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Quinoa: From Experimentation to Production in Turkey

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Background/Introduction

- In recent years, the cultivation of quinoa has shifted from being a crop for local consumption in the Andean countries of Bolivia and Peru to become a cash crop for export to North America and Europe.
- Quinoa was first introduced in Turkey through the SWUP-MED project ‘Sustainable water use securing food production in dry areas of the Mediterranean region’ in 2008.

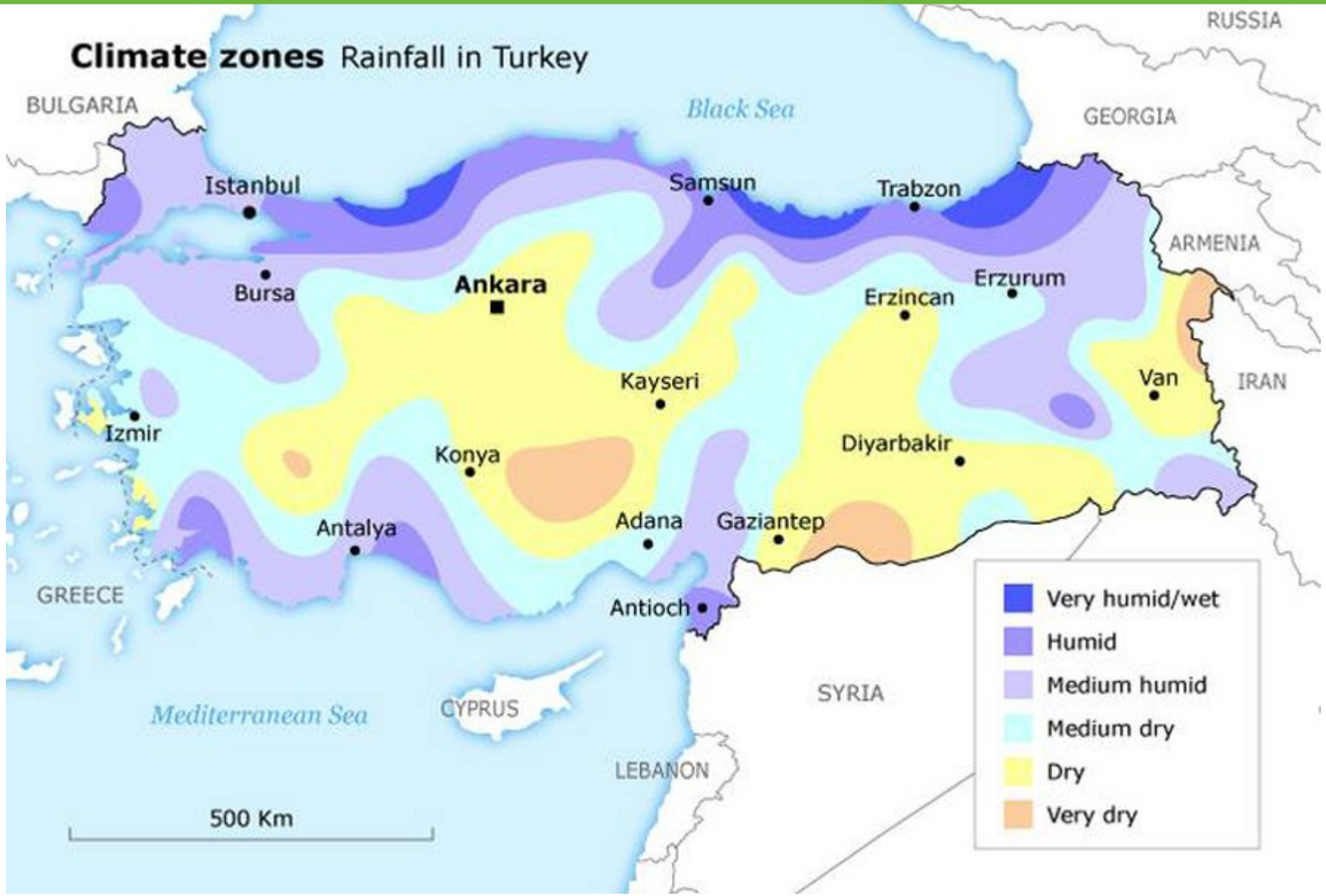
Background/Introduction

- Improving food crop production in the arid and semi-arid regions especially in the Mediterranean region, influenced by multiple abiotic stresses, by strengthening a diversified crop production and introducing new climate-proof crops and cultivars with improved stress tolerance such as **quinoa**.
- In this paper, we present some results of the field experiments carried out at **Cukurova University** in Adana, and **Soil Water Resources Research Station** at Tarsus, and quinoa production activities all over Turkey.

Background/Introduction

Turkey is located in a unique geographical position at the junction of three continents, Asia, Europe and Africa. This “cross-roads” location, combined with the diverse geomorphology and climatic conditions, means that Turkey is a key country for global biodiversity conservation with species originating from the North (Europe), the east (Western Asia) and the south (Africa).

Background/Introduction



Quinoa Experiments at Çukurova University

Experimental Site

This research is conducted in the experimental field of the Irrigation and Agricultural Structures Department of the Cukurova University in Adana, Turkey. The station has latitude of 36°59'N, a longitude of 35°18' E, and is at 50 m above mean sea level.

Experimental Soil

The soil of the experimental site is classified as the Mutlu soil series with **clay texture** throughout the soil profile. Available water holding capacity of the soil is 198 mm in the 120 cm soil profile.

Quinoa Adaptation Experiment

- The first study was an adaptation experiment for evaluating yield performance of 10 quinoa varieties (**L3, 4, 5, 10, 15, 23, 25, 28, 36, 52**) under the Mediterranean conditions in 2009.

- The varieties selected for adaptability trials included a range of species and morphological types that have agronomic potential. **Q52 (titicaca)** and **Q36 (puno)** perfomed better than other varieties tested.

TREATMENTS in 2009

1. Full Irrigation (FIF) using fresh water,
2. Full Irrigation using saline water (FIS) (5.5 dS/m)
3. Deficit Irrigation (DI-50) and
4. Partial Root-zone Drying (PRD-50).

DI-50 and PRD-50 treatments were irrigated using fresh water.

TREATMENTS in 2010 and 2011

Treatment	Description
FIF	Full irrigation with fresh water
FIS-40*	Full irrigation with saline water with EC = 40 dS/m
FIS-30	Full irrigation with saline water with EC = 30 dS/m
FIS-20	Full irrigation with saline water with EC = 20 dS/m
FIS-10	Full irrigation with saline water with EC = 10 dS/m
DIF-50	Deficit irrigation with fresh water; 50 % water applied to FIF
DIF-75	Deficit irrigation with fresh water; 75 % water applied to FIF
DIS-40*	Deficit irrigation with saline water, EC=40 dS/m; 50 % water applied to FIF
DI-25	Deficit irrigation with fresh water; 25 % water applied to FIF
DRY	Rain-fed condition, no irrigation is applied

IRRIGATION SCHEDULING

- Irrigations were applied at weekly interval and soil water deficit in the 90 cm soil profile in FIF treatment was replenished to field capacity.

- DI-25, DI-50, DI-75 treatments received 25, 50 or 75 % of water applied to FIF plots, respectively.

- Drip irrigation was used.

QUINOA (Q52) PLANTING

- Quinoa seeds were sown by hand at 3-4 cm apart in the row and at 50 cm row spacing on **April 10**, 2009; **March 26**, 2010; and **March 28**, 2011.

- At planting a compose fertilizer of (15-15-15) was applied broadcast at a rate of 75 kg/ha N, P2O5 and K2O, and incorporated into the soil. At flowering stage, 75 kg/ha urea was applied.

Results

Table 1. Grain yield, irrigation water applied, seasonal crop water use (ET), water use efficiency, and irrigation water use efficiency data of Quinoa under different treatments in the Mediterrranean region of Turkey in 2009.

•Irrigation Treatment	Irrigation water mm	Seasonal ET mm	Grain Yield kg/ha	IWUE kg/m³	WUE kg/m³
FIF	**383**	450	**2120**	0.55	0.47
DI-50	202	343	1690	0.84	0.49
PRD-50	202	321	1870	**0.93**	**0.58**
FIS (5.5 dS/m)	**383**	**462**	1780	0.46	0.39

Table 2. Grain yield, irrigation water applied, seasonal crop water use (ET), water use efficiency, and irrigation water use efficiency data of Quinoa under different treatments in the Mediterrranean region of Turkey in 2010.

Treat.	Irrig mm	ET mm	Grain Yield kg/ha	DM kg/ha	1000 seed weight g	WP kg/m³	IWP kg/m³	HI %	Yield Reduction %
FIF-100	320	**576**	**2986**	**6786**	3.1	0.52	0.88	44	0.0
FIS-30	320	481	2164	4243	3.1	0.45	0.62	51	31.7
FIS-20	320	524	2362	4921	3.1	0.45	0.68	48	25.5
FIS-10	320	516	2735	5698	2.9	0.53	0.80	48	**13.7**
DIF-50	160	348	1778	3951	2.5	0.51	1.00	45	43.9
DIF-75	240	483	2316	5264	2.7b	0.48	0.89	44	26.9
DIS-50	160	322	1889	3935	2.9	0.59	1.07	48	**40.4**
DRY	0	247	1714b	3809	2.5	**1.39**	0.00	45	46.0
LSD		54	877.3	1245	0.1107	0.12	0.14	ns	

Irrigation of Quinoa Using Drainage Canal Water

- The experiment was laid out using two line-source irrigation systems (Fig.1).
- Irrigation water was applied to replenish soil water deficit in the 60 cm depth to the field capacity; for the 7-day irrigation interval in treatment plots adjacent to sprinkler lateral (I1).

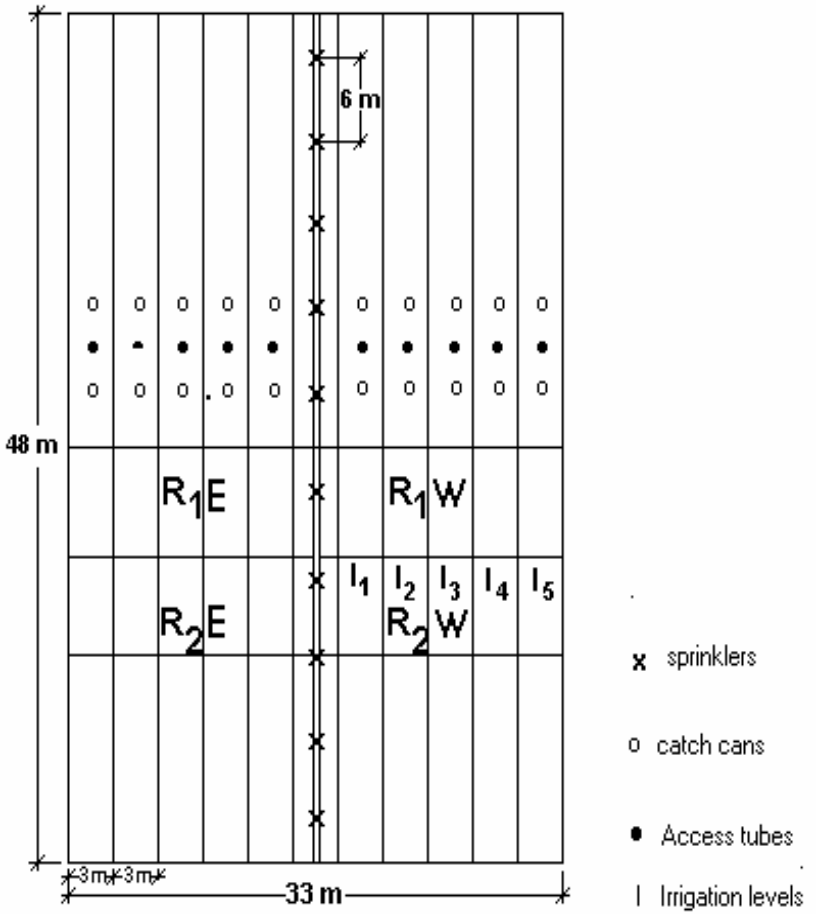


Fig. 1. Layout of the line-source sprinkler system.

Quinoa: Agronomic Practices

- Two planting times (normal and late) were used.
- Normal planting on **11 April**; and late planting was done on **30 April** 2012.
- In this study, ***Chenopodium quinoa Willd. L Titicaca*** variety was used.
- Seedlings were transplanted at 20 cm in row, and 50 cm row spacing.

Quinoa: Agronomic Practices

- At both planting times, 70 kg/ha composite fertilizer of 20-20-20 was applied and incorporated into soil. On May 15, 2012 50 kg/ha urea (46 % N) was applied.
- Quinoa was harvested on July 10, and July 20, 2012, respectively.

Table 3. Seasonal irrigation, water use, yield, water use efficiency, irrigation water use efficiency data of quinoa at in different treatments in 2012

Planting times	Treatments	ET, mm	I, mm	Yield, kg/ha	WUE, kg/m^3	IWUE, kg/m^3
April 11 (Normal)	I_1	**456**	**310**	**6380**	1.40	2.06
	I_2	397	236	5770	1.45	2.44
	I_3	348	165	4550	1.31	2.76
	I_4	262	71	4110	**1.57**	**5.79**
	I_5 (rainfed)	**222**	-	**2210**	1.00	-
April 30 (late)	I_1	**473**	**395**	**2610**	0.55	0.66
	I_2	391	304	2340	0.60	0.77
	I_3	300	201	2250	**0.75**	1.12
	I_4	236	95	1590	0.67	**1.67**
	I_5 (rainfed)	**208**	-	**1100**	0.53	-

Table 5. Grain yield, evapotranspiration (ET), irrigation water applied, water use efficiency (WUE) and irrigation water use efficiency (IWUE) values for the irrigation levels in the experimental years

Years	Irrigation Levels	Yield kg/ha	ET mm	Irrigation mm	WUE kg/m3	IWUE kg/m3	1000 Seed weight, g
2014	I1	**4880** (a)	**514**	**344**	0.95	0.87	3.6 (a)
	I2	4420 (b)	457	266	0.97	0.95	3.4 (a)
	I3	4100 (b)	401	193	1.02	1.15	3.1 (b)
	I4	3550 (c)	345	97	1.03	1.72	2.6 (c)
	I5	1880 (d)	320	20	0.59	0.00	2.4 (d)
2015	I1	**4510** (a)	**459**	**400**	0.98	0.77	3.5 (a)
	I2	4240 (b)	385	309	1.10	0.91	3.2 (b)
	I3	3610 (c)	332	214	1.09	1.02	2.7 (c)
	I4	2860 (d)	267	114	1.07	1.25	2.1 (d)
	I5	1430 (e)	228	15	0.63	0.00	1.8 (e)

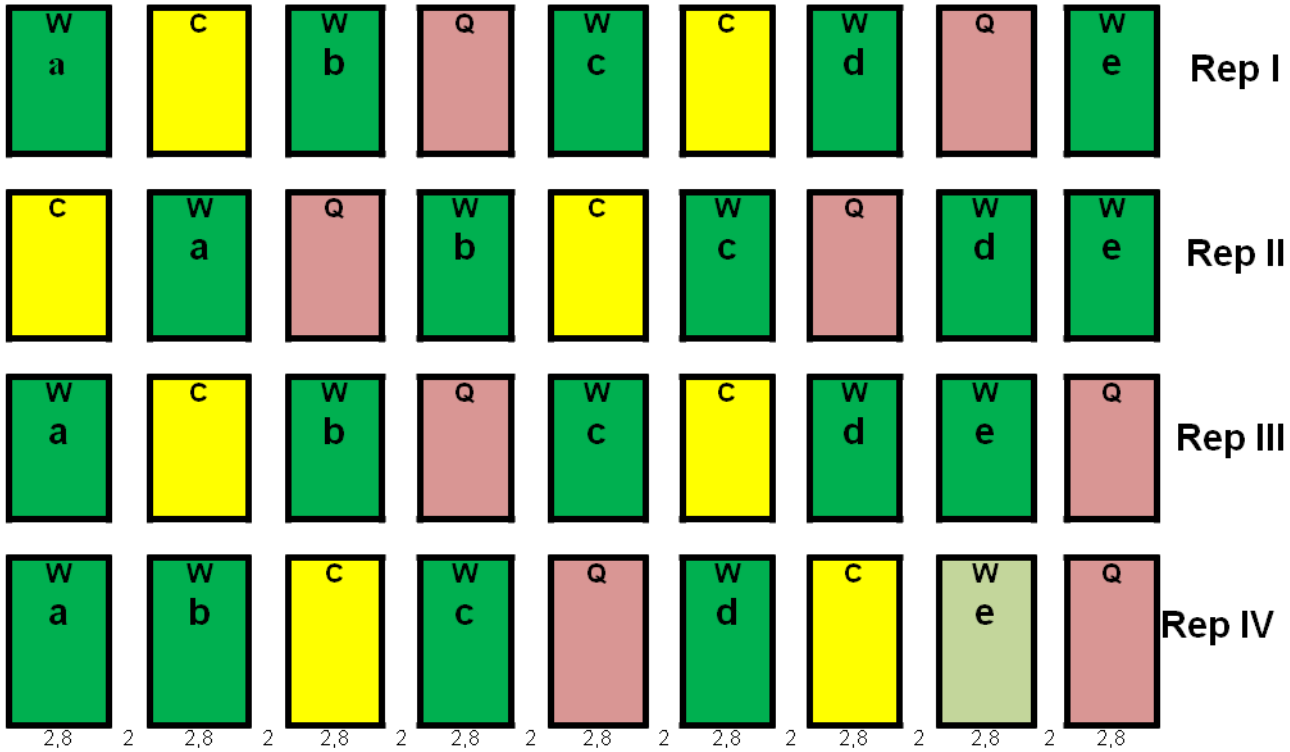
Crop Rotation Experiment

Table 6. Layout of the crop rotation experiment at the Hacıali Farm of Çukurova Agricultural Research Institute in Adana, Turkey. Prior to year 1 the crop has been a cereal.

	Yo	Y1	Y2	Y3	Y4	
T1	Wheat	Wheat	Wheat	Wheat	Wheat	a
T2a	Wheat	Legume	Wheat	New crop	Wheat	
T2b	Wheat	Wheat	Legume	Wheat	New crop	b
T3a	Wheat	New crop	Wheat	Legume	Wheat	
T3b	Wheat	Wheat	New crop	Wheat	Legume	c
T4a	Wheat	Legume	Wheat	Legume	Wheat	
T4b	Wheat	Wheat	Legume	Wheat	Legume	d
T5a	Wheat	New crop	Wheat	New crop	Wheat	
T5b	Wheat	Wheat	New crop	Wheat	New crop	e

*Y0: The season prior to the trials; Y1: Season 2008-09, Y2: Season 2009-10, etc.
a:WWWW; b: WLWQ; c:WQWL; d: WLWL; e: WQWQ

Crop Rotation Experimental Layout



W: Wheat;
C: Chickpea;
Q: Quinoa

- The four year results revealed that there was significant difference in grain and biomass yields, but no significant difference in plant height, harvest index, and 1000-grain weight of wheat among the treatments in crop rotation except number of grains per spike and soil organic matter.

- **Continuous wheat** and **chickpea-wheat-chickpea-wheat** (LWLW) produced significantly greater grain yield in 2010/2011 and 2011/2012.

- **QWLW** and **QWQW** rotation produced significantly lower biomass yield in 2008/2009.

Quinoa Experiment at Ege University, Izmir

Effect of different nitrogen levels on the yield and some yield components of quinoa (titicaca)

N levels (ha^{-1})	Grain yield (kg ha^{-1})	CP content of seed (%)
0 kg	927	7.9
50 kg	1340	9.1
75 kg	1896	11.1
100 kg	2446	13.1
125 kg	2807	14.8
150 kg	2953	15.8
175 kg	2519	16.5

Quinoa Production in Turkey

Quinoa harvest at a farmer’s field

Quinoa production at farmer’s field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Conclusions

- LACK OF AVAILABILITY OF PROPER PLANTING MATERIAL
- LACK OF PROPER AGRO-TECHNIQUES & AWARENESS AMONG GROWERS
- LACK OF MARKET POTENTIAL IN SYSTEM
- LACK OF INFORMATION FOR VALUE-ADDED PRODUCTS
- EXTENSION SERVICES TO BE STRENGTHENED FOR CULTIVATION OF QUINOA

THANK YOU