Quinoa tolerance to saline condition in clay soil: first experience

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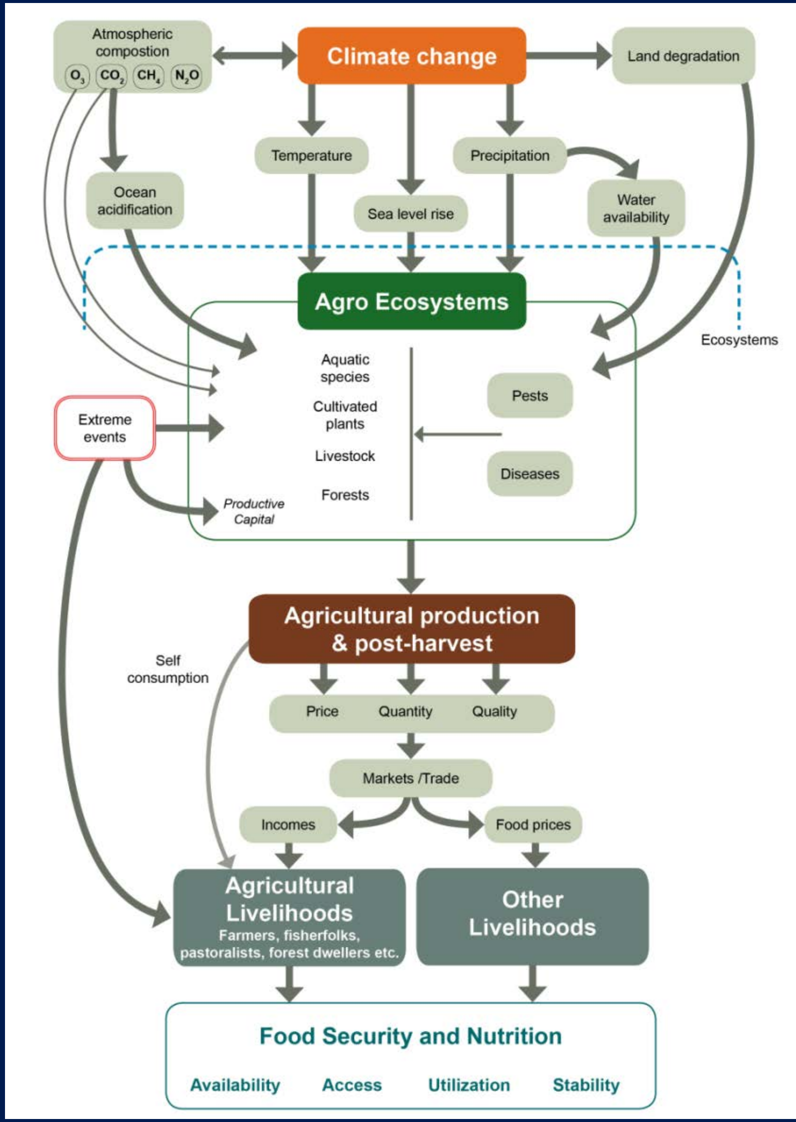
Introduction



Schematic representation of the cascading effects of climate change impacts (FAO 2016)

These climatic and demographic factors are significantly increasing the pressure on biodiversity and agriculture in Azerbaijan

Introduction

- Cultivated area: Kur-Araz lowland of Azerbaijan with semi-arid climate (>600.000 ha)
- Salt affected clay soil area with scarcity of water resources and annual participation < 300 mm.
- Unpredictability of drought occurrence, its severity, duration and interaction with other stresses, complicate the endeavors.
- **Needs:** Alternative agricultural production systems: appropriate evaluation of non-traditional and traditional crops tolerant to abiotic and biotic stress.

  which should assist in exploiting the available soil, water and crop resources, and transferring of innovations in agriculture.

Objectives

- effect of abiotic stress (salinity and drought) on quinoa along with other forage crops growth and quality

- allometric relationships: tolerance and abiotic stress

Long-term

- impact of stresses on transportation of macro and microelements in the soil-root-plant system

- rhizosphere microbiological features

- basic mechanisms and processes relating to morphological, physiological, and metabolic, and biomolecular parameters

Material and Methods

- Multidisciplinary team
  (since 2014 with ICBA & other organizations)

  - plant physiology
  - soil science
  - microbiology
  - agronomy
  - molecular biology

- Variety of forage crops

- Field and greenhouse experiments

Location and Soil

- Kurdemir Experimental station, Institute of Botany,
- Salt-affected soil (EC= 8-12 dS m^{-1})
- Clay soils with weak structure and swelling
- Moderate pH (>8) and low N P (< 15 ppm).
- Plots: 2 x 3 m & 20 x 30 m ● 5 L pots.

Plants

- Quinoa Q3 (ICBA)• Amaranthus • Alfalfa • Sorghum • Maize • Rapeseed • Pearl millet • Fodder beet • (and few more)
- NPK = 50-150 kg $ha^{-1;}$ Microelements = 4-12 gha^{-1}
- Irrigation rate = 200-600 mm; total: 2000-4000 mm

Measurements

- Root and shoot growth of crops under abiotic stresses
- Morphological measurements at various phenological stages
- Sampling: Root, shoot, yield and soil
- Mineral, chemical and quality and image analysis.

Material and Methods

Botanical Garden (Soil texture + late sowing effect)

Institute of Botany - Green house

Institute of Botany - Field

Material and Methods

Field work and measurements : small and large plots

Location

May 2015

March 2016

May 2016

Field laboratory

Material and Methods

Field: small plots

June 2016

July 2016

Material and Methods

Field: small plots

August 2016

September 2016

Material and Methods

Laboratory: Root and Shoot measurements

Quinoa

Sorghum

Amaranthus

Alfalfa

Rapeseed

Material and Methods

Sorghum

Quinoa

Maize

Alfalfa

Amaranthus

Pearl millet

Material and Methods

Quinoa

WinRHIZO image analysis

Amaranthus

Sorghum

Quinoa

Results and discussion

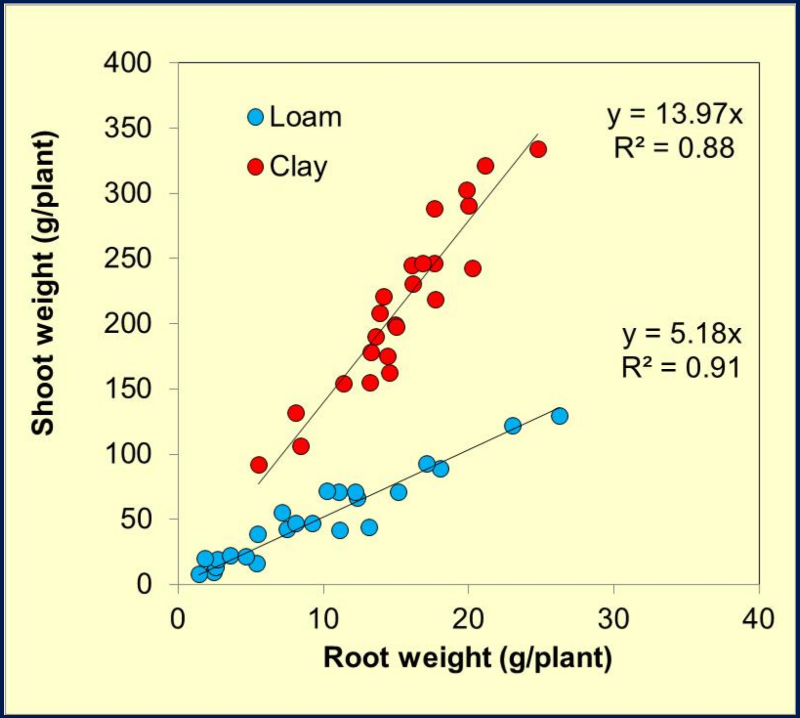
Vegetative & yield parameters of quinoa (Q3); C=Control, F=NPK. I = full irr.

Treatment	Stem diameter (mm)	Plant height (cm)	Shoot dry matter (g)	Root dry matter (g)	Root to Shoot ratio	Grain yield (g m^2)	Harvest index
C - 0.9 I	19.4 ab	160 a	289 a	18.1 b	0.063 b	214 b	0.14 ab
C - 0.6 I	17.3 c	98 d	221 c	13.9 c	0.063 b	177 c	0.15 a
C - 0.4 I	11.1 d	86 e	178 d	8.7 d	0.049 d	123 e	0.13 ab
F - 0.9 I	22.1 a	165 a	303 a	21.6 a	0.071 a	242 a	0.15 a
F - 0.6 I	18.4 bc	123 b	247 b	16.9 b	0.068 ab	203 b	0.15 a
F - 0.4 I	13.3 e	108 cd	208 c	11.8 c	0.057 c	140 d	0.12 b

- Duration of vegetation = 110-114 days
- Height (I, II, III months) = 8-20, 65-138 & 86-165 cm
- Starting to 50 % and ending of flowering time = 44-48 and 56-60 days,
- Branches = 14-24
- Panicle weight = 12-16 g/plant; panicle width & length = 12-18 cm & 40-48 cm .

Results and discussion

Effect of late sowing



Relationship between root and shoot weight of quinoa in loam and clay soils (nutrient deficit).

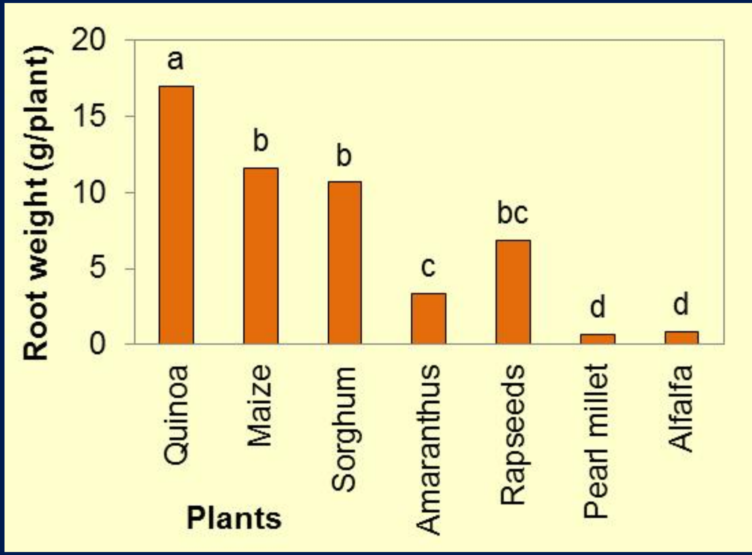
Loam: EC< 3 dS/m
Clay: EC > 6 dS/m

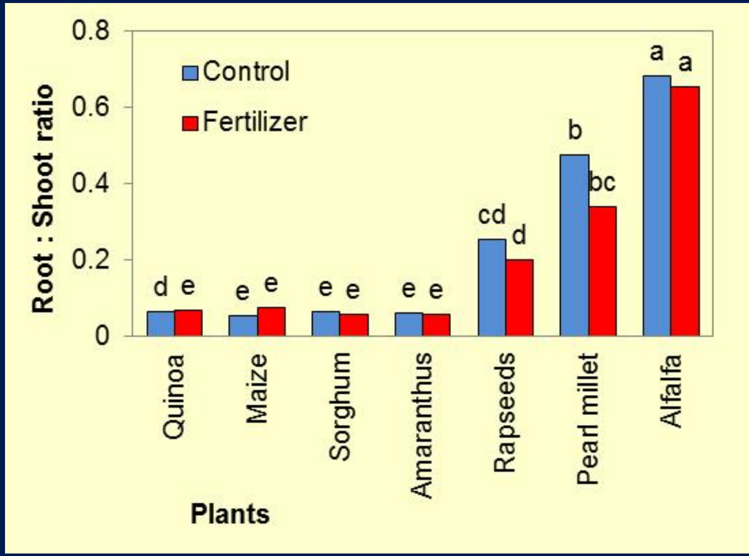
Late sowing:
Loam = 4-5 weeks
Clay = 2-3 weeks

- ✓ Literature review: most of results are comparable with literature data.
- ✓ Yield and harvest index was lower (1.5- 2 times) than Hirich et al. (2012)
- ✓ Better performance = 0.6-0.9 I (full irrigation)
- ✓ Crop performance & yield is highly affected by sowing date and drought.

Results and discussion

Root : Shoot ratio (0.6 l)





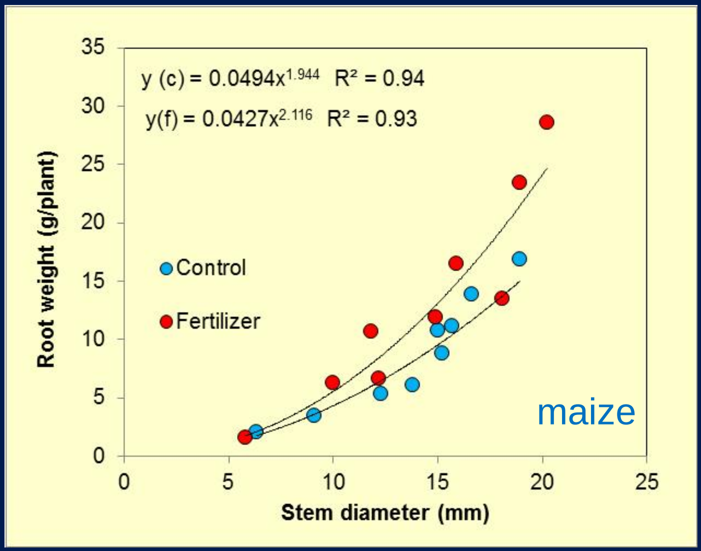
Plant diverse patterns for transportation of photosynthate and distribution to shoot and root is also influenced by abiotic stress.

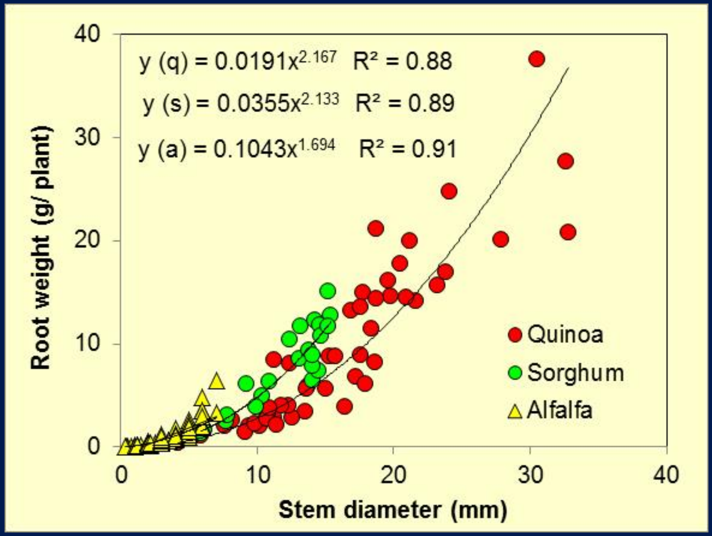
- Root: Shoot ratio of plants increase with decrease in root weight of crops
- Quinoa had one of lowest root: shout ratio, while having highest root weight

- Quinoa may have better adaptability to combined stresses, than other crops

Results and discussion

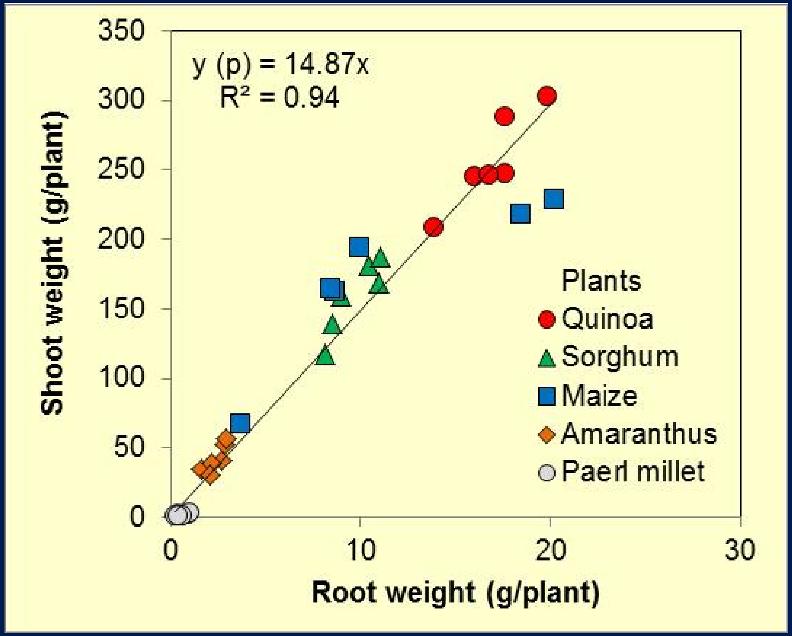
Allometric relationship





- Stem diameter is related to growth parameters.
- Allometric differences is expected between treatments to clarify contribution of abiotic stresses.
- Examples for: (i) maize: control and fertilizer treatments.
  (ii) the crops (or cultivars of the same crops).

Results and discussion



- Comparing the forage crops, Quinoa recorded higher dry biomass for the same growth period.
- Quinoa is more tolerant to the abiotic stresses likely to be successfully cultivated in semi-arid saline conditions (Kur-Araz lowland).

Conclusion

- The saline clay soils of the Kur-Araz lowland (i) appear to be suitable for cultivation of this multi-purpose agro-industrial crop, (ii) could be reclaimed (as an alternative options) by quinoa cropping.

- From the environmental perspectives, the plants studied seems to acclimatize fairly well to a moderate to high salinity with a small loss of root and shoot biomass. In top soil (0-20 cm) layer > 50% of roots mass were accumulated.

- Quinoa root and shoot exposed highest performances and growth under combination of salinity and drought stress than other tested forage crops.

- Quinoa crop rotation could increase soil C sequestration and phytoremediation.

Conclusion

Allometric relationship for forage crop, including quinoa could be a useful tool to evaluate

(i) crop resistance to salinity and drought stress or in general

(ii) crop performance in dependence of soil properties and management practices associated with environmental conditions.

Quinoa (along with other salt tolerant forage crops) could be recommended for large scale cultivation in this semi-arid climatic region with degraded salt affected soil having clay texture and limited water resources, though

more extensive field trials are required to select the best genotypes (cultivars) and to develop principal practices for their cultivation.

Acknowledgment

Travel support:

- International Center for Biosaline Agriculture (ICBA)
- Conference Organizers

We wish:

To continue our collaboration (e.g. joint projects) with International Center for Biosaline Agriculture (ICBA).

Good initial results were received in 2015 with ICBA provided Amaranthus • Pearl Millet • Sorghum, etc. (not presented)

Thank you for your attention !