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ECOLOGICAL AND ECONOMIC IMPORTANCE OF STUDYING PROPAGATION TECHNIQUES OF COMMON HAWTHORN *Crataegus monogyna* Jacq.

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Climate change as a fact of global warming requires the development of different perspectives on the planning and implementation of sustainable forestry techniques. Increasing temperatures cause drought on a global basis. In connection with, this using drought tolerant species in afforestation work is of great importance. In recent years *Crataegus* L. species (hawthorn) are also involved in afforestation. One of these species, *C. monogyna*, is characterized by drought tolerance. Furthermore, *C. monogyna* is the most important non-wood forest product species of Turkey. Hawthorn is widely used in medicine (treatment of coronary heart diseases), and cosmetics industry, agriculture and animal husbandry and human nutrition. On the other hand, it is used in erosion control, afforestation, industrial energy resources and for landscaping. Economic and ecological contribution of hawthorn to the national economy is quite high. Therefore, determination of suitable generative and vegetative reproduction techniques and vast production of seedlings of hawthorn species are extremely important. The characteristics of generative and vegetative propagation of *Crataegus* are discussed. For generative propagation of hawthorn species, the most effective and suitable procedure is treatment of seeds in ash solution. For vegetative propagation in culture *in vitro* the growth induced by BA (benzyladenine) and IBA (indole butyric acid) hormones increases the rate of callus formation and rooting. The best grafting technique is that splicing.

Keywords: *climate change, drought, non-wood forest product, generative and vegetative propagation.*

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INTRODUCTION

Greenhouse gas emission, one of the ecological problems that causes serious problems, is among the factors that contributes to global warming and climate change. The largest share in greenhouse gas emission is mainly carbon dioxide – 82 % (Akin, 2006). Besides this, fossil fuel burning, deforestation, land-use changes, industrial processes and atmospheric accumulation of greenhouse gases released to the atmosphere have increased rapidly since the onset of the industrial revolution. Increasing temperatures cause drought on a global basis. Hence, there is a pressing need of using drought tolerant species in afforestation work has been increasing day by day. *Crataegus* L. species (hawthorn), known for its drought tolerance, was also involved in the afforestation work in recent years (Bayar, Deligöz, 2016).

The genus *Crataegus* has 200 different species in Northern hemisphere and 17 of these species grow in Turkey (Dönmez, 2004, 2007). For example, *C. monogyna* Jacq. is quite common in Turkey. Hawthorn is also known in different regions of Turkey under different names, such as «haluç», «wild rose», «june», «nuts», «alucus» or «sour medlar». This deciduous species is a bush or a small tree that can grow 5–6 metershigh. Fruits that remain on the plant until mid-winter are an important source of food for birds (Mamıkoğlu, 2007). In addi-

tion, it is resistant to sea breezes and air pollution. Fruits, flowers and leaves of hawthorn species are significant constituents of herb medicine industry (Meriçli, 1989; Arslan et al., 2011). *C. monogyna* is of special interest for medicine. The World Health Organization (The world health report…, 2004) reported that hawthorn flowers and leaves can enhance the myocardial function of the heart.

The hawthorns, which are of great importance for human health are also suitable for creating living fences especially in agricultural areas as they are effective in protecting land sites (Kovar et al., 1996; McAdam et al., 1996).

It is a good advantage for planting design that they can easily adapt to urban climate and do not endanger electric lines (Good, Steele, 1981). Hawthorn bushes or small tree forms are used to create privacy in home gardens and town squares. The hawthorn, also utilized as an ornamental plant, is one of the popular species among humans in arid and semi-arid cold regions due to its fruitfulness. It is also used for animal nutrition in terms of wildlife, as well as a source of income.

Besides, it is used for fencing and windbreaking in the harsh climate conditions. Hawthorns are wind resistant species with deep and pile root systems and can be used as curtain system in forming wind protection strips. In addition, although they spread their leaves, they can also be used in noise scarification facilities due to numerous branches. Among the most durable species planted for green belts against pollution, hawthorns can also be used in industrial districts. Because of the strong root systems, hawthorns are also effective in erosion control playing an important role in controlling surface flow in rocky slopeareas.

Consequently, hawthorn species is a plant with high ecological and economic rolewhich is used for creating biological diversity, wildlife, human nutrition, industrial wood materials, potential energy sources, pharmaceutical and cosmetic materials, erosion control and urban afforestation, rural landscape, agriculture, animal husbandry and alternative medicine fields. So, in the near future, the demand for this species should further increase.

SPECIAL PART

In this study, a few research paperson vegetative propagation of Hawthorn species have been analyzed (Bush et al., 1991; Kumar, Bist, 2002; Lapichino, Airò, 2009; Hartmann et al., 2010; Bayar, Deligöz, 2016; Kirillov,Trofimuk, 2016). Several relevant articles, publications, theses and projects were used as research material in the study. The best vegetative propagation techniques about Hawthorn species were tested according to literature data. By the way, it has been tried to create a working base for future work.

The scientific work which has t been carried out was not sufficient to overcome the problems in vegetative and generative propagation of hawthorn species in the world and in Turkey. It is obvious that the scientific studies on hawthorn were not performed up to the level and the work was often conducted by a limited number of methods. The propagation of plants was generally made by generative and vegetative methods. However, generative propagation of fruit trees is not usually performed except for some special purposes. Generative propagation is commonly used in breeding studies and for the production of mother trees needed for obtaining grafts, especiallyin some fruit trees.

There are several studies on generative propagation of hawthorn species (Morgenson, 2000; Bujarska-Borkowska, 2002, 2006, 2007, 2008; Dönmez, 2004, 2007 and others). In generative propagation studies, the importance of seed collection time was emphasized and investigated. Failures, such as self-incompatibility, flushing of flowers and morphological infertility make foreign fertilization necessary for many kinds of fruit. For this reason, plants produced from seeds do not resemble each other and show different characteristics. As is the case in many sectors of the economy, the aim is to produce standard fruit for commercial purposes. The indispensable condition of standard production is to establish a garden with standard varieties with superior features. It is necessary to use vegetative production methods in order to be able to produce standard fruit varieties, while preserving their features. As is characteristic of a vegetative propagation method, in propagation with cutting a trunk, root or leaf is cut from the mother tree and rooting and shooting are provided under suitable environmental conditions. Thus, a new individual plant retains all the features of the mother tree.

Propagation with cutting is an important and practical method of propagation of fruit trees and shrub species, as well as evergreen, broad-leaved and coniferous plant species (Hartmann et al., 2010). Propagation with cutting is the cheapest and most practical method for plants with clonal regeneration ability. In vegetative propagation with cutting it is expected that cutting should form a new root system. However, there should be already buds on the cutting that will allow the formation of shoots. It was noted that the factors such as the age

of the mother plant, type and size of the cutting, the presence or absence of vegetative bud or leaf on the cutting, and the content of water and nutrients in mother plant or in cutting affected the success of rooting process.

Hartmann et al. (2010) reported that three conditions are important to ensure adequate rooting in cutting propagation: 1 – cutting source and its adequate internal state, 2 – special treatment between cutting preparation and planting, 3 – proper environmental conditions during the rooting period. Some researchers have emphasized that the environment into which the cutting is planted and appropriate temperature and humidity content of the environment are important for the rooting process.

It is especially true for propagation of semihardwood or softwood cutting; some conditions, such as water, temperature, light and rooting environment, must be kept at an optimum level so that the cutting could survive during rooting and gain maximum renewal ability (especially for difficult-to-root species and varieties). There are many different types of rooting environment that have important functions, such as keeping the cutting steady during the rooting, providing the necessary moisture for the cutting and allowing air to enter the bottom of the cutting. These media are peat moss, sand, vermiculite and perlite and their mixtures in different proportions. Perlite is a good rooting environment and it should be used because it can be supplied easily and cheaply.

Cutting date has important effect on rooting process. Softwood cuttings should be made as early as possible, although hardwood cuttings must be performed simultaneously with the rest of the trees. In softwood cuttings the leaves must grow up to their full size. It has been determined that one month delay in cutting date may cause reduction in hormones effects (Dumanoğlu et al., 1999). It was between 1925 and 1935 when the importance of hormones in the rooting of the cuttingwas recognized. Nowadays, there are many synthetic substances that stimulate rooting (Kirillov, Trofimuk, 2016). They can be applied to cuttings in pure form or in the form of ready-made preparations with added filler material. Among these, synthetic oxidesIBA and NAA are most often used. Dumanoğlu et al. (1998) tested the effects of IBA and Putrescine at the roots of the wild pear and obtained the best results with 8000 ppm IBA and 1500 ppm Putrescine application.

On the other hand, vegetative propagation with cutting does not provide the desired effect for every plant. Despite the use of different growth regulators, the desired result cannot be achieved for many plants. Growth regulating substances are not effective enough to allow each plant to grow with a cutting. These substances play an important role shortening the rooting period and increasing the rooting rate of species able to grow with cutting. Despite the application of growth regulators, some plants did nottake root.

There is not much information in literature concerned with the propagation of hawthorn especially on rooting after cutting. In our literature review, there is some evidence on this problemin the study conducted by Hartmann et al. (2010). In this work, the researchers noted that they achieved 35 % rooting success with the application of 8000 ppm IBA, 2000 ppm NAA on softwood hawthorn cuttings. In this study wood cuttings made in 2009 and 2010 were planted in the rooting environment after being treated with 6 different IBA doses (500, 1000, 2000, 4000, 6000, 8000 ppm), with the aim of determining the possibilities for the propagation of the hawthorn cuttings with little information about cutting propagation. As a result of the test, roots were not obtained in the cuttings subjected to both control and IBA. It was concludedthat it is difficult to produce the hawthorn with cutting, and the application of IBA for root formation is not sufficient (Ahmadlo et al., 2016).

J. A. Payne and G. W. Krewer (1990) studied the samples with cutting after treatment with a mixture of indole butyric acid (IBA) and naphthalene acetic acid (NAA), taking young and softwood shoots of two cultivars with a resultant 35 % rooting. Hardwood cutting studies were also conducted, but after 12 weeks callus formation was observed and 10 % rootingwas obtained (Bush et al., 1991). The softwood cuttings collected from the shoot tips of *C. monogyna* plants naturally grown in Sicily, the Mediterranean Sea, at 5 concentrations (0, 2.22, 4.44, 8.88 and 17.76 uM) and benzyladenine (BA) at 2 concentrations 0 and 2.46 uM in indole-3-butyric acid 2 × 5 factorial experiment with all possible combinations of IBA,were performed.

Rooting and auxiliary bud propagation rate were checked to determine the optimal combination of growth regulators for shoot propagation. The highest auxiliary bud propagation rate was observed for the Murashige and Skoog (MS) agar medium in the presence of 4.44 uM BA and 2.46 uM IBA. The highest rooting rate was determined for MS agar medium containing 4.90 μM IBA (Lapichino and Airò, 2009). Kumar and Bist (2002) applied a tissue culture method by using the shoot tips of *Crataegus oxycantha.* They used 2 mg/L BA and 0.02 mg/L IBA in the MS nutrient medium for

shoot formation and stated high success in rooting rate after using 0.2 mg/L IBA and 0.2 mg/L NAA in 1/2 MS medium. The embryo and bud explants from *C. pontica* and *C. meyeri* were cultivated in MS and LS nutrient media containing different doses and combinations of BA (Benzyladenine acid), kinetin, BA + IBA, BA + NAA and BA + kinetin. After *invitro* rooting experiments the best rooting (48 %) was obtained for *C. pontica* and 52 % for *C. meyeri* in 1/4 MS environment which include 1 mg/L of IAA (Dinçer, 2010; Dinçer et al., 2016).

Grafting methods have also been utilized for hawthorn species. Among grafting techniques, most commonly used technique is bud grafting; root grafting can also be used (Hartmann et al., 2010). However, the last method is not practical enough. E. W. Bush et al. (1991) reported that, the most commonly used grafting method is clef grafting which should be used for obtaining hawthorn species.

CONCLUSION

The results obtained in the cited references showed that hawthorn is of high ecological and economic value proved difficult for vegetative and generative propagation. For generative propagation of the species, the most suitable procedure showing the highest success rate is treatment of the seeds in ash solution. As a result of the studies on propagation with tissue culture, it is clearly seen that *in vitro* growth medium induced by BA and IBA hormones increases the rate of callus formation and rooting success. The best grafting technique is splice grafting technique. There is an inadequate number of studieson cutting propagation techniques. The highest rooting results were obtained for softwood cuttings treated with IBA and NAA hormones.

In order to fill in the gaps, various combinations should be applied and the results should be checked and recorded. Much more attention should be paid to the issue in order to increase the quality and quantity of seedling production in order to satisfy the future requirements for plants of the hawthorn specie, which are used as non-forest product and are adaptable to harsh habitat conditions and climate change. Many hawthorn species propagate in different regions of Turkey. Each hawthorn species shows different requirements to habitat conditions. Therefore, the studies should be conducted on the habitat conditions of hawthorn species. In addition, new methods and techniques should be developed for both generative and vegetative production of seedlings.

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ЭКОЛОГИЧЕСКОЕ И ЭКОНОМИЧЕСКОЕ ЗНАЧЕНИЕ ИЗУЧЕНИЯ МЕТОДОВ РАЗМНОЖЕНИЯ БОЯРЫШНИКА ОДНОПЕСТИЧНОГО *Crataegus monogyna* Jack.

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Изменение климата, связанное с глобальным потеплением, требует разработки различных подходов к планированию и внедрению новых методов устойчивого ведения лесного хозяйства. Увеличение температуры может привести к глобальной засухе. В связи с этим большое значение имеет использование засухоустойчивых видов для мероприятий по лесовосстановлению. В последние годы виды боярышника *Crataegus* L. также вовлекаются в эти работы. Один из видов – боярышник однопестичный *C. monogyna* Jack. – характеризуется устойчивостью к засухе. Кроме того, боярышник однопестичный является наиболее важным из древесных видов Турции, дающих недревесную продукцию леса. Боярышник имеет многоцелевое использование в медицинской (лечение ишемической болезни сердца) и косметической индустрии, в сельском хозяйстве и животноводстве, а также в качестве продуктов питания. С другой стороны, он используется для борьбы с эрозией, в работах по лесовосстановлению и озеленению, в качестве промышленных энергоресурсов. Вклад боярышника в экономику и экологию страны довольно высок. Таким образом, выявление подходящих методов генеративного и вегетативного размножения и массового выращивания сеянцев у видов боярышника чрезвычайно важно с точки зрения общего его распространения в пределах рассматриваемых районов. Обсуждаются особенности генеративного и вегетативного размножения видов *Crataegus*. Для генеративного размножения видов боярышника наиболее подходящей и успешной методикой является обработка семян в зольном растворе. Для вегетативного размножения в культуре *in vitro* используют среду с добавлением гормонов бензиладенина (БА) и индолилмасляной кислоты (ИМК) для увеличения скорости формирования каллуса и процессов укоренения. Лучший способ прививки – черенкование в расщеп.

Ключевые слова: *изменение климата, засуха, недревесная продукция леса, методы размножения, генеративное и вегетативное размножение.*