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THE ROLE OF HAZELNUTS (*CORYLUS AVELLANA* L.) FOR THE SUSTAINABILITY OF THE AGROECOSYSTEM

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Abstract: Hazelnut (*Corylus avellana* L.) belongs to the Betulaceae family and is a popular tree nut worldwide. Hazelnuts are grown around the world and require a mild temperate climate. Today, the most popular hazelnut tree is grown mainly in Europe and in Asia Minor, with Turkey and Italy as the leading producers. In Turkey, hazelnut cultivation plays an important role in economic, environmental and rural development. It is one of the primary cash crops for many farmers, especially in the Black Sea region. Hazelnut crops are also beneficial in that they protect the land against erosion. Hazelnuts are hardy plants with large fibrous root systems that are excellent for soil and water conservation, and at the same time help to control floods. The tree species can also function as a windbreak of agricultural fields. Cultivation of hazelnuts in rows makes it possible to grow annual crops in the alleys formed between the rows, which is also additional income for the farmer, as the soil is improved, biodiversity in the agroecosystem is increased. A very important feature of the hazelnut is that the well-developed, highly branched root system, the main part of which is located at a depth of 20- 40 cm, is especially suitable for growing summer black truffles (*Tuber melanosporum* Vitt., *Périgord black truffle*).

Keywords: agroecosystem, biodiversity, *Corylus avellana* L., Hazelnut, *Tuber melanosporum* Vitt.

INTRODUCTION

Hazelnut (*Corylus avellana* L.) belongs to the Betulaceae family and is a popular tree nut worldwide (Alasalvar et al., 2012; Tshering et al., 2017). *Corylus avellana* L. (European hazelnut, or common hazelnut) is a temperate, diploid ($2n=2x=22$), monoecious (Mehlenbacher, 2014; Cristofori et al., 2019) and wind-pollinated broadleaf species (Mehle et al., 2019). The genus name *Corylus* comes from the Greek word korys (helmet or hood). The word hazelnut is derived from the Anglo-Saxon word haesel (bonnet) (Olsen, 2013). Contorted filbert is the common name given to the hazelnut tree named “*Corylus avellana*”. This species, which is native of Europe, is the most widespread in plantations across the world. In North America, the indigenous species are the “*Corylus americana*” and the “*Corylus cornuta*” (Levesque, 2009).

Hazelnuts are grown around the world and require a mild temperate climate (Redpath, 2016), on steep slopes and in hilly areas (Tshering et al., 2017). Hazelnuts grow well in most soils because they have deep fibrous roots, but the soil must have good drainage because these shrubs do not like to have their roots too wet. Exposure is also essential, as warm days in the beginning of the season can cause premature flowering, so it is necessary to avoid planting at southern exposure, where frost can be a problem (Josiah, 2014). The tree has a mainly fibrous root system, but deeper soils allow for greater exploitation of soil resources and heavier production in the mature orchard (Snare, 2008).

The European hazelnut (*C. avellana*) grows in many parts of Europe and Asia and has been a food source for humans since prehistoric times. Since 7500-5500 BC the European hazelnut has been one of the first shrub-like trees to spread northward after the last glacial period in northern Europe (Olsen, 2013). It can be found in southern Europe (Italy, Spain, Portugal, and France) (Gönenç et al., 2006), and East as far as the Urals (Mehle et al., 2019) and in some areas of the United States (Oregon and Washington). Hazelnut is also grown in New Zealand, China, Azerbaijan, Chile, Iran, and Georgia (Pourbabaei and Adel, 2015; Król and Gantner, 2020). European hazelnut grows best in areas with mild coastal tempered winters, and the vast majority of the world's hazelnut production is centered in the Black Sea region of Turkey (Rowley et al., 2018). That's why Turkey is the homeland of hazelnut culture (İslam, 2018). Cristofori et al., (2015) indicate that according to Richardson, (1997); Salas-Salvadò and Megias, (2005) the nutritional properties of hazelnut and its health benefits related to the richness of high-value fatty acids and natural antioxidants, have been emphasized. It has a high nutritional value of 10-20% protein, 55-72% lipids, 3-9% glucose (Ashoori-Latmahalleh and Noorhosseini-Niyaki, 2013; Pourfarzad and Mehrpour, 2017; Król and Gantner, 2020), excellent source of vitamin E and B6 (Pulsipher and Josiah, 2001; Alasalvar et al., 2012; Tshering et al., 2017), rich in Omega 9 (Levesque, 2009) and also high in fiber (Rowley et al., 2018) and thiamine, magnesium (Enescu et al., 2016). Nevertheless, other minor components, such as sugars, organic acids, and phenolic and aromatic fractions, can be involved in the expression of nut taste and quality (Bignami, et al., 2005; Cristofori, et al., 2009; Jones, 2019).

Due to its high nutritional value, hazelnut has been traded commercially for 600 years (Bozoğlu et al., 2019). Cristofori et al. (2019) quote FAOSTAT, (2018) saying that approximately 660 000 ha of the world's surface is used to cultivate hazelnuts. Turkey is the largest producer with approximately 74% (64-78% range) of the world production. Italy is the second largest producer (12-16%) followed by the USA (4%) (Lippert, 2009; Fischbach, 2011; Valentini et al., 2015; Tshering et al., 2017; von Bennwitz, et al., 2019), Spain, Georgia, and Azerbaijan (approximately 3% each) (Redpath, 2016). Today, the most popular hazelnut tree (*Corylus avellana* L.) is grown mainly in Europe and in Asia Minor, with Turkey and Italy as the leading producers (Mehlenbacher, 1991; Pourfarzad and Mehrpour, 2017). Globally, most hazelnuts are

grown in Turkey where they produce over 600 thousand tonnes per year (O'Dell and Argen, 2013), as the total production area is 705 thousand hectares (İslam, 2018).

In Turkey, hazelnut cultivation plays an important role in economic, environmental and rural development (Taşdemir and Reis, 2011; Saralioglu et al., 2016; İslam, 2018). It is one of the primary cash crops for many farmers, especially in the Black Sea region (Alasalvar, et al., 2012). In Turkey, the production of hazelnuts is the most important economic activity (monoculture) and a source of income for rural households in the Black Sea Region, where the hazelnut sector has been supporting since 1962 (Gönenç et al., 2006). From the Black Sea coast of Turkey, hazelnut culture quickly spread throughout Europe and in the second half of the 19th century-in the USA and Canada (Hammond, 2006; Enescu et al., 2016; Kosenko et al., 2019), Australia (Baldwin, 1998; Baldwin et al., 2003; Baldwin, 2004).

Hazelnut crops are also beneficial in that they protect the land against erosion (Tuncer et al., 2017). Bozoğlu et al. (2019) quote Tshering et al., (2017), according to whom hazelnuts are hardy plants with large fibrous root systems that are excellent for soil and water conservation. Hybrid hazelnuts offer a new agricultural opportunity - a system of woody agriculture that supplies food staples from domesticated woody perennial plants (Josiah, 2014). Jones (2019) points out the innovative techniques outlined by the USDA National Agroforestry Center to increase the ecosystem benefits of hazelnuts on the farm. They are expressed in the possibility that through their root system hazelnuts can stabilize the soil in the riparian environment, and at the same time help to control floods. The tree species can also function as a windbreak of agricultural fields. It is pointed out that parts of the farm, if not suitable for traditional crops, for example pivot irrigation corners (Rad et al., 2018) or high topography areas, can be a prime location for the resilient Hazelnut. As hazel bushes are quite dense, they are an effective windbreak in blocking the wind, both in the summer and winter. It is pointed out that with the help of one or two rows of hazelnuts, as the bushes are arranged in a checkerboard pattern, a living barrier can be created, which will be a denser barrier to wind and snow. This type of barrier provides: year-round wind protection; food and shelter for the wildlife, nesting places for birds that feed on insect pests on the cultivated crop (Josiah, 2014).

Hybrid hazelnuts are a cross between the European hazelnut- *Corylus avellana*, which is grown for large nuts, and the native American species- *Corylus americana*, which gives the created hybrid winter hardiness and disease tolerance. Unlike the European hazelnuts, these hybrids are grown as multi-stemmed bushes, not as trees. This is important because it reduces their maintenance costs at the same time as increasing their ecological value to the landscape (Braun and Jensen, 2015).

On the periphery of the orchard it is necessary to plant shrubs that are rich in nectar, that are good for insects in the spring, and attract birds, e.g. berberis, hawthorn and spindle (www.wildlifetrusts.org). Birds are attracted to berries, whilst thorns provide a barrier for safe nesting sites (www.rspb.org.uk). After its very early spring bloom, the Vernal Witch Hazel (*Hamamelis vernalis*) forms seed pods that many birds eat, and their berries are eaten by more than 40 species of birds, including Hermit thrush (*Catharus guttatus*), Cardinals (family *Cardinalidae*), Woodpeckers (family *Picidae*) and Robins- the American robin (*Turdus migratorius*) and the European robin (*Erithacus rubecula*). Hazel leaves provide food for the caterpillars of moths, including Large Emerald (*Geometra papilionaria*), Small White Wave (*Asthenes albulata*), Barred Umber (*Plagodis pulveraria*) and Nut-tree tussock (*Colocasia coryli*). Hazelnuts are also eaten by woodpeckers, nuthatches, tits, wood pigeons, jays and small mammals. Hazel flowers provide early pollen as bee food (www.wildlifetrusts.org).

Enescu et al., (2016) report that according to Wang et al., (2007) during the growing season leaves provide food for animals and species of *Lepidoptera*, and according to Rodolfi (1994) and Wall (2001) hazelnuts are an important food supply for several deer species, squirrels and birds

during the cold season. Josiah (2014) reports that hazelnuts, in addition to producing food, also have an ecological aspect for the agroecosystem by reducing the loss of topsoil, often associated with the production of annual cereals. Cultivation of hazelnuts in rows makes it possible to grow annual crops in the alleys formed between the rows, which is also additional income for the farmer, as the soil is improved, biodiversity in the agrocenosis is increased (Josiah, 2014). Rowley et al. (2018) point to another environmental opportunity to use the potential of hazelnuts as biofuels.

Among the reasons to explain the contrariness of Italian hazelnut growers to introduce organic management in their orchards, we could remember: the lower productivity (about 20-30%); the worse fruit quality; the manual de-suckering needing; the impossibility to control grass ground with herbicides. On the other hand, the introduction of organic management in hazelnut orchard could be encouraged by: economic support from regions and/or states; higher price of “biological” nuts; lower management costs; ideological reasons (Roversi, 2016).

A very important feature of the hazelnut (*Corylus avellana*) is that the well-developed, highly branched root system, the main part of which is located at a depth of 20- 40 cm, is especially suitable for growing summer black truffles (*Tuber melanosporum* Vitt., *Périgord black truffle*). Fischer et al. (2017) quote Bonito et al. (2010) who point out that the term “truffle” is often used to refer to all hypogeous or ‘underground’ fungi, but precisely refers to those species included in the genus *Tuber* with at least 180 species currently known in the world. Todesco et al. (2019) cite publications by (Bonito et al., 2010, Bonito et al., 2013), which state that the genus *Tuber* is presented globally in temperate areas including over 200 species, of which at least 30 species are naturally presented in Europe (Ceruti et al., 2003)

Mycorrhizas are the structures, which enable the symbiotic (mutually beneficial) relationship between the host tree and the fungus to be formed (Weston and Park, 2014; Ocete et al., 2015). Truffles are the fruiting bodies of ectomycorrhizal fungi, which live on and around the roots of certain tree species (García- Montero et al., 2006; Weston and Park, 2014). The common name (black truffle from Périgord) comes from the name of a region in France where it is famous. Bruhn and Hall (2011) also point out that the black truffle, like no other, has unique life cycle features and a characteristic habitat requirement. Another important point is that this species matures in winter and is destroyed if not harvested before the soil freezes (Bruhn and Hall, 2011). Weston and Park, (2014) point out that the hazelnut (*Corylus avellana*) is one of the species that can be used as a host for the black truffle. Publications also mention other hosts of the black truffle, such as oak (Reyna, et. al., 2001).

The first uses of truffles date back to 6,000 years ago when the ancients believed that truffles had magical powers aphrodisiacs. In France, Louis XIV commissioned the very first scientific research dedicated to cultivating truffles, thus leading to the development of the culture of truffles, and at the end of the XIX century truffle production reached about 2000 tons of black truffles in a single year (Ştefan, 2016).

Black truffles from natural woodlands are in decline throughout Europe. Truffle collections have suffered dramatically over the last century (Reyna, 2000). In France, during the twentieth century, the production of *T. melanosporum* dropped from 1,000 to 50 tons (Callot et al., 1999). The current decline in wild truffles is so significant that the most viable alternative to restore production is the improved management of cultivated black truffle plantations or orchards (Fischer et al. 2017).

Todesco et al., (2019) cite Murat, (2015) and Reyna and Garcia- Barreda, (2014) who points out that after the first commercialization of seedlings inoculated with *T. melanosporum* in 1973, considerable progress has been made to improve the quality of the inoculated plants. When creating a hazelnut garden, it is possible to use truffle-infected plants that are sold by specialized institutes to make double investment (<https://e-agro.bg>).

CONCLUSION

We can summarize that the presence of hazelnuts in the agroecosystem has many benefits: can stabilize the soil in the riparian environment, and at the same time help to control floods; limiting the onset of erosion; increasing the ecological benefits of land- increasing the biological diversity of the presence of beneficial species, birds. Hazelnuts (*Corylus avellana*) increase the ecological value of the landscape. On the periphery of the orchard it is necessary to plant shrubs that are rich in nectar, that are good for insects in the spring, and attract birds.

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