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Effect of mulch on initial coverage of four groundcover species for low input landscaping in a Mediterranean climate

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ABSTRACT

Groundcovers play a very important role in the creation of urban green spaces. They provide many agronomic and environmental benefits while simplifying the urban landscape management.

In the areas with a Mediterranean-type climate, the development of low-input landscapes, with the ability to maintain their functions and aesthetical appeal, is pivotal. The aim of this study was to identify groundcover species that could be suited to the local environmental conditions and to evaluate the effect of different mulching systems on plant growth and weed suppression.

Digital image analysis was used to measure the green cover percentage of four species (*Hedera helix* L., *Hypericum calycinum* L., *Rosmarinus officinalis* L., *Vinca minor* L.) grown on two different types of mulch (EcoCover® and wood-chips) and on bare soil. Changes in plant coverage, NDVI (Normalized Difference Vegetation Index) and weed biomass were recorded over a two year period.

The prostrate *R. officinalis* established rapidly and reached more than 80% of coverage within 3 months after planting. Also, it was not affected by weed competition. Non-native *H. calycinum* also exhibited a quick spread, but it was unsuitable for low-input Mediterranean landscapes because it died during late summer from fungal disease. *H. helix* and *V. minor* were also adversely affected by pathogens and, due to their slow initial growth and low percent cover in the second year, they did not control weeds during the study. With the exception of *R. officinalis*, mulching materials did not significantly improve the establishment and cover ability of the tested species, but had significant effects on weed suppression. Digital image analysis and spectral reflectance proved to be reliable and objective techniques to assess groundcover performance.

1. Introduction

Landscape groundcovers include different trailing or spreading species that naturally form a continuous soil covering. Their canopy height is usually less than about 1.0 m and they may be woody, herbaceous, or succulent (Pittenger et al., 2001).

In urban environments, these kinds of plants play a crucial role in the management of green public areas. They are commonly used for erosion reduction, slope consolidation, weed control and ornamental purposes (Eom et al., 2005; Amoroso et al., 2010; Foo et al., 2011). Further, many of these species provide a good habitat for desirable organisms such as pollinators or other beneficial insects (Bell et al., 2012). Moreover, their use is suggested in cities as a mitigation strategy to help cool the urban environment (EPA, 2008).

Many times, groundcovers are one of the few options for greening areas difficult to manage and maintain, like those under trees and hard-to-reach slopes and cliffs.

Although a wide range of groundcovers are available, only a few species are commonly used to improve the urban environment, giving the cities a repetitive and often unappealing design (Kingsbury, 2004; Amoroso et al., 2010).

Commercial and residential landscaping has grown to depend on a matrix of inputs including irrigation, fertilizer, pesticide application, mowing and pruning. This dependence has developed over years, thus managed landscapes and gardens are very demanding in resources and often have high annual management costs. This high cost of labor, water and materials has encouraged the selection and use of species that require low inputs without jeopardizing their function, attractive characteristics or economic value (Pittenger, 1998; Asgarzadeh et al., 2014; Smith and Fellowes, 2014). Furthermore, an important effort has been made to develop propagation and plant production methods to meet the demand for more sus-

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tainable landscapes (Iles, 2003; Hitchmough, 2004; Franco et al., 2006).

In many regions of the world, Mediterranean climates commonly display great opportunities and challenges for landscape designers. Mild winters and a long growing season are favorable conditions for a wide choice of ornamental plants including many exotic species. The introduction of these species has modified ecological systems and the characteristics of local landscapes, because they often appear misplaced in the environment such as the presence of Eucalyptus trees in the Negev desert (Kotzen, 2004).

For this reason, and for the ability to tolerate the adverse environmental conditions (e.g. drought and extreme temperatures), the use of native plants is becoming more and more common in landscape design (Martínez-Sánchez et al., 2003; Clary et al., 2004; Smith and Fellowes, 2014). These species offer opportunities for an aesthetic transition to a more natural urban environment, as well as saving costs in labor and chemical inputs.

The use of chemicals has been limited by EU policy (European Parliament and Council of the European Union, 2009) due to public health implications and environmental damages (Gilliam et al., 1992; Amoroso et al., 2012). Consequently, alternative methods for weed and pest control have become particularly important (Eom et al., 2005; Henry et al., 2011), since hand-weeding is too expensive to be adopted as sole method of weed control (Everest et al., 1998). Thus, the selection of appropriate groundcovers and the use of agronomic mulching, represent pivotal management techniques during plant establishment.

The effects of mulch on environmental factors and on nursery containerized crops' growth have been widely investigated (Chong, 2003; Altland and Lanthier, 2007; Chalker-Scott, 2007; Samtani et al., 2007; Cregg and Schutzki, 2009; Amoroso et al., 2009). Regardless, only few studies have been conducted in the field to evaluate the influence of organic mulches on groundcovers establishment (Foo et al., 2010). Moreover, even though some attempts have been made to provide ecological and agronomic information in different climatic conditions (Foo et al., 2011; Bell et al., 2012), the establishment ability of many ornamental ground-cover species is still relatively unknown.

Understanding factors that influence plant establishment is an important aspect for any species. This is especially true for groundcovers, as improper or delayed establishment can cause significant problems to the management of the targeted area. The percentage of ground surface covered by plants and the rate at which they produce new tillers are parameters commonly used by researchers to measure and determine perennial grass and shrub growth (Afolayan, 1979).

Previous techniques generally used to estimate percent cover or growth rate in groundcovers involve visual rating (Foo et al., 2010, 2011). Although some information can be collected using this approach, the resulting data can be prone to observer bias and can be difficult to reproduce by other investigators (Stohlgren et al., 1998; Richardson et al., 2001; Luscier et al., 2006).

New technologies involving digital image analysis (DIA) and spectral reflectance have gained increasing interest for agronomical studies during the last decade. These technologies have been applied to the determination of canopy coverage and light interception in soybean plants (Purcell, 2000), normalized difference vegetation index (NDVI) (White et al., 2000; Nagler et al., 2004), ground cover in vegetation plots (Richardson et al., 2001; Behrens and Diepenbrock, 2006) and also have been used in practical applications, e.g. mapping of plant stress (Hughes et al., 2000). Findings show a substantial lack of data on the use of digital image analysis for the measurement of ornamental groundcovers growth.

The objective of this work was to provide information for low-input Mediterranean landscapes about the establishment and weed control ability of four ground cover species grown under two different mulching materials. In particular, we wanted to investigate if: (1) native species would out-perform non-natives under semi-arid conditions, (2) mulches would have potential in promoting plants growth and controlling weeds, and (3) DIA and spectral reflectance could be successfully used for objective assessment of groundcovers performance.

2. Methods

The research was conducted in Viterbo, Italy at the Experimental Farm of the University of Tuscia, Central Italy (42°26′N, 12° 04′ E, altitude 310 m asl), from April 2006 to August 2008.

The site is 40 km away from the sea and has a typical Mediterranean climate, with an average temperature of 14.4 °C and an average annual rainfall of about 777 mm (20-year average). Climate data records were obtained from the University's meteorological station, located 350 m away from the plots.

Meteorological data shows exceptional amounts of rainfall occurred in late summer 2006 and also in 2008 from winter to early summer (Fig. 1).

Particularly, rainfall in August 2006 was 88 mm versus 20-years average monthly rainfall of 15 mm. Moreover, in September 2006, rainfall was 160 mm versus an average of 24 mm. At the same time, maximum temperatures were slightly lower as compared to the average monthly temperature recorded. Similarly, rainfall occurred in 2008 was out of range while the minimum temperature was the lowest in this year, reaching −5.7 °C in February.

The trial was set up in a flat area of 1050 m^2 on a sandy clay loam soil according to USDA system (Soil Survey Division Staff, 1993). Soil chemical and physical properties are reported in Table 1.

The experimental design was a two-level split plot design with three blocks. Each block was 12 × 7.2 m and was divided in four main plots containing four groundcover species: *Hedera helix* L. (Ivy), *Rosmarinus officinalis* L. var. '*prostratus*' (rosemary), *Vinca minor* L. (common periwinkle) and *Hypericum calycinum* L. (st. John's wort). The first three species were Mediterranean native plants while st. John's wort is a neophyte native to north-western and north-eastern Turkey and south-eastern Bulgaria (Pilepić et al., 2011).

The main plots each had three 1.8 by 1.8 m subplots with different mulching treatments: i) mulching with EcoCover®; ii) mulching with a 7.5 cm thick layer of wood-chips; iii) no mulch (control). EcoCover® is a 8–10 mm thick biodegradable mulch mat used in the horticulture, agriculture and land management industries. The thickness of wood-chip layer was chosen according to the outcomes of previous studies (Greenly and Rakow, 1995; Foo et al., 2010; Van Donk et al., 2011).

Plots were tilled with a plough at 0.4 m depth and then harrowed two times to obtain suitable soil for planting. Herbicides were applied on September 12th 2005 and March 22nd 2006 to eliminate annual and perennial weeds. Chemical weed control was made over the entire area using Glyphosate at the rate of 1.58 kg ha^{-1} in September 2005 and Glyphosate and Pendimethalin at the rate of 1.58 and 0.95 kg ha^{-1}, respectively in March 2006.The species were planted in April 2006 with 16 plants per sub-plots for rosemary and st. John's wort (0.6 × 0.6 m spacing), 25 plants for ivy (0.45 × 0.45 m spacing) and 36 plants for common periwinkle (0.36 × 0.36 m spacing). The EcoCover® mulch was applied before planting while wood-chips were applied immediately after. By February 2007, species were considered to be established.

In creating new landscapes, the establishment phase is considered input-intensive, since the intensive management allows planting to establish and develop (Cook and VanDerZanden, 2011). After the establishment phase, the low-input management becomes a very important target and, consequently, the ability of