The “jardinu” of Pantelleria as a paradigm of resource-efficient horticulture in the built-up environment

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Abstract

The idea of garden is expressed, for the first time in history, by the Mesopotamian civilization as early as the IV millennium BCE as drawings and poetry texts showing a wall fencing one single tree. This is the first representation of the idea of sheltering/protecting a tree by human artifacts and, in its simplest form, brings the idea of the tight relationship between horticulture and urban environment. The “jardinu” of Pantelleria, a drystone wall shaped into an open-top tower encircling a single citrus tree, fully matches both in its founding idea and its physical implementation the elemental idea of the Mesopotamian garden. Such traditional growing system, developed in Pantelleria to cope with water scarcity, is an artifact at the service of households, fully integrated into the urban settlements of the Island and providing a valuable source of fresh fruit to families despite the lack of irrigation water. Currently, as many as 500 of such structures are still active in Pantelleria, standing as the distinguishing landmarks of the island. The simple, albeit expensive, principle of enclosing a tree inside a protective wall has many effects on the surrounding environment and on the eco-physiological behavior of the tree itself. We discuss here this system from the point of view of the interactions between the tree and the enclosing wall, focusing on the ability of the “Pantelleria citrus garden” to affect the water cycle of the tree and to avoid irrigation at all. Our analysis shows beyond simple, easily recognizable effects such as wind protection and the related reductions in transpiration, diurnal thermal dynamics of wall’s stones actively affects the water balance of the system. Implications of this analysis suggest that the knowledge behind the empirical building-rules developed over the years for the construction of such structures are expression of the physical principles underlying the environmental dynamics of the “Pantelleria citrus garden”.

Keywords: landscape, terraces, garden, water, ecosystem services

INTRODUCTION

Pantelleria is located in a strategic position at the centre of the Mediterranean trade routes, and a set of noticeable traditional cultural adaptations have been put in place during centuries of human colonization to cope with its harsh environment and lack of resources. The extensive use of peculiar practices capable to match agricultural needs turned the island into a unique dry-stone landscape made of terraces and dry-stone gardens (jardinu) that strongly mark the character of the island.

THE TRADITIONAL AGRICULTURAL LANDSCAPE

80% of the island’s surface is covered by terracing/dry-stone walls and buildings that develop a complex network throughout the landscape (Figure 1). The presence of dry-stones is one the most distinctive aspect of the island’s cultural heritage, both for simple terracing and for the delimitation of land patches and the diffuse presence of artefacts and buildings. The climate has a strong Mediterranean connotation, the water deficit being the most limiting factor. Rainfall (400-500 mm year⁻¹) follows the typical seasonal pattern of the semi-

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arid Mediterranean with a long dry season during the warmer months. A further enhancement of evapotranspiration losses is due to the high wind frequency, occurring in more than 300 days every year (Barbera et al., 2010).

Figure 1. Vineyards in the Pantelleria terraced drystone landscape.

Most features of the agricultural landscape are then shaped in relation to these particular environmental traits. A strong limitation to the diffusion of subsistence agriculture was found by inhabitants as related to the massive presence of volcanic stones. De-stoning has been the most important driver in structuring of the horticultural system of Pantelleria since almost all the agricultural land has been reclaimed through it. Such a common need to create suitable living conditions has a consolidated social convention, given the mutual work sharing and retribution on the basis of 50% of de-stoned land surface, as coded in the *cunzàri e spàrtiri* (arrange and divide) local custom (D'Aietti, 2009). The consequent land fractioning led to the fact that each farmer even now owns patches of land in three-four different locations. This latter aspect has several benefits to ensure food/income security against occurrence of adverse events, an efficient labour organization and mutual sharing, a good diversity of crops and local races/genotypes. Altogether, these aspects have concurred to an uncommonly high biocultural diversity and to the identity of the island itself. Due to the lack of fresh-water sources or wells, water provision for human and agricultural usage on the island is only through water harvesting, and a widespread system of facilities reached a full development as early as the Punic ages (Mantellini, 2015). Rainwater harvesting is shaping every aspect of human activity on the island: there are almost 500 cisterns for storing rainfall storage, and architectural elements for home roofs and gutters especially suited for conveying the rainfall give birth to the typical *dammuso* houses, easily recognizable Pantelleria icons.

Dry-stone artefacts present in Pantelleria accomplish a number of functions beyond soil confinement/formation and erosion prevention. An important recognized aspect is the wind-sheltering, protecting crops both from the mechanical effect of the wind and lowering the evaporative demand of the atmosphere by strongly reducing wind speed at canopy level. Dry-stone walls are ubiquitous elements on the island, both as a part of a terrace or simply as a fencing element of enclosures delimiting the fields. The importance attributed by growers to the aerodynamic role of the dry-stone walls easily emerges from observing that, even in terraces, where their most prominent role is to physically support the soil, they stand above ground level offering their wind-sheltering effect to the crops enclosed.

THE JARDINU AND THE EFFECT OF WALLS ON MICROCLIMATE

Walls in terraces, standing 50-100 cm above ground level, create a confined space of still air hosting crop canopies, with a fair degree of decoupling from the surrounding atmosphere. Within this confined air space, crops are cultivated according to a number of specialized cultural adaptations that share the common objective of preventing canopies to grow outside this space to limit evapotranspiration. It is important to remark that canopy confinement is not the result of a natural-shaping effect of the winds but is imposed by an accurate and accurately planned pruning and canopy management totally controlled by the farmers. This is easily recognizable when observing an abandoned olive terrace, where olive

trees grow into a full high-bush clearly standing out of the drystone walls. The techniques adopted largely depend on the specific physiological characters of the species, particularly on their growth habit. The caper, a prostrate low bush woody species, fits naturally within the limits defined by the drystone walls. In other species, suitable dwarfing practices able to strongly reduce canopy height to less than one meter, approximately the level of the enclosing walls, are adopted. This is the case, for example, of grapevines grown in a typical prostrate low bush training system (the alberello pantesco), with three-to-four branches, spur pruned, growing close to the soil and the dwarf olive trees, a training system for olive unique to the Island of Pantelleria (Figure 2, right).

The giardino pantesco is the most extremely significant example of dry-stone walls usage for adaptation to water deficit conditions (Barbera, 2017). The citrus garden (Figure 2, left) is a circular open-top dry-stone tower where a single orange tree is successfully grown in total absence of irrigation, otherwise mandatory in the Mediterranean climate. In citrus species, in fact, tree vigour control cannot be achieved through strong pruning without significant losses in yield and, consequently, citrus trees could not be confined within the regular terraces or field enclosures walls. To benefit from wind protection effect and to limit air movements around tree canopy, the dry-stone wall is raised to the level of the minimum tree height that can be attained in citrus trees without compromising tree productivity, i.e., up to four-meter tall. The jardinu (Sicilian vernacular for giardino pantesco) is a facility at the service of families, always close to or part of a house, to provide locally a supply of fresh fruits. The jardinu and its embedded fruitful orange tree can be considered altogether as an evidence of the effectiveness of dry-stone walls as instruments to reduce evapotranspiration losses and improve water availability to tree crops.

Beyond wind sheltering, the peculiar agricultural systems in Pantelleria play a role on the regulation of the water balance through dewfall condensation. While dewfall is not considered to play a substantial role in water availability of agricultural systems in the Mediterranean, the small size of Pantelleria and the closeness of agricultural fields and terraces to the sea seems to be able to increase the incidence of this component. For example, dewfall rates under similar conditions were estimated in the order of 0.2-0.4 mm night⁻¹ in Lanzarote (Graf et al., 2004) and up to 19% of total annual precipitation in the coastal drylands of Madagascar (Hanisch et al., 2015). Even if dewfalls have never been measured in Pantelleria, observations suggest that the walls could create local conditions of higher soil water availability in the proximity of the wall itself.

Figure 2. The jardinu (giardino pantesco) drystone tower with a single citrus tree growing inside (left). An olive tree growing horizontally within the airspace delimited by drystone walls (right). Four-meter long branches are supported by stones to prevent rooting.

Our microclimate observations of the giardino pantesco (Barbera et al., 2012; Georgiadis et al., 2014) (Figure 3) show that the drystone wall substantially influences the

internal patterns of atmospheric parameters and enters into the diurnal dynamics of the general energy balance of the system in a less-than-intuitive way due to the high thermal inertia of the stones (Figure 3). Such active role may greatly enhance dewfall occurrence both on stones and on foliage surfaces. As evidenced in Figure 4, a 24-h temperature cycle is observed: during the day the internal stones are cooler than the exterior, so that air humidity is in conditions to condensate, while at night they are warmer than the exterior. The consequent dissipation of the heat cumulated during the night reduced temperature excursion at night, and it is positively affecting citrus adaptation.

Figure 3. Wind, temperature and humidity sensors positioned in the internal and external of the FAI jardinu.

Figure 4. IR thermal images of the jardinu wall.

CONCLUSIONS

An intelligent development of knowledgeable agricultural techniques still connotes human impact in Pantelleria. The local agricultural systems have been developed with time to cope with the need to ensure a food supply for local use and, then, for external market, in a difficult environment, scarce in resources and exposed to strong winds. Landscape was shaped through drystone (locally obtained through an efficient de-stoning) terracing, and the process has been accompanied with concomitant adaptations of cultural systems to the specific features of the terracing system in a highly specialized and intimate way. The empirism of the techniques is only apparent, since they are based on a deep understanding of sophisticated atmospheric and physiological processes. In a resource-limited environment such as the Mediterranean (Laureano, 2005), with a long dry summer season, the use of walls to protect crops has a long history: growing rainfed crops under a long water-deficit period would be a challenge to self-provisioning and survival of human activities and settlements that have to rely on the local resources.

The jardinu represents an example of extreme adaptation that can be found elsewhere in the Mediterranean, specifically in a relic form of semi-abandoned remains in the Island of Folegandros (Greece), but also in the Lanzarote grapevines growing in holes through the lapilli to reach the soil layer, or in the Dalmatian Islands drystone circles in Kornati National Park (Croatia).

These examples, altogether suggest a deep historical linkage in traditional agricultural knowledge that has proved to be able to permeate through cultures across the history of the Mediterranean. This flow of knowledge has allowed the persistence of physical structures such as the drystone walls composing the physical landscape. And, in addition, the knowledge materially associated to their building and maintenance, and the agricultural techniques and crops growing inside these structures in a remarkably high bio-cultural diversity, are still alive. UNESCO (2014) has identified the community of the island as "... the true custodians of the traditional knowledge regarding the technique of cultivating the "head trained bush vines" (*vite ad alberello*) ..., and Pantelleria terraces and gardens have to be considered as whole corpus of traditional knowledge recognized".

In its complex, then, the special landscape characterizing the island integrates built-up environment into a fully functional, resource-efficient, agricultural system (Barbera and La Mantia, 1998). The special landscape features in Pantelleria, including a number of jardinu (many of them restored and brought back to the island heritage), concentrate traditional knowledge, host a high bio-cultural diversity, and offers a wide range of ecosystem services, including a re-invigorated tourism.

Today Pantelleria, and its peculiar horticulture, is living on the tracks of such a multi-cultural tradition, but there is the urge to cope with the recent changes that occurred in the global economic scenario, finding new ways of keeping the traditional agricultural landscape of the Island still active and profitable despite the high costs for human labour and

investments required. The added value of the heritage represented by the traditional agricultural landscape and its ecosystem and cultural services may greatly contribute in this respect.

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