors, Universidad Nacional Agraria La Molina, Lima, Peru.
4. Schlick, G. and Bubenheim, D. L. (1996). Quinoa: candidate crop for NASA's controlled ecological life port systems, Progress in new crops: Proceedings of the Third National Symposium indianapolis, indiana, 22-25 October,1996, 632-640, American Society for Horticultural Science, Alexandria, USA.
5. Galway, N. W.; Leakey, C. L. A.; Price, K. R. and Fenwick, G. R. (1990) . Chemical composition and nutritional characteristics of quinoa (*Chenopodium quinoa* Willd.), Food Sciences and Nutrition, 42 F:245-261.
6. Schlick, G. and Bubenheim, D. L. (1996). Quinoa: candidate crop for NASA's controlled ecological life port systems, Progress in new crops: Proceedings of the Third National Symposium indianapolis, indiana, 22-25 October,1996, 632-640, American Society for Horticultural Science, Alexandria, USA.
7. Galwey, N. W. (1992). The potential of quinoa as a multi-purpose crop for agricultural diversification. Industrial Crops and Products, 1:101 -106.
8. Jacobsen, S. E. and Stolen, O. (1993). Quinoa - morphology, phenology and prospects for its production as a new crop in Europe, European Journal of Agronomy, 2:19-29.
9. Jacobsen, S. E.; Hollington, P. A. and Hussain, Z. (2002). Quinoa , a potential new crop for Pakistan. (Tasks for vegetation science 37), Prospects for saline agriculture, 247-249 , Kluwer Academics, Dordrecht, Netherlands.
10. Prado, F. E.; Boero, C.; Gallardo, M. and Gonzalez, J. A. (2000). Effect of NaCl on germination, growth, and soluble sugar content in *Chenopodium quinoa* Willd. Seeds, Botanical Bulletin of Academia Sinica, 41:27-34.
11. Gesinski, K.(2006).Evaluation of growth and flowering of *Chenopodium quinoa* Willd, under Polish conditions ,Acta Agrobotanica, 59:487- 496, Polskie Towarzystwo Botaniczyne (Polish Botanical Society) ,Warszawa, Poland.
12. Geel, W. V (1997). Quinoa in foodstuffs offers prospects, PAV Bulletin Akkerbouw, 17-20, November,
13. Wong, L.S.L. and Baker, R. J. (1986), Selection for time to maturity in durum wheat. Crop . Sci. 26 ; 1171-1175.
14. Geerts, S.; Raes, D.; Garcia, M.; Vacher, J.; Mamani, R.; Mendoza, J.; Huanca, R.; Morales, B.; Miranda, R.; Cusicanqui, J. and Taboada, C. (2008). Introducing deficit irrigation to stabilize yields of quinoa, European Journal of Agronomy, 28: 427- 436, Amsterdam, Netherlands.
15. Steel, R.G.D., Torrie, J.H.., and Dickey, D.A.. (1997). Principles and procedures of statistics, a biometrical approach. 3rd edition. McGraw-Hill Co. Inc., New York NY.
16. Eisa, S., Hussin, S., Geissler, N., and Koyro, H.W.. (2012). Effect of NaCl salinity on water relations, photosynthesis and chemical compositionof quinoa (Chenopodium quinoa Willd.) as a potentialcash crop halophyte. Aust. J. Crop Sci. 6, 357–368.
17. Eisa, S., Hussin, S., Geissler, N., and Koyro, H.W.. (2012). Effect of NaCl salinity on water relations, photosynthesis and chemical compositionof quinoa (Chenopodium quinoa Willd.) as a potentialcash crop halophyte. Aust. J. Crop Sci. 6, 357–368.
18. Moreno. C., Seal, C. E., and Papenbrock, J.(2017) Seed priming improves germination in saline conditions for Chenopodium quinoa and Amaranthus

caudatus. J Agro Crop Sci. 2018;204:40–48. DOI: 10.1111/jac.12242.

19. Jbawi, E.A., Danoura, R., Yaacoub, A. (2018) Effect of Deficit Irrigation and Manure Fertilizer on Improving Growth and Yield of Quinoa in Syria. Open Acc J Agri Res: OAJAR-100007.
20. Munns, R., James, R.A (2003) Screening methods for salinity tolerance: a case study with tetraploid wheat. Plant Soil 253:201–218
21. Eisa, S., Hussin, S., Geissler, N., and Koyro, H.W. (2012). Effect of NaCl salinity on water relations, photosynthesis and chemical compositionof quinoa (Chenopodium quinoa Willd.) as a potentialcash crop halophyte. Aust. J. Crop Sci. 6, 357–368.
22. Moreno C., Seal, C. E., and Papenbrock, J. (2017) Seed priming improves germination in saline conditions for Chenopodium quinoa and Amaranthus caudatus. J Agro Crop Sci. 2018;204:40–48. DOI: 10.1111/jac.12242
23. Jbawi, E.A., Danoura, R., Yaacoub, A. (2018) Effect of Deficit Irrigation and Manure Fertilizer on Improving Growth and Yield of Quinoa in Syria. Open Acc J Agri Res: OAJAR-100007.
24. Abdullah M. A., Mohammed, M. E.., Badran, A. E. and Abdulrahman, M. A., (2015). Effect of Irrigation Water Salinity on the Growth of Quinoa Plant Seedlings. Journal of Agricultural Science; Vol. 7, No. 8: 205 -214.
25. Panuccio, M.R., Jacobsen, S.E., Akhtar, S.S and Muscolo, A. (2014). Effect of saline water on seed germination and early seedling growth of the halophyte quinoa. J Plant Sci. DOI:10.1093/abobpla/plu047. http://www.aobplants.oxfordjournals.org.
26. Koyro, H.W. and Eisa S.S. (2007). Effect of salinity on composition, viability and germination of seeds of Chenopodium quinoa Willd. Plant Soil 302: 79-90.
27. Razzaghi, F., Ahmadi, S.H.., Jacobsen, S.E., Jensen, C.R.., Andersen, M.N. (2012). Effects of salinity and soil-drying on radiation use efficiency, water productivity and yield of quinoa (Chenopodium quinoa Willd.) J Agron Crop Sci 198: 173- 184.
28. Peterson, A and Murphy, K. (2015). Tolerance of lowland quinoa varieties to sodium chloride and sodium sulfate salinity. Crop Sci 55: 331-338. DOI: 10.2135/cropsci2014.04.0271.
29. Cocozza, C., Pulvento, C., Lavini, A., Riccardi, M., d'Andria, R, and Tognetti, R. (2013). Effects of increasing salinity stress and decreasing water availability on ecophysiological traits of quinoa (Chenopodium quinoa Willd.) grown in a Mediterranean-type agroecosystem. J Agro Crop Sci, 199, 229-240. http://dx.doi.org/10.1111/jac.12012.