Adapting to climate change: testing possible measures to stabilize wheat and barley yields in a Mediterranean environment

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Abstract

Mediterranean agricultural systems are vulnerable to climate change. Under the combined pressure of temperature increase and the drop in precipitations, cropping systems could suffer from yield variability inducing an increase variability of farmers' income. The general objective of this study is to test possible adaptation measures to climate change for durum wheat and barley agricultural systems grown under the semi-arid conditions of the Bekaa valley in Lebanon. Two experiments were conducted at Tal Amara Research Station of the Lebanese Agricultural Research Institute; in the first experiment, two varieties of wheat, Icarasha and Miki, were tested in combination with early sowing coupled with 50 mm amount of irrigation, spring supplemental irrigation and conservation tillage arranged in a split split plot design. In the second experiment, two varieties of barley, Rihane 03 and Assi, were tested in combination with the same management practices. Besides yields and the irrigation water use efficiency defined as the ratio of yield over the amount of water supplied, other agronomic data were collected throughout the growing season. The results showed that farmers in the region should seriously consider adopting these agricultural practices that could constitute possible adaptation measures to climate change, particularly if combined with promising varieties.

Objectives

- The research presented here investigates the most appropriate adaptation measures to climate change impacts on cereal yields grown under the semi-arid conditions of the Bekaa valley in Lebanon.
- More specifically, the objective of this study is to test the effectiveness of three common management options such as early sowing coupled with a small amount of irrigation water, spring supplemental irrigation and conservation tillage when combined with promising wheat and barley varieties.

Materials and Methods

- Two field experiments were carried out in Tal Amara located in the Bekaa valley (Lebanon) (33o51'44''N lat., 35o59'32''E long. and 905 m above sea level) at the experimental field of the Lebanese Agricultural Research Institute (LARI) during the growing season 2012-2013.
- The climate is typically Mediterranean, characterized by an average annual rainfall of 592 mm mostly concentrated in autumn and winter months (October to March). Seasonal precipitation was 732 mm, compared to historical average of 592 mm (Fig. 1). The soil of the study area is characterized by 44% clay content.

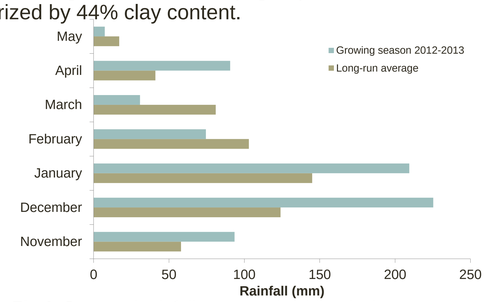

Fig.1. *Seasonal rainfall compared to historical average*

- Experiments were carried out to assess the response of early sown wheat and barley under two water supply regimes (rainfed (0) and spring supplemental irrigation (SI)) and two soil tillage practices (conventional tillage (Cv) and conservation tillage (Ca)). In the first experiment, two wheat varieties (W1: Icarasha and W2: Miki) were combined with the considered management practices while in the second experiment, two varieties of barley (B1: Assi and B2: Rihane) were used.
- The volumetric soil water content was monitored by time domain reflectometry (TDR) probes (Tektronix, Model 1502 C, USA). Soil moisture probes were installed vertically and horizontally at four subsequent soil layers: 0–0.15, 0.2 m, 0.4 m and 0.6-0.75 m.
- Phenology was recorded according to Zadoks et al. (1974). Plant sampling was performed, almost regularly during the season on a 2 weeks basis. Irrigation water use efficiency (expressed in $kg.m^{-3}$) was calculated as the ratio of dry aboveground biomass/yield to the seasonal rain + irrigation (WUEb and WUEy).

Results

The main results are reported in table 1 and figures 2, 3 and 4.

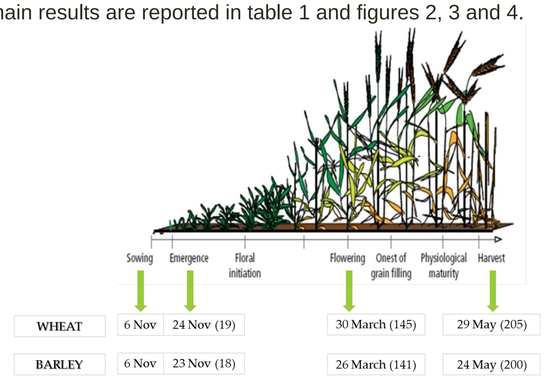

Fig.2. *The main phenological stages for durum wheat and barley during the growing season*

Results

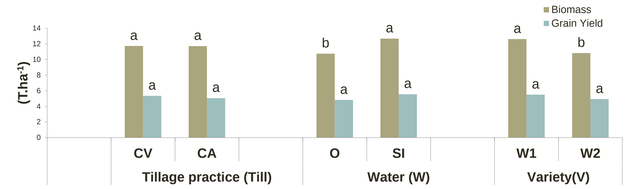

Fig.3. *Biomass and yield results for wheat*

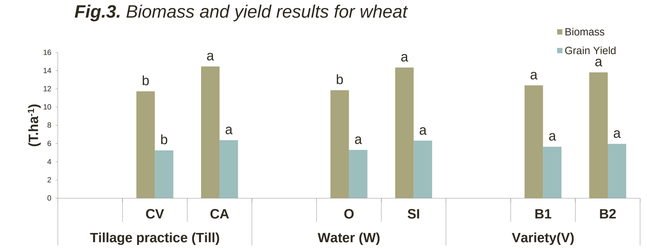

Fig.4. *Biomass and yield results for barley*

Table 1. *Multi-way ANOVA results for biomass and yield water use efficiencies for wheat and barley*

	WHEAT				BARLEY			
Source of Variation	WUEb		WUEy		WUEb		WUEy	
	Pr.	Means	Pr.	Means	Pr.	Means	Pr.	Means
Tillage practice (Till)	0.91		0.18		0,02 *		0,016 *	
CV		1,42 a		0,65 a		1,42 b		0,64 b
CA		1,42 a		0,61 a		1,75 a		0,77 a
Water (W)	0,04 *		0.69		0,04*		0.09	
O		1,30 b		0,58 a		1,43 b		0,64 a
SI		1,54 a		0,67 a		1,74 a		0,77 a
Variety(V)	0,03*		0.17		0.31		0.99	
W1		1,53 a		0,67 a		1,50 a		0,68 a
W2		1,31 b		0,59 a		1,67 a		0,72 a
Till* W	0.94		0.87		0.5		0.79	
Till *V	0.15		0.26		0.55		0.68	
W* V	0.84		0.74		0.81		0.7	
Till*W*V	0.37		0.51		0.71		0.76	

Means followed by the same letter in each column are not significantly different according to the Duncan multiple range test (P<0.05)

Conclusions

- Farming practices such as early sowing, supplemental irrigation and conservation tillage can assure the sustainability of agriculture, particularly under the challenges of climate change.
- Farmers are encouraged to adopt the techniques, which are productive and relatively simple. The techniques can stabilize cereal yields, which is important issue that will gain prominence in the region as the implications of climate change unfold.
- Our analysis can help farmers in planning future farming management.

Acknowledgements

The work was financed by the European research project ACLIMAS – Adaptation to Climate Change of Mediterranean Agricultural Systems – (ENPI/2011/269-668) that is a demonstration project within the 'Sustainable Water Integrated Management' program - SWIM. We are grateful to the European community for all support and assistance.