

## International Quinoa Conference 2016:

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# Effects of salinity on seed yield and nutritional quality of Quinoa

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# Outline

- Background - Production systems in the UAE
- Quinoa R&D at ICBA
- Multi-location yield trials
- Growing environment and nutritional quality
- Conclusions

# Production systems in the UAE

- Harsh climate - severe limitation to productivity
- Scarcity of fresh water and increasing ground water salinity
  - ✓ Some 30-40% of the farms have groundwater salinity of  $>4\text{dS/m}$
- Many of the currently grown major crops are water-thirsty (e.g. Alfalfa, Rhodes grass) and salt-sensitive (vegetables)
- Likely to become hotter and drier due to climate change - increased water scarcity and salinity further impacting agricultural production
- Diversification of production systems through introduction of new salt-tolerant and water-use efficient crops needed to sustain agricultural production



# Crops investigated

## Forages

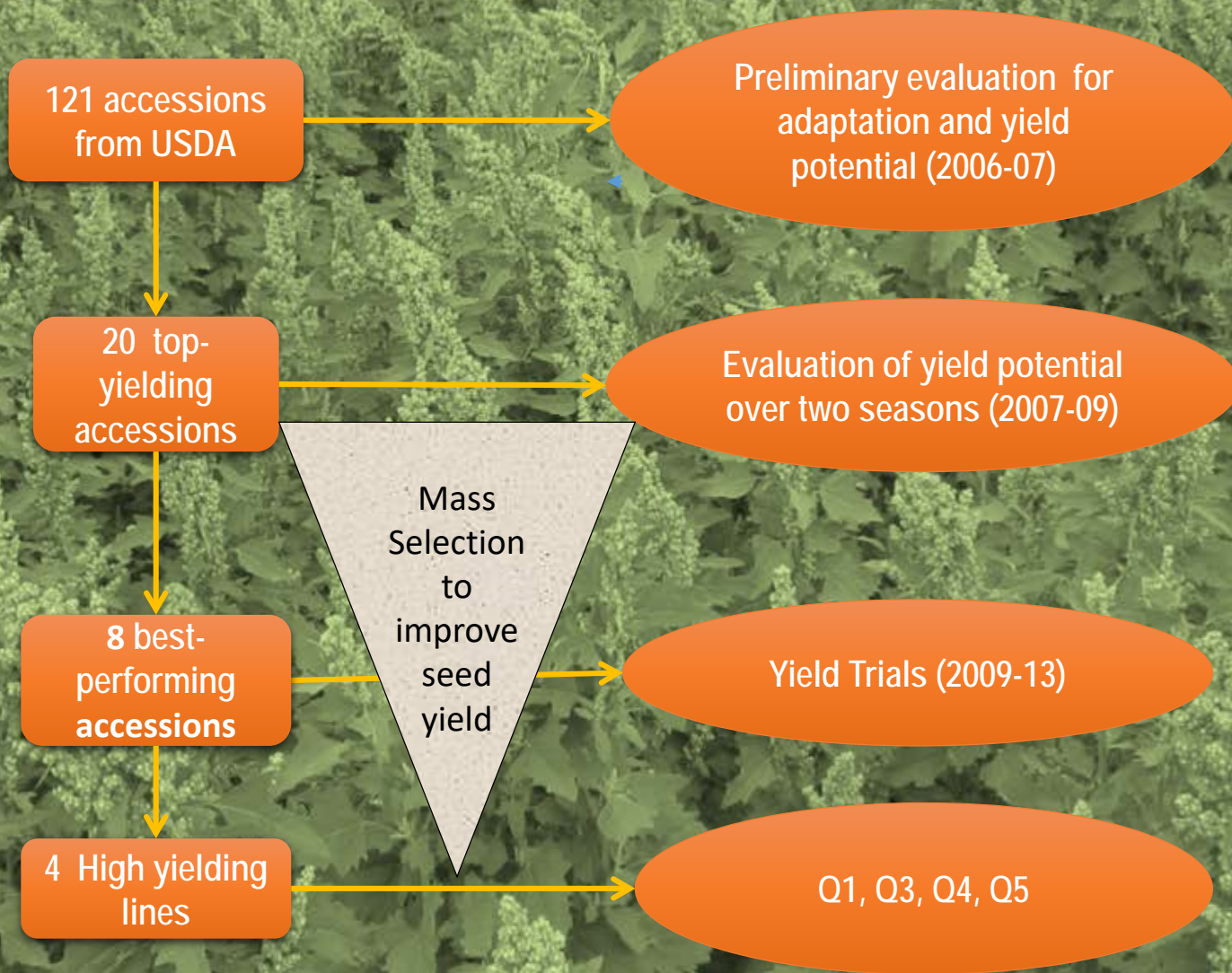
- Pearl millet
- Sorghum
- Barley
- Triticale
- Fodder beet
- Buffel grass
- Sesbania

## Other crops

- Quinoa
- Mustard
- Safflower
- Cowpea
- Guar
- Amaranth
- Castor

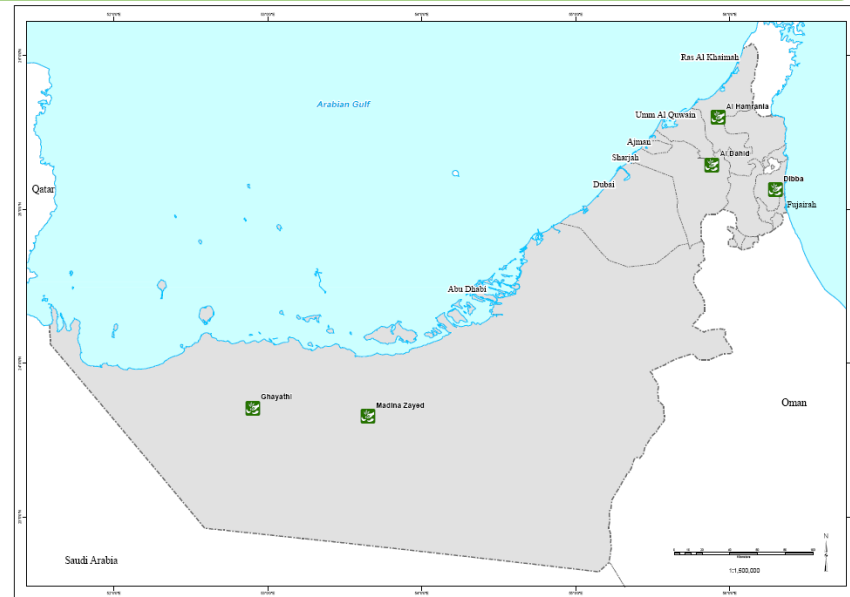
Among food crops, Quinoa ranked high in terms of local adaptation and grain yield potential – hence regarded as a promising alternative crop for the region

# Quinoa R&D at ICBA



# 1. Multi-location yield trials (2013-14)

- Locations: 5
  - ✓ Northern Emirates (3): Dibba, Hamraniah, Al Dhaid
  - ✓ Western region, Abu Dhabi (2): Ghayathi, Madinat Zayed
- Genotypes: 4 (Q1, Q3, Q4, Q5)
- Design: RCBD
- Plot size: 14-30 m<sup>2</sup>
- Irrigation water salinity 2-20 dS/m
- Sampled: 1 x 1 m
- Reps: 3
- Collaborators:
  - ✓ Ministry of Environment and Water (MOEW)
  - ✓ Abu Dhabi Farmer's Service Center (ADFSC)



Line No.	Derived from
Q1	Ames 13727
Q3	Ames 13761
Q4	Ames 22157
Q5	NSL 106398

# Soil and water characteristics of the farms

## Northern Emirates: Agricultural Res. Stations with Varying biophysical environments

Location	Water Salinity (dS/m)	Soil					
		Texture Class	pH	ECe (dS/m)	Clay	Silt	Sand
Dibba	6.1	Sand	7.55	35.86	2.83	4.87	92.30
Hamraniah	4.5	Sandy loam	7.49	48.50	8.53	18.83	72.63
Al Dhaid	2.3	Loamy sand	8.34	2.49	4.20	9.30	86.50

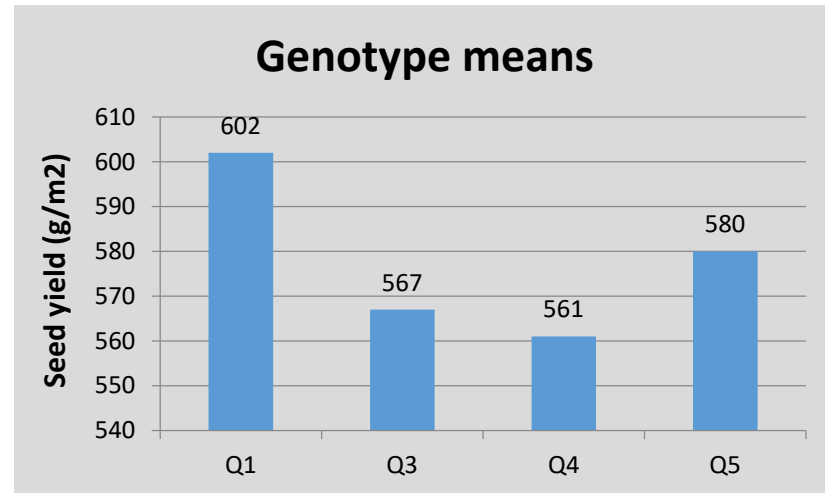
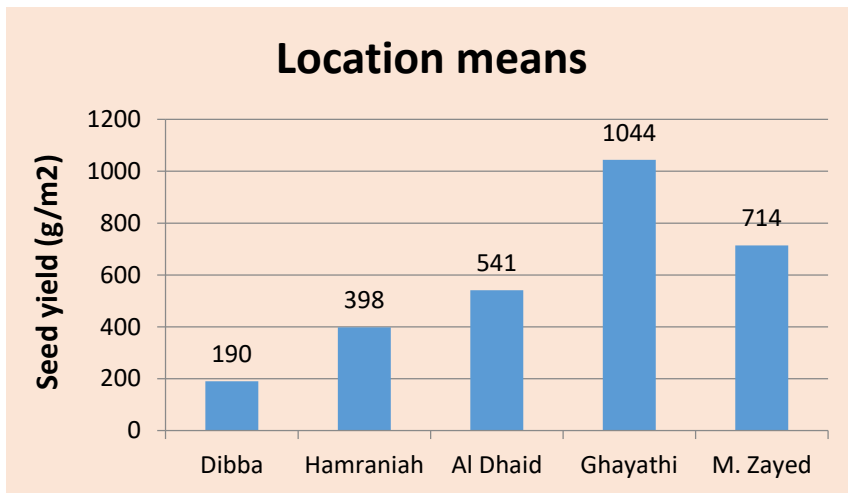
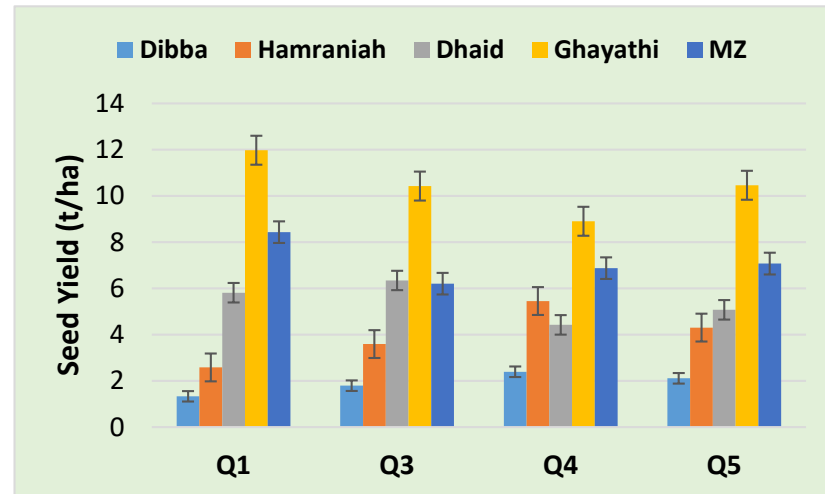
**Western Region: Abandoned farms - Soil and water quality rather poor to support the production of the traditionally grown forages and vegetables**

Water quality -Variable	Unit	Tolerant limit	Madinat Zayed	Ghayathi
EC <sub>w</sub>	dS/m	3	20.5	14.1
Sodium (Na <sup>+</sup> )	Meq/l	40	146.28	129.66
Chloride (Cl <sup>-</sup> )	Meq/l	30	172.5	108.5
Calcium (Ca <sup>+2</sup> )	Meq/l	25	52.56	14.58
Magnesium (Mg <sup>+2</sup> )	Meq/l	-	37.56	27.56
Sulfate (SO <sub>4</sub> <sup>-2</sup> )	Meq/l	20	65.9	64.9
Bicarbonate (HCO <sub>3</sub> <sup>-1</sup> )	Meq/l	10	0.4	0.26
Carbonate (CO <sub>3</sub> <sup>-2</sup> )	Meq/l	0.1	0	0
SAR	mmoles/l x 0.5	10	21.79	28.25
pH	—	6.0 – 8.5	6.92	7.32



# Multilocation trial - Seed Yields

- Significant differences among locations for seed and biomass yields ( $p>0.001$ )
  - Differences among genotypes were insignificant ( $p>0.05$ )
  - Mean seed yield of Locations: 1.9 t/ha in Dibba to 10.4 t/ha in Ghayathi
  - Mean seed yield of genotypes: 5.6 t/ha in Q4 to 6.0 t/ha in Q1
- ✓ Grand mean: 5.8 t/ha





## 2: Effect of growing conditions on nutritional quality

Nutritional quality of seeds harvest from low to highly saline environments assessed

- Locations: 3
  - Al Dhaid (2.3 dS/m)
  - Ghayathi (14.1 dS/m)
  - Madinat Zayed (20.1 dS/m)
- No. of Genotypes: 4 (Q1, Q3, Q4, Q5)
- Replicates: 3
- Parameters studied
  - Proximate composition
  - Amino acid content
  - Mineral content
- Methods/Protocols: Association of Official Analytical Chemists (AOAC, 1995)/Standard procedures
- Collaborator: McGill University, Canada



# Results - Nutritional assays

Location	Line	Proximate composition (g/100 g DW)						Minerals (mg/100 g DW)								
		Carbos.	Starch	Protein	Fat	Fiber	Ash	Na	K	Ca	Mg	Fe	P	Cu	Zn	
Al Dhaid (2.3 dS/m)	Q1 (Ames 13727)	74.6	55.5	14.4	5.3	19.1	5.7	56.4	1635.1	241.8	685.2	84.7	471.7	0.2	1.5	
	Q3 (Ames 13761)	74.7	55.5	14.2	5.3	19.2	5.9	72.6	1652.3	296.4	710.9	97.4	453	0.3	1.6	
	Q4 (Ames 22157)	74	53.8	14.1	5.8	20.2	6.1	60.1	1534.4	257.2	824.2	128.7	456.6	0.3	1.6	
	Q5 (NSL 106398)	75.6	58	14.3	5.3	17.6	4.8	62	1412.9	179.8	572.5	68.6	435.1	0.6	1.3	
	Mean	74.7	55.7	14.3	5.4	19.0	5.6	62.8	1558.7	243.8	698.2	94.9	454.1	0.4	1.5	
Ghayathi (14.1 dS/m)	Q1 (Ames 13727)	74.6	57.7	15.4	5.4	17	4.6	141.9	1721	57.4	344.4	0.5	472.4	0.4	2.4	
	Q3 (Ames 13761)	77.4	63.1	14.1	4.7	14.3	3.7	24.2	1280.5	39.3	283.1	2.8	406.6	0.4	2.3	
	Q4 (Ames 22157)	73.5	53.3	15.3	6.6	20.2	4.6	328.4	1900.8	112.3	399.2	1.9	491.1	0.1	2.1	
	Q5 (NSL 106398)	76	61.4	14.8	6	14.6	3.1	137.5	1008.6	81.1	228.6	7	441.9	0.2	1.9	
	Mean	75.4	58.9	14.9	5.7	16.5	4.0	158.0	1477.7	72.5	313.8	3.1	453.0	0.3	2.2	
Madinat Zayed (20.1 dS/m)	Q1 (Ames 13727)	75.6	60.2	14.8	5.8	15.4	3.8	111	1490.9	57.4	256	3.7	465.9	0.3	1.9	
	Q3 (Ames 13761)	75.3	60.4	15.5	5.3	14.9	3.9	137.2	1233.2	64.7	321.9	14.6	545.6	0.2	1.5	
	Q4 (Ames 22157)	77.7	66.7	14.1	4.6	11	3.5	96.3	1066.9	32.9	279.9	4.6	408.4	0.2	2.5	
	Q5 (NSL 106398)	74.3	62.4	14.6	7.4	11.9	3.8	230.6	1327.8	63.5	334.7	2.4	437.4	0.3	2.1	
	Mean	75.7	62.4	14.8	5.8	13.3	3.8	143.8	1279.7	54.6	298.1	6.3	464.3	0.3	2.0	
LSD (0.05)		<i>n.s.</i>	5.14	<i>n.s.</i>	<i>n.s.</i>	3.37	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	55.14	122.1	24.21	<i>n.s.</i>	<i>n.s.</i>	0.45	

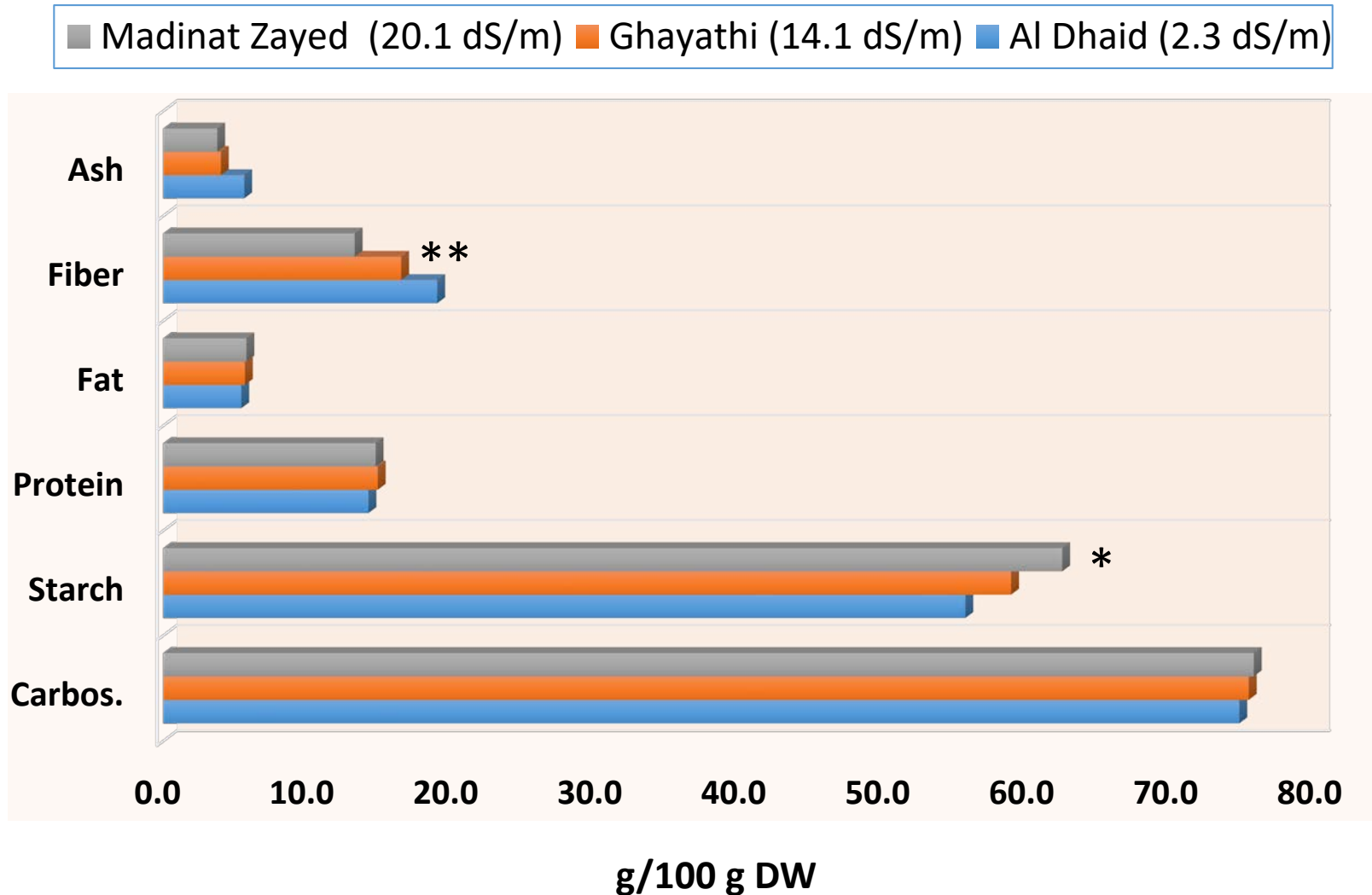
Proximate composition & Mineral content

Amino acid	Amino acid content (mg/g Protein)		
	Al Dhaid	Ghayathi	Madinat Zayed
ALA	4.63	4.99	4.25
ARG	2.11	3.07	3.62
ASN	6.49	7.74	6.45
ASP	23.23	26.74	27.79
GLN	5.17	7.03	3.24
GLU	21.29	9.99	11.07
GLY	3.38	3.82	2.64
ILE	4.75	5.03	5.41
LEU	3.11	3.26	1.91
LYS	3.1	4.3	3.42
PHE	11.99	12.95	13.49
SER	4.38	4.91	4.83
VAL	7.46	6.17	7.17
LSD (0.05)	A. Acid	2.324	
	Location	1.117	
	A. acid x		
	Location	4.026	

Amino acid content

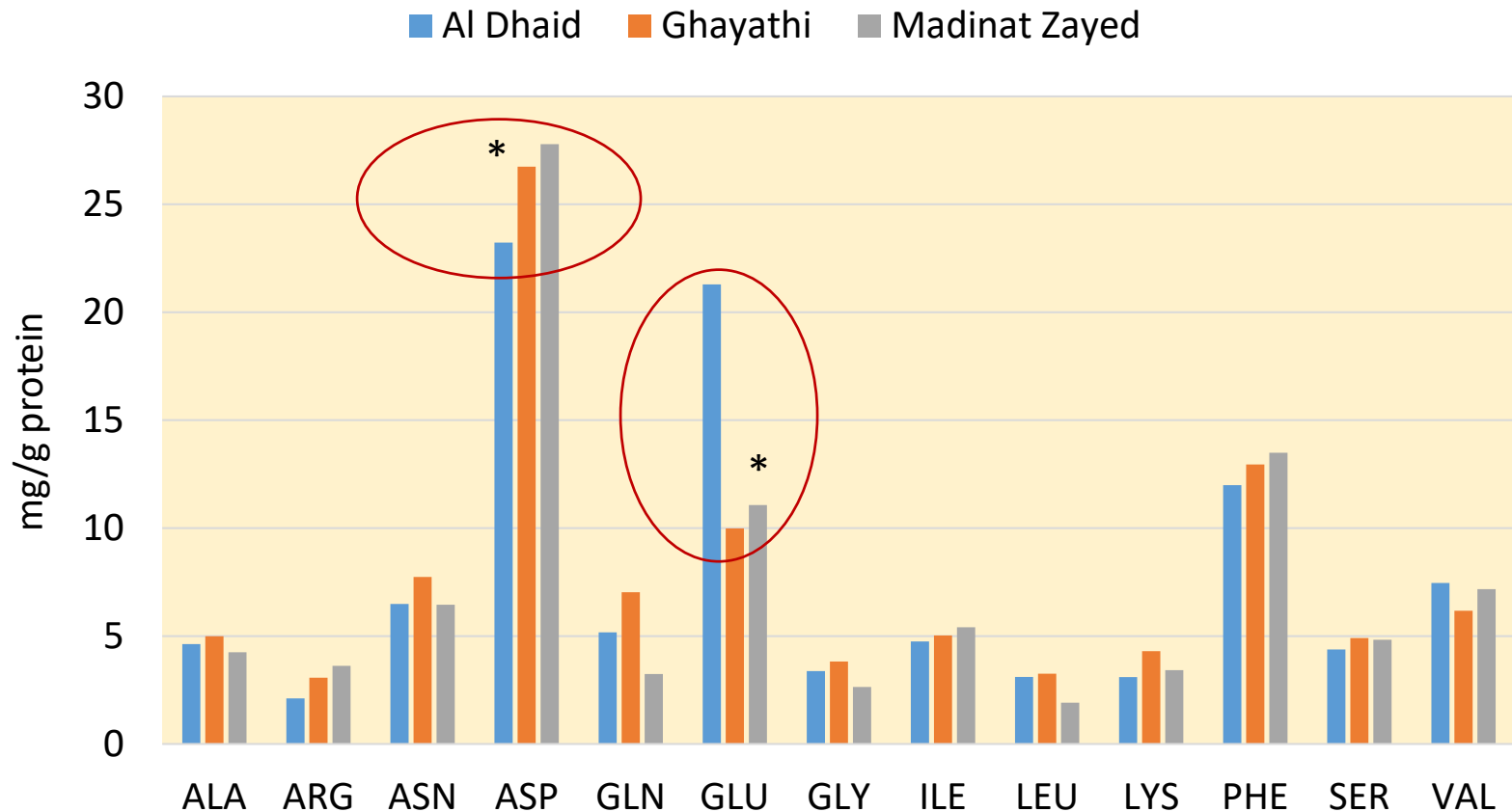
# Nutritional quality – Proximate composition

Proximate composition of the seeds not greatly altered by growing environment



# Nutritional quality – Amino acid content

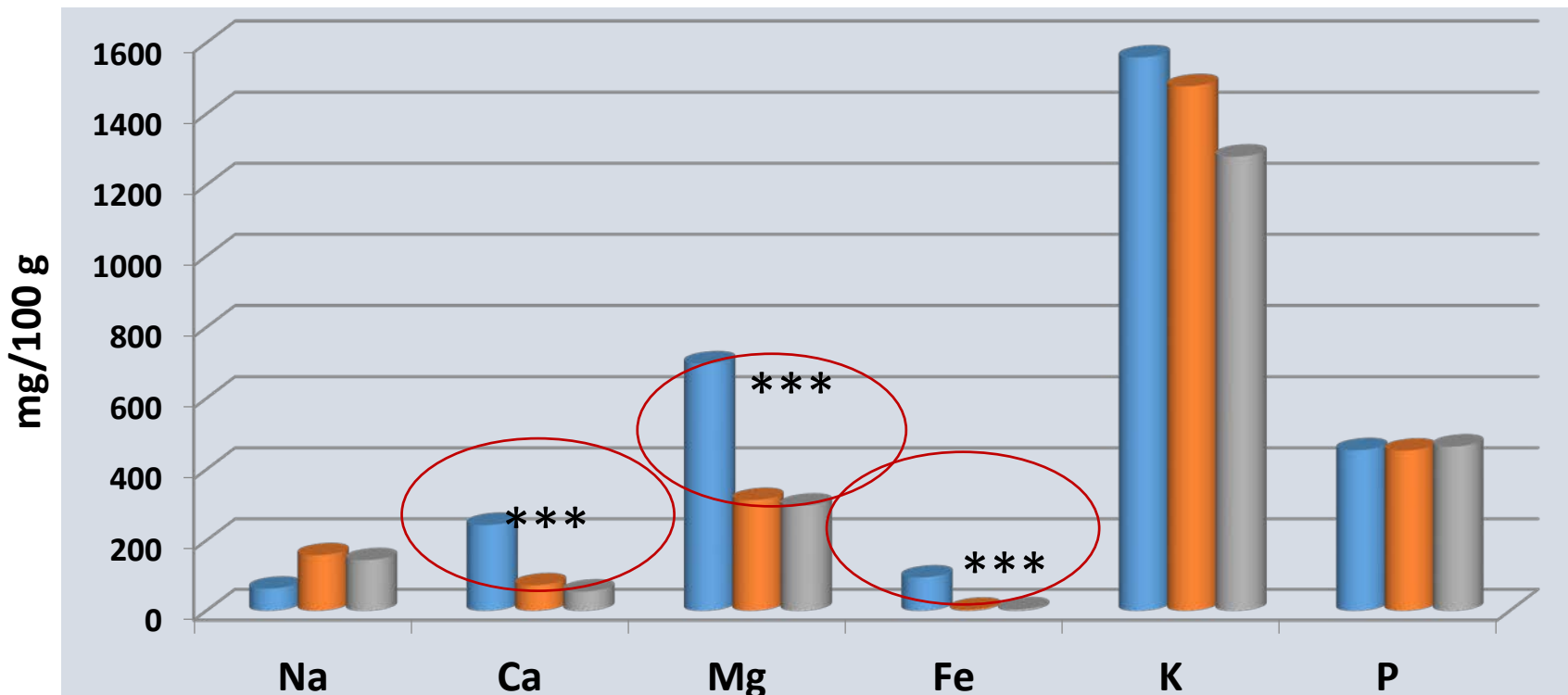
Amino acid content of the seeds from the three locations largely similar except for Asparagine and Glutamine



# Nutritional quality – Mineral content

Seeds harvested from Ghayathi and Madinat Zayed had higher Na and Zn content, but significantly lower levels of Ca, Fe compared the harvest from Al Dhaid

■ Al Dhaid (2.3 dS/m)   ■ Gayathi (14.1 dS/m)   ■ Madinat Zayed (20.5 dS/m)



# Conclusions

- Quinoa has good adaptation to the hyper-arid desert environments - excellent candidate for crop diversification in the UAE and other countries with similar climatic conditions
- Quinoa's ability to withstand high salinity confirmed - excellent potential as an alternative crop to rehabilitate salt-affected farms.
- Salt-stress has deeply altered the mineral composition, especially calcium, magnesium and Iron
- Further studies recommended in order to enhance our understanding of the response, especially to higher levels of salinity and help in selecting nutritionally stable genotypes



# Northern Emirates, UAE



# Western Region, Abu Dhabi Emirate, UAE





**Thank you**

