



Research paper

Exploring the potential of hop as a dual purpose crop in the Mediterranean environment: shoot and cone yield from nine commercial cultivars



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ABSTRACT

In hopyard management, surplus shoots are generally considered a useless by-product once hop bine training has been completed. Considering the rising interest towards healthy and traditional foods, they may be a valuable resource, especially for small scale hop farming. Despite this economic and nutritional interest, there is a lack of information about hop shoot yield potential both in the heartlands and new growing areas such as the Mediterranean basin. A 2-year field trial was conducted in Central Italy to investigate the shoot yield potential of nine commercial hop cultivars and how this yield is related to other traits such as earliness of shoot emergence and shoot number and weight. Cone yield potential was also assessed. The results showed that there was significant variability among the genotypes for all characters investigated. Cascade was the highest yielding variety producing 470 g of cones per plant (two-year mean) at 10% moisture. The number of shoots per plant varied from 14 of H. Aroma to 29 of Cascade over a two year average, while green shoot yield ranged from 15 g per plant of H. Aroma in 2014 to 37.5 g per plant of Cascade in 2013. Marketable shoot yield was positively correlated with number of shoots, while no significant correlation was found with average shoot weight.

Since the number of shoots was negatively correlated with growing degree days (GDD) to shoot emergence, the early emerging genotypes such as Cascade, Yeoman and H. Magnum outperformed the other cultivars when grown in the Mediterranean environment for shoot production.

1. Introduction

Hop (*Humulus lupulus* L.) is a dioecious perennial climbing plant mainly cultivated for its female inflorescence (known as cone but formally strobilus), rich in alpha acids and other secondary metabolites.

Commercial production of hop is generally limited to regions between 35° and 50° latitude in both hemispheres, as the plant has specific chilling and day-length requirements for optimal growth and flowering (Haunold, 1981; Mahaffee and Pethybridge, 2009; Turner et al., 2011). Germany, U.S.A. and China are the top producers of hop in the world, but the production of all European countries is from 50 to about 62% of world production (European Commission: Agriculture and rural development, 2017).

Even though hop is mainly known as a brewing ingredient, it has been used over time for various medicinal, household and culinary purposes (Small and Catling, 1999). An ancient use concerns the harvest of wild young spring shoots to be eaten like asparagus. It seems that this dietary habit was already known by the Romans as Pliny the Elder (23–79 C.E.), in Book 21, Chapter 50 of his *Naturalis Historia*, possibly refers to the wild hop plant when he mentions the *lupum*

salictarium (“willow wolf”) as a toothsome rather than a nourishing food.

In England, the young green shoots are eaten but it is not a common dish while, in Belgium, hop shoots are regarded as a delicacy (Neve, 1991). In the Mediterranean region the use of wild hop as a vegetable is quite popular, and its shoots are cooked according to traditional recipes (di Tizio et al., 2012; Hadjichambis et al., 2008; Tardio et al., 2006). After boiling, young shoots have very low lipid content (< 0.2 g/100 g), energy value (25 kcal/100 g) and Na content (< 40 g/100 g), whereas they are a good source of dietary fibre and vitamin B₉ and C (García Herrera, 2014; Morales Gómez, 2011; Sanchez-Mata et al., 2012).

Given the renewed attention towards the recovery of food traditions and the demand for a healthy diet, wild species should be better exploited and promoted (Sanchez-Mata et al., 2012). This is particularly true in those countries where food consumption is not increasing and differentiation represents a key factor for marketing (D’Antuono et al., 2009). Moreover, the domestication and cultivation of wild plants traditionally used for food, may represent a successful strategy for niche markets (Benincasa et al., 2007; D’Antuono and Lovato, 2003; Molina

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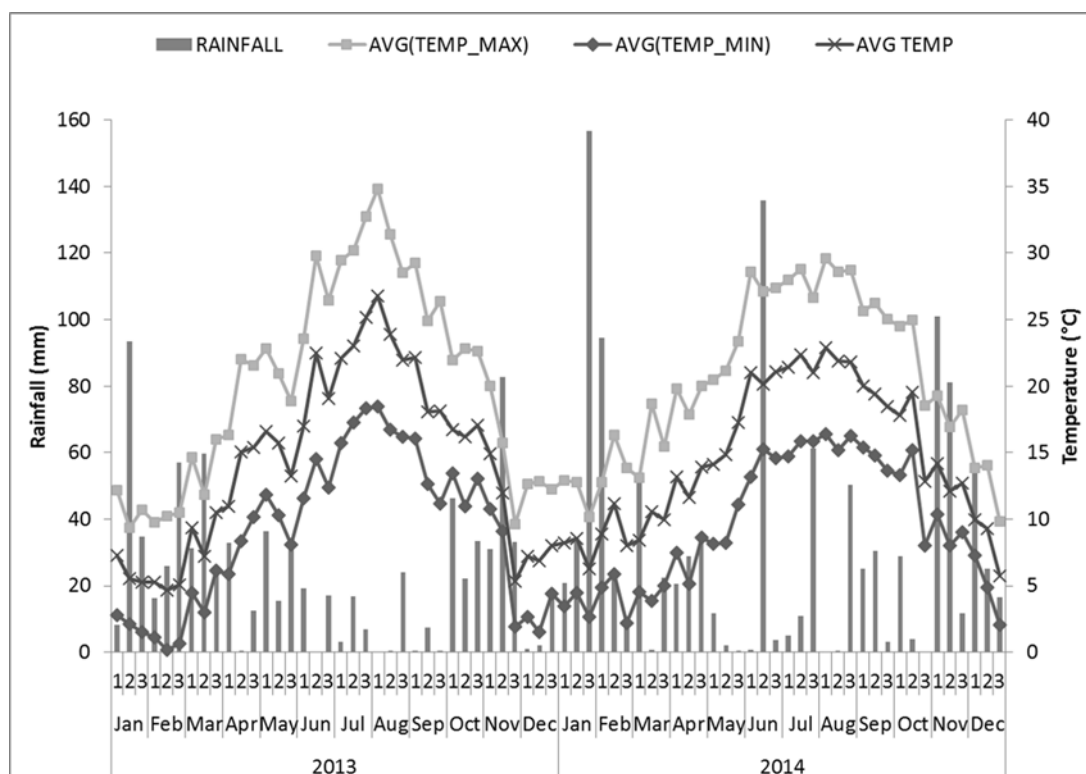


Fig. 1. Decadal mean maximum, mean minimum and average air temperature and rainfall during 2013 and 2014 growing seasons, as retrieved from the meteorological station of the experimental farm of the University of Tuscia, Viterbo (Italy).

et al., 2016).

Despite this economic and nutritional interest, there is still little knowledge about yield potentials of wild edible plants, particularly in the Mediterranean region (Molina et al., 2014).

Hop shoots are produced from the buds of the rootstock in early spring. In grown hop plants, most of these shoots are removed by pruning, while just a few shoots (from three to six) are trained up strings for cone production (De Keukeleire et al., 1999). For brewers, the surplus shoots are a useless by-product of the supply chain, but for gastronomes, they can be one of the most valuable vegetables in the world. Their extraordinary value is based on the limited availability (just few days) and the laborious harvest.

Recently, the proliferation of microbreweries has led to a growing interest in agricultural beers and, consequentially, in hop cultivation, also in countries which are not typical producers such as Italy. In these new growing areas, very limited knowledge is available on hop phenology and feasibility of cultivation. Furthermore, while many studies have been conducted to investigate factors affecting cone yield and quality (Beatson et al., 2003; Čeh, 2014; Fandino et al., 2015; Mongelli et al., 2015; Rossini et al., 2016), no information is available on shoot production.

The use of young shoots as vegetables, on the other hand, may be a valuable additional source of income for hop growers.

This study aims to increase our understanding of the potential of cultivated hop in the Mediterranean environment, by verifying the following hypotheses:

1) There is a genotypic variability among hop cultivars for shoots yield as previously found for cones (Rossini et al., 2016);

2) As for asparagus (*Asparagus officinalis* L.), the number of shoots is positively related to marketable yield (Caruso et al., 2012; Moon, 1976) and negatively to earliness of shoot emergence (Cravero et al., 2002);

3) Since the number of shoots before training is a predictor of plant vigour (Skinner et al., 1975), varieties with a high number of shoots have also high cone yield.

Such results would provide hop growers with important information for the supplemental production of shoots and would be of use in the selection of dual purpose cultivars in the Mediterranean region.

2. Materials and methods

2.1. Location, experimental design and hopyard management

The experiment was carried out during two consecutive years, 2013 and 2014, at the experimental farm of the University of Tuscia, Central Italy (42°26' N, 12° 04' E, altitude 310 m a.s.l.).

The growing area is characterized by a Mediterranean climate, with mean annual air temperature of about 14.5 °C and precipitation of 790 mm (Figure 1).

The experimental design was a randomized complete block with three replicates; treatments were varieties. The hopyard was constructed in the spring of 2011 using a standard high trellis system with a finished height of 8 m. Aircraft cable was used for trellis wires. The soil was tilled with a moldboard plow, tilled again with a rotary tiller, and then planted with two hop rhizomes per hill (hereafter referred to as plant) on April 13th, 2011. Plants were distanced 1.5 m apart, and rows

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