Screening Of Wheat Varieties For Shade Tolerance Within A Specialized Poplar Orchard For Future Implementation In Agroforestry Farming Systems

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Introduction

Silvoarable systems, which combine trees with arable crops on the same agricultural land, are receiving increasing interest for their high potential to reduce vulnerability to climate change (Lorenz and Lal, 2014), although they currently cover only ~0.1% of the agricultural area in Europe, i.e. 358,000 hectares (Nerlich et al., 2013). This scarce implementation is due to the farmers' concern for lower crop yield in the neighboring of trees, due to resources competition, and to the lack of knowledge on the most susitable crop varieties. Up to date, genetic variability has been poorly explored and mainly in pot experiments with artificial shading trials, and limited to aboveground interactions. For these reasons, there currently are no criteria for screening suitable varieties to implement within sustainable silvoarable systems according to tree characteristics and pedoclimatic conditions.

Within this framework, an open field experiment was conducted in Northern Italy to investigate the response of ten different common wheat varieties, including modern and old local varieties, cultivated in the narrow inter-row (6 m) of a specialized 4-year old poplar orchard (AF), i.e., without excluding belowground interactions with trees, in comparison with controls under full sun (C).

Materials and Methods

The trial was carried out during 2020-21 in a specialized poplar grove (AF) with 4-year old poplar trees (*Populus* × *euroamericana*) and 6×6 m planting design, located at the "Sasse Rami" pilot farm of Veneto Agricoltura, in Ceregnano (Rovigo, NE Italy). Trees were 14 m high, with 18 cm of trunk diameter at breast height at the beginning of the trail. Ten varieties of common wheat (*Triticum aestivum* L.) were cultivated in the AF treatment and in a neighboring field (100 m to the east) without trees serving as control area (C). Wheat included both old varieties preserved at the Nazareno Strampelli Institute in Lonigo (Vicenza, NE Italy), and modern commercial varieties, with contrasting synthetic index of quality, i.e. bread-making, biscuit-making and hard type varieties.

Wheat was sown on 25 October 2020 with a plot seeder with 240 kg ha^{-1} of seeds, 15 cm apart rows. Wheat plots were 1.2-m wide and 3-m long (3.6 m^2) arranged in a line in a tree alley with three replicates (n=3) completely randomized in both AF and C treatments (Figure 1).

Leaf area index (LAI; *LI-3100C Area Meter*, Li-Cor), leaf chlorophyll content (by SPAD-502), NDVI (by Greenseaker) and aboveground dry biomass were measured

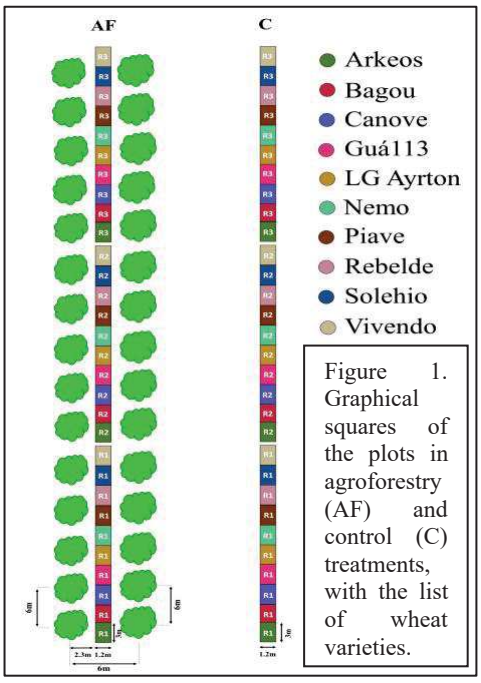

Figure 1. Graphical squares of the plots in agroforestry (AF) and control (C) treatments, with the list of wheat varieties.

at flowering. At harvest (29 June 2021), plants sampled on a 1-m^2 area for each replicate × variety × treatment were threshed to determine grain yield, TGW (Thousand Grain Weight), testing weight and grain protein content (by Kjeldahl method). Statistical significant differences were detected by R studio software v. 2.7 (Tukey's HSD test, $P \leq 0.05$).

Results

A significant genetic variability in response to agroforestry was revealed, as grain yield reductions in AF ranged between -31% and -75% depending on variety choice (-57% as average of all varieties). Under shading, the lowest yield reductions were observed in old varieties (-40% vs. C), a response that was associated to the most relevant delay of leaf senescence and improvement of leaf area index (from +20% up to +225% vs. C) and chlorophyll content (+12% up to +18% vs. C), while achieving the highest protein content in the grain (>17.3% DW). Modern varieties, despite the higher yield reductions under AF (-60% vs. C) and lower morpho-pohysiological plasticity as compared to old varieties, still achieved the highest absolute yield level under shading, particularly in the type bread making (469 g m^{-2}). Multigroup Discriminant Analysis (MDA) revealed a different behavior among variety types, i.e., according with their index of quality (Figure 2). Within modern varieties, the effects of shading on the type biscuit-making were mostly associated with variations in LAI/CAI and SPAD, while the effects on the type bread-making with yield, NDVI and HI. Differently, the impact of agroforestry on old varieties was mostly linked to protein content, leaf area and aboveground biomass.

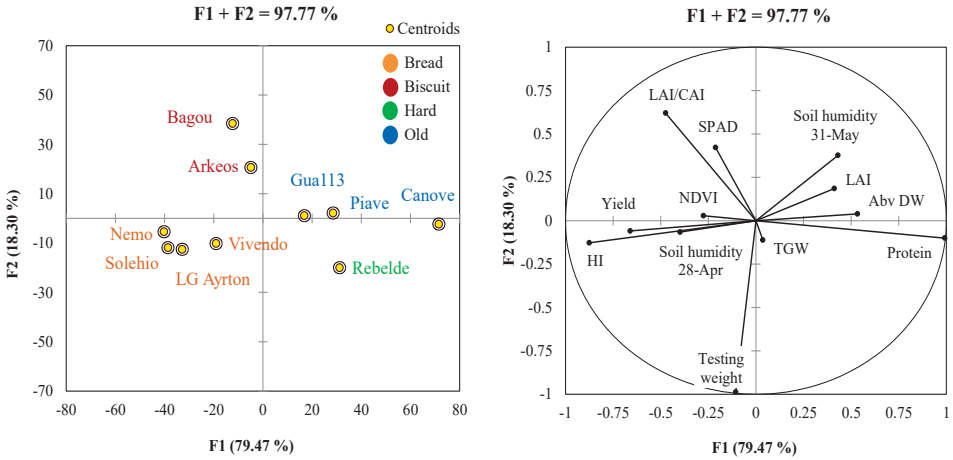

Figure 2. Principal component analysis (PCA, right) and discriminant analysis (DA; left) for the ten common wheat varieties in the agroforestry (AF) treatment.

Conclusions

The screening of wheat varieties cultivated in the narrow alleys of a poplar orchard is an innovative trial that was suitable for highlighting key traits of shade-tolerance, and possibly root competition, and contrasting responses among wheat varieties. Some interesting acclimation strategies associated to better light harvesting were highlighted, such as the increase of the leaf-to-culm area ratio in the modern type bread-making and old varieties, and longer maintenance of high leaf photosynthetic activity in the type biscuit-making, that could be used in future screening and breeding programs oriented toward agroforestry farming systems.

Literature

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