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Microclimate Modification and Yield Responses of Different Varieties of Durum Wheat within an Olive Orchard Agroforestry System

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Introduction

The Mediterranean region has been identified as one of the most prominent "Hot-Spots" in future climate change projections (Arena-Corraliza et al., 2018; Lu et al., 2019). Greater occurrence of extremely high temperature events associated with climate change has shown to accelerate the growth stages of wheat, shorten the grain filling period, thus causing yield reductions (Ren et al., 2019). Agroforestry (AF) is receiving considerable attention for its potential role in improving resilience to climate change. However, despite the many hypotheses of tree impact on the crop understorey, few scientific data are available in the Mediterranean climate. About 70% of the Mediterranean olive groves are low-density (5 to 9 m inter-row) old orchards progressively abandoned over time due to low productivity and fluctuations of olive oil market prices (Kavvadis & Koubouris 2019), that could be optimized in the frame of AF systems.
This paper investigates the effects of an alley-cropping model, which combines olive trees and durum wheat in a typical Mediterranean climate region in the southern France. The study was carried out from 2014 to 2017, with the aim of assessing (i) the microclimate modification due to olive trees windbreak and shade effects (amount of PAR reaching the crop, soil water availability and fertility) and (ii) the effects of the modified climate on the phenology and the yield of 25 wheat varieties.

Materials and Methods

The experiment was conducted at the Experimental DiaScope unit of INRA (Mauguio, France -43^0 35'N, 3^0 45'E) for 3 years. 25 durum wheat varieties (*Triticum turgidum* ssp. *durum*) in annual rotation with legumes were sown each year after olive harvesting in 3 experimental conditions: AF: yearly pruned olive orchard, AF+: never pruned olive orchard (both 6×6 m planting design; Fig. 1), C: open field.

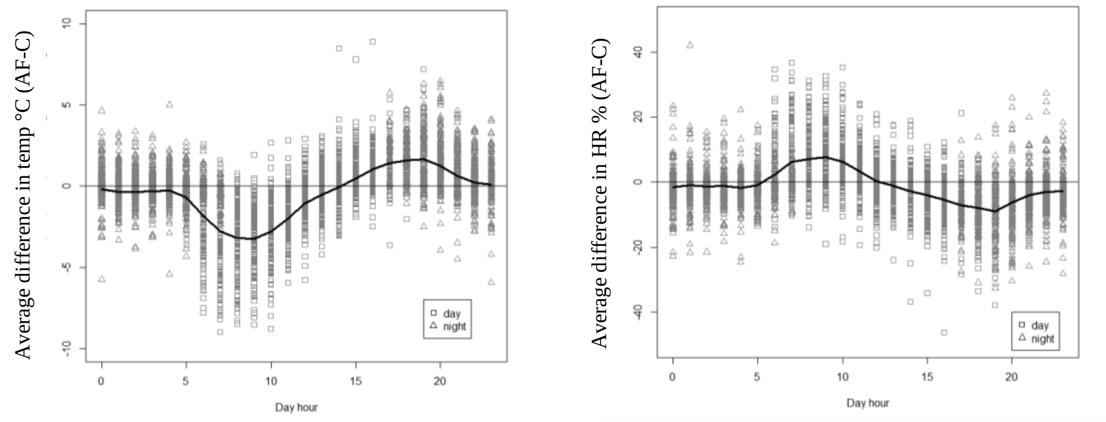
Figure 1. Picture of the AF (left) and AF+ (right) treatments taken on 28 March 2017.

A Meteo-France weather station (CLIMATIK) provided continuously air temperature and humidity, rainfall, global radiation and wind speed. Additional temporary sensors were placed directly in the experimental treatments and provided global radiation, PAR, air temperature and relative humidity, wind speed and water availability in the soil. Wheat phenology was recorded weekly from BBCH 20 (tillering). Wheat phenotyping at maturity (plant density, number of spikes/plant and grains/spike, thousand seed weight TSW, harvest index HI, and morphological traits, like plant height, spike length, etc.) was recorded in a rectangular area within 2 plant rows in a 40-cm length. At the end of June, after mechanical harvesting, grain yield was determined for each genotype/treatment.

Results

Microclimate modifications. Olive trees modified the microclimate for the crop understored due to their evergreen canopy and the small inter row (6 m vs. 15 to 25 m in classical AF designs). PAR radiation reaching the wheat canopy was reduced by 20 to 30% in AF (depending on the year) and by around 55% in AF+, as averages over the whole wheat cycle (data not shown). A buffer effect was clearly noticed: air temperature was lower (up to 4°C less) from 5 a.m. to 3 p.m., and higher (up to +2°C) from 3 p.m. to midnight in AF compared to C (Fig. 2). As regards the relative humidity of the air, the greatest differences between treatments were recorded at 9 a.m. (+8% in AF) and at 8 p.m. (-9 % in AF).

Figure 2. Difference T_{AF}-T_C (T=temperature [°C]) (left) and difference HR_{AF}-HR_C (HR=relative humidity [%]) (right)



for each hour of the day during wheat growing cycle (November 2016-June 2017).

Yield and morphology. The grain yield of wheat was reduced in agroforestry systems according to the shading level: from -43% in AF to -83% in AF+ (3-year mean), with variations depending on the considered year and variety. The most affected yield component was the number of grains per spike (-37% in AF; -62% in AF+), although HI was 6% higher in AF treatments. Plant height and spike length were significantly decreased in the two AF treatments, while the distance between flag leaf and spike was greater in AF. A large variability was observed among genotypes and type considered (modern and old varieties).

Conclusions

In AF the amount of PAR is considered the main limiting factor for yield of the crop understored, and the marked yield losses may be due to the fact that currently cultivated wheat varieties have been selected under full light conditions, so having low tolerance to shading. According to the wide variability among genotypes in response to reduced PAR, there probably is large scope for improving the agroforestry systems by variety screening or specific breeding programs.

References

Arenas-Corraliza M.G. et al. 2018. Winter cereal production in a Mediterranean silvoarable walnut system in the face of climate change. Agric Ecosyst Environ, 264:111-118.

Kavvadias V. & Koubouris G. 2019. Sustainable soil management practices in olive groves. In soil fertility management for sustainable development (pp. 167-188). Springer, Singapore.

Lu J. et al. 2019. Uncertainty and hotspots in 21st century projections of agricultural drought from CMIP5 models. Sci Rep 9:4922.

Ren S. et al. 2019. Contrasting wheat phenological responses to climate change in global scale. Sci. Total Environ. 665:620-631.