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Using Long-Term Data and Crop Modelling to Assess Climate Change Impacts on Durum Wheat Production in the Mediterranean

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Future projections of climate for the Mediterranean area indicate an increasing trend for temperature and a reduction in annual rainfall amounts during the next decades (IPCC, 2007). Different crop models were recently used to predict responses of crops to climate changes, to analyse the most appropriate actions to mitigate potential effects, and to propose guidelines for adaptation (Ludwig and Asseng, 2006; Tubiello 2000). In this study, 30-year climate and durum wheat yield datasets from two experimental sites located in southern Sardinia, Italy, were used for CERES-Wheat model calibration and validation, with the purpose of determining the impact of climate change on production.

Methodology

CERES-Wheat model calibration was performed using an iterative procedure until differences between measured and simulated data of yield, anthesis dates, and seed weight, were below defined error thresholds. Errors in predicting yield, anthesis date and seed weight for *Creso*, *Duilio* and *Simeto* varieties in two experimental sites located in Southern Sardinia (Italy) were evaluated using several statistics. In addition, a total of 48 simulated climate change scenarios were computed as incremental differences from the observed time series (1973-2004) of air temperature (1°C to 6°C) and/or decremental percentage of rainfall (5% to 30%). The simulated effects of climate change scenarios on crop yield, anthesis and seed weight of durum wheat varieties were determined for each site and variety.

Results

Crop modelling results were consistent with yield and anthesis field data both in the calibration and validation phases and over all varieties (table 1). High significant values of correlation coefficients (r) were found both for anthesis date and yield. Coefficient of residual mass (CRM) negative values indicate a slight tendency of the model to overestimate the observed values. The positive value of modeling efficiency index (EF) indicates that the model is a better predictor than the mean of measured values, particularly for anthesis. In addition, the low values of root mean square error (RMSE) values indicate a low level of bias and a good performance of the model (table1).

The effect of future increasing temperature was a gradual reduction in yield for all varieties and sites. *Simeto* was the most sensitive variety, and it showed the highest yield loss when temperature increases were combined with rainfall decreases (figure 1, left). For the other varieties yield reduction due to combined climatic changes scenarios ranged from -2.2% to a maximum of -38.3% from mean observed yield (table 2). In general, increasing temperature led to shortened cycle. As expected, decreased rainfall had no significant effect on flowering occurrence dates as in the CERES-Wheat model rate of development is function of temperature (figure 1, right). An advancement ranging between 2.5 to more than 12 days from the mean observed flowering dates was simulated (table 2). The model showed low accuracy for predicting seed weight with a slight trend of increasing weight for the combined-scenarios. This tendency was observed for all varieties and sites (data not shown).

	Anthesis date (dap)	Yield (kg ha^{-1})
CALIBRATION		
R^2	0.84	0.62
RMSE	5	802
VALIDATION		
r	0.80 (p<0.001)	0.80 (p<0.001)
RMSE	9	894
EF	0.98	0.63
CRM	-0.03	-0.05

Table 1. Calibration and validation results for anthesis date (dap, days after planting) and yield (kg ha^{-1}) simulations performed using wheat data (*Creso*, *Simeto* and *Duilio* varieties) from Benatzu and Ussana sites (Southern Sardinia, Italy). Values of the coefficient of determination (R^2), correlation coefficient (r), root mean square error (RMSE), modeling efficiency index (EF), and coefficient of residual mass (CRM) are reported.

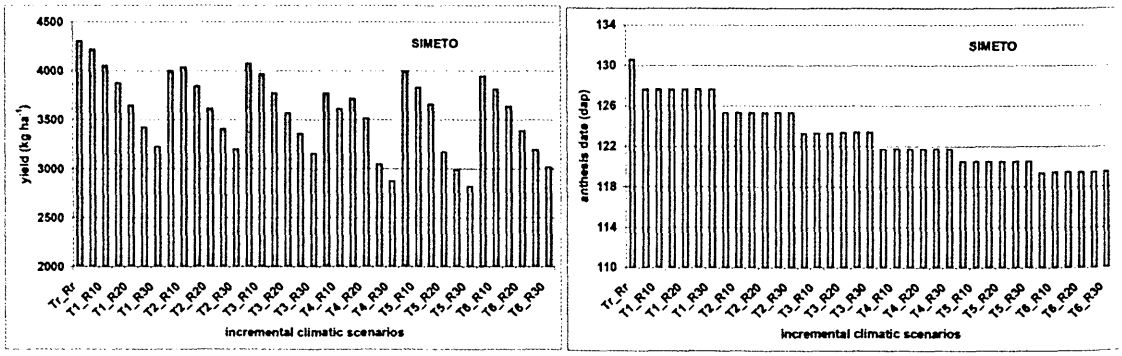

Figure 1. Effect of incremental climatic scenarios on yield (left) and anthesis date (right) for *Simeto* variety at Benatzu site.

	YIELD (%)		ANTHESIS (days)	
	Benatzu	Ussana	Benatzu	Ussana
CRESO	-2.2% / -27.2%	-2.6% / -29.3%	-2.5 / -7.6	-2.9/ -9.0
DUILIO	-2.6% / -26.0%	-3.3% / -25.0%	-2.9 / -11.7	-3.0 / -12.4
SIMETO	-2.0% / -34.4%	-6.7% / -38.3%	-2.9 / -11.2	-3.1 / -12.5

Table 2. Effects of the simulated climate change scenarios on crop yield and anthesis of *Creso*, *Duilio* and *Simeto* varieties. Maximum and minimum values of changes relative to the mean observed yield values (percentage) and anthesis dates (number of days) were reported.

Conclusions

The analysis reported in this study showed that crop modelling was a useful and efficient tool for predicting the yield and phenological responses of durum wheat to climate changes. Their application in the Mediterranean area can be a valuable support for developing adaptation strategies.

References

IPCC 2007. *Climate Change 2007: The Physical Science Basis. Working Group I Contribution to the Fourth Assessment Report.*

Ludwig F., Asseng S. 2006. Climate change impacts on wheat production in a Mediterranean environment in Western Australia. Agric. Syst., 90:159-179.

Tubiello, F.N. et al. 2000. Effects of climate change and elevated CO_2 on cropping systems: model predictions at two Italian locations. Eur. J. Agron., 13:179-189.