OLIVE (*OLEA EUROPEA* L.) AND WILD ASPARAGUS (*ASPARAGUS ACUTIFOLIUS* L.) AGROFORESTRY SYSTEM: ASPARAGUS PERFORMANCE AND ITS BEST POSITIONING IN THE OLIVE ORCHARD

Mantovani D.[1], Benincasa P.[2], Rosati A.[1]*

*Correspondence author: adolfo.rosati@crea.gov.it

(1)Consiglio per la ricerca in agricoltura e l' analisi dell' economia agraria, via Nursina 2, 06049 Spoleto (PG) Italy
(2)Dipartimento di Scienze Agrarie, Alimentari ed Ambientali, Università di Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy

Introduction

Traditional olive groves are low input systems, often established in marginal land with trees at relatively low densities. They cover vast areas in the Mediterranean, however, due to low profitability and the decoupling of subsidies from production, many fields risk abandonment. To make them more profitable, such olive groves could be converted into olive agroforestry systems to produce additional crops or grazing animals, thus exploiting the space made available by the low trees density (Rosati, 2009). The EU is promoting new agroforestry practices to encourage sustainable intensification of land use. Among the innovative agroforestry systems, the cultivation of a wild asparagus (*Asparagus acutifolius* L.) in olive orchards as an understory crop has been proposed (Rosati *et al*., 2012). The species is a perennial herbaceous plant, with prickly cladodes and tender spears used in Mediterranean diet since ancient times (Aliotta *et al*., 2004). It is widely distributed on marginal land and until now the market is sustained by harvesting from naturally occurring plants, though recently appropriate management practices for its cultivation as (a monoculture) have been developed (Rosati *et al*., 2005; Benincasa *et al*., 2007). However, there is no information about its ecophysiological requirements and its adaptability to be grown in the olive or other orchards, nor on its yield when grown in such agroforestry systems. In this paper we attempt to fill this gap, reporting on the species growth, photosynthetic characteristic and yield, when grown under two different types of olive orchards (i.e. traditional and super-high-density) compared to an open field (i.e. monoculture) control. We also report on the species tolerance to water and heat stress. In addition, we investigated the variability of the microclimatic and edaphic conditions at different positions under the olive orchards, as compared to the open field. Finally, coupling the microclimatic and edaphic information with the plant's ecophysiological response to them, we modelled the wild asparagus photosynthetic and growth response, in order predict the plant's performance at different positions in the two olive orchards. This will help designing better-performing systems.

Material and methods

The plant photosynthetic adaptation to different light regimes was studied by measuring the photosynthetic response to light of spears, current-year and previous-year cladodes of potted plants grown under either full sun or constant shade as provided by a shading cloth transmitting about 40% of incident PAR. In addition, photosynthetic response curves to temperature (from zero to 45°C) were also investigated in well-watered plants as well as in moderately and severely water stressed plants.

In a field experiment, wild asparagus plants were transplanted along the rows of olive trees in a traditional and a super-high-density olive orchard, as well as in an open field as a control. Plant growth was measured in all situations by measuring at regular intervals the number, length and basal diameter of all mature shoots of each plant. Biomass was estimated using biometric correlations developed using data from some destructive sampling. Spear production was measured the second year after transplanting.

The PAR incident at different distances from the tree row was measured every minute on sample days, using calibrated photosensors and dataloggers. Soil moisture sensors were placed at 20 and 40cm of depth in all three field situations (i.e. traditional, super-high-density and control).

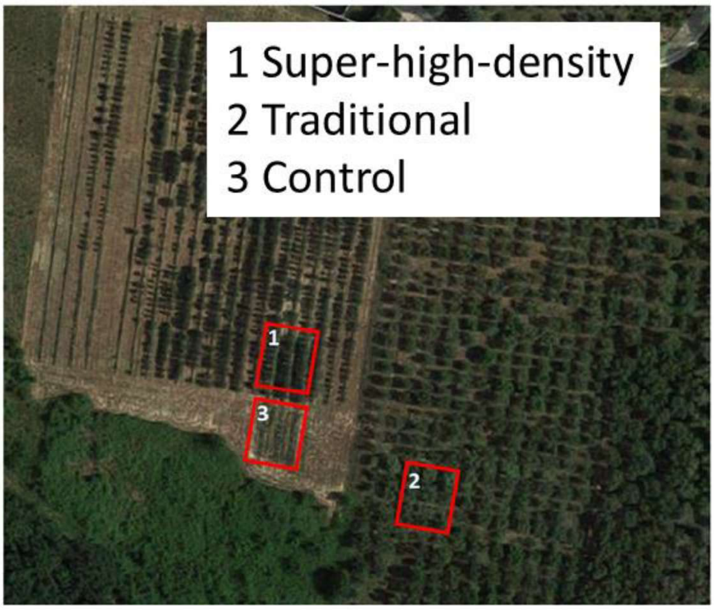

Figure 1: Experimental plots at Colle Cecco experimental farm

Results

Early results showed that the spears of the wild asparagus are photosynthetically active, contributing to their trophism, though never becoming autotrophic (i.e. they always had negative net CO2 assimilation). The spear tips had higher gross photosynthetic rates, but, due to greater dark respiration, they had more negative values of net photosynthesis, compared to the sub-apical portion of the spear.

The photosynthetic rates of current-year and previous-year cladodes was comparable, while cladodes from plant adapted to full light had higher photosynthetic rates under high irradiance, compared to plant adapted to shade. Morphological adaptation to light levels accompanied and explained these results: full light cladodes were thicker and shorter.

Cladodes were photosynthetically active under a wide range of temperature, from zero to 45°C, though photosynthesis peaked at 30°C. This makes the plant photosynthetically active during most of the year under the Mediterranean climate typical of the species habitat, when water is not limiting.

Under mild drought stress, the plant was photosynthetically active up to 40 °C, while under severe drought stress, photosynthesis was already negative at 35 °C.

Potted plants maintained under full light condition produced 15% more biomass than shaded plants and had an 11% higher root/shoot ratio.

The mean daily transmitted PAR was higher in the super-high-density olive orchard (46% of incident PAR), as compared to the traditional orchard (40%). However, under the super-high-density orchard, mean transmitted PAR ranged from 24% (under the trees) to 62% (between rows), while the variability decreased under the traditional system, where transmitted PAR ranged only from 36% to 47% and with no clear pattern. The evaporative demand in terms of water pressure deficit (VPD), was comparable for the two agroforestry systems, but higher in the control plot. At both 20 and 40 cm of depths, the soil water content during the summer was lower for the control plot as compared with the traditional and super-high-density plots, the latter two with comparable values.

Despite higher VPD and lower soil humidity, asparagus plants reached almost double biomass in the open field control than in both olive systems, suggesting that the more intense summer drought and temperature stress limited growth less than the shade did. It must be noticed that in this study, asparagus plants were planted along the row of trees, where light availability was at its minimum. If plants had been planted in between rows, especially in the super-high-density orchard, where transmitted PAR was about 60% instead of 24%, results might have been different. This remains a question that could be partly answered with modelling the plant performance as described above. At the time of submitting this abstract, this modelling was underway.

Conclusions

Compared to the cultivated asparagus, the wild asparagus here studied is evergreen. This, coupled with the ability to have positive photosynthesis under high (up to 45°C) and low (down to 0°C) temperatures, and intense water stress, as well the ability to morphologically adjust to the light environment, makes this species able to grow under a variety of extreme conditions. Particularly, the photosynthetic activity at low winter temperature, combined with the evergreen habitus, makes the plant especially suitable as an understory crop in deciduous tree plantations. However, considering that olive orchards typically intercept no more than 55% of the photosynthetically active radiation (Villalobos et al., 2006), the wild asparagus appears to be well suited to turn part of the transmitted unutilized radiation into an additional crop. In this case, however, the best positioning of the plant is probably in the most sunlit areas of the olive orchard, which is the inter-row, assuming that rows are oriented north-south.

Acknowledgments

This research was funded from the European Community's Seventh Framework Program under Grant Agreement No.613520 (Project AGFORWARD).

References:

Benincasa P, Tei F, Rosati A (2007) Plant density and genotype effects on wild asparagus (*Asparagus acutifolius* L.) spear yield and quality. Horticultural Science 42(5):1163–1166.

Rosati A, Castellini C, Dal Bosco A, Mugnai C, Paoletti A, Caporali S (2012) Olive agroforestry: an inverse approach to agroforestry. In "What priorities for European agroforestry", M.R. Mosquera-Losada, A. Pantera, A. Rosati, J. Amaral, J. Smith, C. Dupraz Editors. Book of abstracts of the 1rst European agroforestry conference, 9-10 October 2012, Brusseles. ISBN: 978-84-96351-79-0, pag 24.

Rosati A, Caporali S, Paoletti A (2009) Olive, Asparagus and animals: an agroforestry model for temperate climate in developed countries. Proceedings of the III OLIVEBIOTEQ (For a renovated, profitable and competitive Mediterranean olive growing sector), Sfax, Tunisia, 15-19 December 2009, ISBN: 978-9938-9513-0-1, 229-233.

Rosati A, Pepe R, Senatore A, Perrone D, Falavigna A (2005) Produttivita` dell'asparago selvatico. L'Informatore Agrario 8 (61): 75–77.

Villalobos FJ, Testi L, Hidalgo J, Pastor M, Orgaz F (2006) Modelling potential growth and yield of olive (Olea europaea L.) canopies. European Journal of Agronomy 24 (4): 296-303.