
Effects of Some Hormone Applications on Germination and Morphological Characters of Endangered Plant Species *Lilium artvinense* L. Seeds

Kerim Guney, Mehmet Cetin, Hakan Sevik and
Kudret Betül Güney

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/64466>

Abstract

Lilies are economically important plants because of their large and attractive flowers. Thus, many wild species of lilies have been cultivated to produce *Lilium* bulbs or flowers. This work was conducted to analyse the effect of hormone applications on *Lilium artvinense* (Syn: *Lilium ponticum* K. Koch., *Lilium ponticum* var. *artvinense* (Miscz.) P. H. Davis and D. M. Hend., *Lilium carniolicum* var. *artvinense* (Miscz.) P. H. Davis and D. M. Hend and *Lilium pyrenaicum* var. *artvinense* (Miscz.) V.A. Matthews) seeds on germination percentage and seedlings morphological traits. In the research, 1000, 3000 and 5000 ppm doses of IAA, IBA, NAA and GA3 hormones were applied to *L. artvinense* seeds and approximately 180 days later, the number of roots, root length, offset stem height and diameter were assessed. As a result, while the control group except 5000 ppm NAA application achieved an increase in the percentage of germination (40%) of all the applications. Germination frequency up to 100% was obtained using 5000 ppm GA3. Effects of hormone applications on other key morphological characters (rooting percentage, root height, number of scions, scion height and width) are described in terms of growth rate between 1.27 and 2.44.

Keywords: *Lilium artvinense*, hormone, seed, germination, morphological characters, endangered species, root height, scion height, scion width

1. Introduction

In 2000, 47% of world population (2.9 billion people) was living in urban areas, while it is expected that 60–90% of the world's population will be living in urban areas by 2030 [1, 2]. In European countries, more than two-thirds of the whole population are living in urban areas [2, 3].

Rapid urbanization and industrialization caused human beings to distance themselves from nature more and more with each passing day and disrupted humanity's harmony with landscape. As a part of the natural world, humans have brought a piece of universe to every single place they have lived—be it a houseplant, a small garden or a carefully organized park [4]. In today's modern life, vegetation is recognized as an indicator of life quality and livability in cities [5].

In the place they grow, plants reduce air pollution [6–10], reduce noise [11], increase aesthetic value [12], have a positive psychological effect [13, 14], provide energy conservation [15], prevent erosion [16], reduce wind speed and hold the soil with their roots, thus preventing washing away of the soil with rainfalls and streams, and protect wildlife and hunting resources. Open-green areas with plantation are important activity areas for both adults and children [17, 18]. Besides, indoor plants increase the productivity of people working in the environment they grow in [19] as well as relieving physiological stress and reducing negative emotions [20–22].

Such functional use of plants led to the development of ornamental plants market, which finally has reached a point which is economically significant. In 145 countries around the world, the cultivation of ornamental plants is carried out on a total area of 220,000 ha, and the trade volume of ornamental plants is around \$50 billion USD [23].

Such advancement of the ornamental plants market made the researchers to be interested in various issues such as defining the distribution areas [24, 25], protection [26–30], cultivation [31, 32], resistance to stress factors [33, 34], various applications [11, 35, 36], genetic variability [16, 37–40], their relationship with the environment [41–44], raising awareness about plants and legal dimension of the issue [45–47], thus resulting in various works on these issues. In addition to these, a large number of reports were conducted on especially the generative [48–55] and vegetative cultivation methods, and the studies are still going on [56]. However, it is of particular importance to define new species, variations, forms, cultivars or hybrids that can be launched especially to the ornamental plants market, as all plants are of high economic importance.

One of the species that can be dealt with in the ornamental plants market is *Lilium*. *Lilium* belongs to tribe *Lilieae* of *Liliaceae* and contains about 120 species [57]. Lily is one of the most important horticultural plants, and many wild species and cultivars have been cultivated for bulb and ornamental flower production [58]. Thus, many wild species of lilies have been cultivated to produce *Lilium* bulbs or flowers. Almost all cultivars of lilies are used in ornamental flower. Especially Asiatic and oriental hybrids receive a great deal of attention in the international market [59]. Due to the demand for *Lilium* in recent years, the production of *Lilium*

has rapidly increased. For example, *Lilium* was being grown in the Netherlands in an area of 102 ha in 1960, which rose to 2412 ha in 1990 [60, 61].

However, picking especially rare and endemic species in some countries damages the populations of the species in the natural world. The easiest and the most effective way of picking the species from the natural environment is the identification of methods for producing the species in nursery conditions. If such methods are easy, cheap and practical, they can be put into practice more effectively. Seed-based production is of vital importance so as not to damage the natural populations of endangered species in particular.

'IUCN Red Data BOOK' and 'National List of European Threatened Plants List' contain three *Lilium* species from Europe. *Lilium artvinense* (Syn: *Lilium carniolicum* var. *artvinense*, *Lilium ponticum* K. Koch., *Lilium ponticum* var. *artvinense* (Miscz.) P. H. Davis and D. M. Hend., *Lilium carniolicum* var. *artvinense* (Miscz.) P. H. Davis and D. M. Hend and *Lilium pyrenaicum* var. *artvinense* (Miscz.) V. A. Matthews) [62] is one of them [63]. Exposed over a limited area, *L. artvinense* draws attention with its yellow flowers. Its natural population is severely damaged when its bulbs are picked from the natural world. To protect the natural population of the species, easy and cheap means of producing this species should be taught to locals, thereby preventing them from picking the species from the natural environment.

Previous research has mostly attempted to determine the microculture techniques of producing lilies. However, these techniques are difficult, expensive and impracticable for locals. This report examines the production of *L. artvinense* by the use of seeds.

The present review aims to define the effect of some plant growth regulators (hormones) on germination and certain morphological traits of *L. artvinense* seeds. Plant growth-regulating substances are organic chemical compounds, produced naturally in plants or applied externally, and that, even in small amounts, can have positive and negative effects on growth, development and other physiological functions, alone or in combination with other growth regulators. They can be effective in the tissue where they are synthesized, or transported to other parts of the plant and sustain this effectiveness in other organs of the plant [64, 65].

Since 1930s, plant growth regulators have been investigated for their function in agricultural products [64]. Today, there are many works with the aim to define the effects of external application of hormones commonly used to affect the growth rate and development of a plant from the stage of germination to the harvest and post-harvest treatment, and to determine proper type, concentration and time for the application of hormones. The use of hormones is so common today that they are investigated and used in agriculture, forestry and production of various plant species from ornamental to medicinal and aromatic ones [66–68].

The most relevant role of hormones is related to the control and coordination of cell division, growth and differentiation [69]. Plant hormones including ethylene, gibberellins, auxin (indole-3-acetic acid (IAA)), abscisic acid (ABA), brassinosteroids and cytokinins are biochemical substances controlling many biochemical processes and physiological in the plant [69–71]. These key molecules are produced not only by plants but also by soil microbes.

The hormones can be said to be mainly used to ensure propagation by cutting, to increase germinating power of seed, to promote and inhibit blooming, to increase plant resistance

against cold, to increase seed formation in fruits, to increase fruit size, to extend fruit storage time, to increase plant resistance against diseases and pests, to control weeds, to prevent lodging in cotton and cereals, to prevent pre-harvest fruit drop, to synchronize maturity of all plants, to hasten maturity, to remove dormancy and to initiate the growth of suckers and tubers especially during the tissue culture studies [64].

Among all hormones, auxins and gibberellins are the most widely used hormones with usage rates of 20 and 17%, respectively [64]. Auxins, which were firstly used in 1929 [72], mostly cause the expansion and growth of cells and initiate cell elongation, tissue growth and root formation. Auxins are synthesized in all higher plant species, and the most commonly found auxin is indole-3-acetic acid [73].

Other commonly found auxins other than IAA are indole butyric acid (IBA), naphthalene acetic acid (NAA), naphthoxyacetic acid (NOAA), phenoxyacetic acid (POAA), 2,4-D, phenylacetic acid (PAA), para-chlorophenoxyacetic acid (4-CPA) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) [64].

The oldest and most common use of growth-regulating hormones is to stimulate rooting process. Among the hormones in the auxin class, IAA, IBA and NAA are used for stimulating the rooting of cuttings. However, the most commonly applied hormone in agricultural practices is IBA [74]. IBA is applied as a highly concentrated (1000–8000 ppm) and dilute (10–250 ppm) solution. In achieving successful rooting, temperature, light conditions and water supply are also effective parameters [75].

The findings of this study are in conformity with other reports in the literature. Guney et al. [61] reported that hormone treatment caused a significant increase in the rooting percentage of *Lilium martagon* seeds, and the rooting percentage of 28.40% in the control groups could be increased with IAA, IBA, NAA and GA3 treatments. They found the highest rooting percentage in the seeds treated with IAA at 5000 ppm (86.6%).

Turhan [65] reported that the effect of hormone treatment on the rooting percentage of *L. martagon* was statistically significant. He stated that the highest rooting percentage was 66.67%, which was obtained with 3000 ppm IBA + 1000 ppm IAA treatment. In his report, the rooting percentage was found to be 61.73% with 3000 ppm IBA + 3000 ppm NAA treatment and 59.26% with 1000 ppm IBA + 1000 ppm GA3 treatment, while it was 45.83% in the control group. Sevik and Cetin [76] also reported that 3000 ppm IAA treatment in *L. artvinense* seeds increased the rooting percentage from 28.57 to 80.22%.

Rooting percentage can be said to be one of the most important morphological traits that have been examined in the researches. The main focus of the works conducted so far has been the treatments that can increase rooting percentage. The effects of auxins on rooting and plant growth have been so far widely demonstrated [77]. These hormones have been proven to increase rooting percentage in the seeds of *Robinia pseudoacacia* [78], *Pseudotsuga menziesii* [79], *Oryza sativa* [80], *Pisum sativum* [81] and many other plant species.

IBA is one of the most commonly used and studied hormones. Its impact on rooting is continuous and extremely high [82]. There are many works showing that IBA treatments alone

are highly effective in increasing rooting percentage. Polat et al. [83] reported that the rooting percentage of 5% in the control group of plum cuttings increased up to 60% with 500 ppm IBA treatment and to 62.50% with 2000 ppm IBA treatment. In another work, it was revealed that the rooting percentage of 6.7% in the control group of plum cuttings increased up to 46.7% with IBA treatment [84].

Edizer and Demirel [85] reported that IBA treatments at 2000, 3000 and 4000 ppm significantly increased rooting percentage in cuttings of cherry, peach and two different plum species. They indicated that the rooting percentage of 15% in the control group of peach cuttings increased up to 80, 85 and 86.67% with IBA treatments at 2000, 3000 and 4000 ppm, respectively. In the same work, the rooting percentages of 46.67 and 60% in the control groups of plum cuttings and the rooting percentage of 48.34% in the control group of cherry cuttings were found to be 90% with 3000 ppm IBA treatment [85]. Similarly, there are studies reporting that IBA significantly increased rooting percentage in sage cuttings, and the rooting percentage of 16.25% in the control groups was increased up to 78.75% with 100 ppm IBA treatment [86].

Naphthalene acetic acid, which has a significant effect on rooting, was used in this report. It is a synthetic hormone that has been used in orcharding for many years for thinning heavy fruit set. With the effect of thinning, fruit size and quality can be increased [64]. However, the positive effect of NAA on rooting was also proven by many reports. In a study, the rooting percentage of 51.14% in the control group of *Schefflera arboricola* L. was found to have increased to 75% with 5000 ppm NAA treatment [87]. Similarly, a 6-h NAA treatment at 250 ppm was reported to increase the rooting percentage from 0 (control group) to 23% in cuttings of *Capparis sipinosa* L. [88].

Among the natural plant-growing regulators, gibberellins are the third most widely used class (estimated rate of 17%) [65], especially for horticultural applications. GA3 is mostly produced by fermentation from the fungus *Gibberella*. Today, there are approximately 100 known GA molecules, more than 50 found in plant seeds. GA3 is the most widely used one for commercial purposes [64].

There are many reports examining the effect of GA3 on rooting such as the one by Hepaksoy [89] on *Prunus avium* L. and *Prunus mahaleb* L., the work by Aygün and Dumanoglu [90] on *Cydonia oblonga* Miller., the research by Coşge et al. [91] on *Capparis ovata* Desf. and *Capparis ovata* L., the work by Selby et al. [92] on *Picea sitchensis* (Bong.) Carr, the study by Sevik et al. [87] on *S. arboricola* L. and the research by Sevik and Guney [93] on *Melissa officinalis* L. Although it has not been determined that GA3 has a significant effect in many species, there are studies showing that it increases rooting percentage to a considerable extent [61, 94].

This work found that hormone treatments affected root number to a considerable extent. The root number, which was 1.3 in the control group, increased to 1.5 and 1.7 with 5000 ppm IAA treatment and 5000 ppm NAA treatment, respectively.

The findings of this report are in conformity with other works in the literature. Sevik and Turhan [95] reported that all hormone treatments increased the number of roots, and they found that the average root number of 0.97 in the control group of *L. martagon* was increased to 1.33 with 3000 ppm IBA + 1000 ppm NAA treatment. They also reported that the average

root number of 1.14 in the control group of *L. artvinense* was increased to 2.50 with 1000 ppm IBA treatment [76]. Guney et al. [61] also reported that the root number of 1.2 in the *L. martagon* seeds increased up to 2.0 with 3000 ppm GA3 treatment.

The reports conducted on other plant species also show that root number can be increased with hormone treatments. Sevik and Guney [93] reported that the root number of 2.67 in the control group of *M. officinalis* L. was increased to 5.5 with 5000 ppm IBA treatment. Yildiz [96] also reported that the root number of 1.67 in the control group of plum was increased to the average number of 2.3 in the seeds treated with IBA, whereas Ayanoğlu and Özkan [86] indicated that the root number of 4.22 in the control group of *Salvia officinalis* L. was increased to 22.35 with 100 ppm IBA treatment. Similarly, there are studies revealing that IBA treatment can increase the number of roots four to five times in peach, plum and cherry cuttings [85]. In the work by Demiral and Ülger [97], the root number of 4.40 in the control group of cherry cuttings was increased to 16.29 with 6 mg/l NAA treatment, while in the research by Sevik et al. [87] the average root number of 5.82 in the control group of *S. arboricola* L. was increased to 9.63 and 12.33 with 1000 ppm NAA and GA3 treatments, respectively. In the report by Polat et al. [83], the root number of 0.38 in the control group of plum cuttings was increased to 10.43 with 2000 ppm IBA treatment, while in the research by Sevik and Guney [98], the root number of 4.8 in the control group of *M. officinalis* L. could be increased to 12.5 with 1000 ppm IAA treatment.

The findings of this study also reveal that hormone treatments have affected the root length of the plants to a considerable extent, increasing the root length of 27.153 mm in the control group up to 66.419 mm with 5000 ppm IBA treatment. However, more importantly, root lengths were found to be higher than those in the control groups after all hormone treatments. Therefore, the treatments can be said to have a positive effect on the root length.

The highest root lengths were obtained with 3000 ppm IBA treatment in the work by Turhan [65] on *L. martagon*, in the report by Guney et al. [61] on *L. martagon* seeds and in the research by Topacoglu et al. [99] on *Ficus benjamina* cuttings.

The works conducted show that the root length can be increased to 2.75 times in *L. artvinense* with 3000 ppm GA3 treatment [76], 16.17 times in plum cuttings with 2000 ppm IBA treatment [83], 2.34 times in cherry cuttings with 4000 ppm IBA treatment [85], 1.63 times in *S. arboricola* with 1000 ppm IBA treatment [10] and 2.26 times in sage with 100 ppm IBA [87], as compared to the control group.

Besides, results also show that, just like the root length, the highest stem height and diameter values have been obtained with 5000 ppm IBA treatment. Stem height and diameter values are 34 and 27% higher than those of the control group, respectively. Therefore, the treatments can be said not to have such a huge effect on stem formation as to make a significant difference. Similar results were also obtained from *L. martagon* seeds. The stem height of 7.16 mm in the control group of *L. martagon* increased to 8.17 mm with 3000 ppm IBA treatment, and the stem diameter of 2.93 mm increased to 3.78 with 5000 ppm IBA treatment [61]. Likewise, Turhan [65] reported that the stem number of 0.82 in the control group of *L. martagon* increased to 0.91 with 1000 ppm IBA + 1000 ppm IAA treatment, the stem height of 9.05 mm increased to 9.19 mm

with 1000 ppm IBA + 1000 ppm NAA treatment and the stem diameter of 2.40 mm increased to 2.81 mm with 3000 ppm IBA + 1000 ppm NAA treatment.

However, it was indicated that, in *L. artvinense* plants treated with hormones, the stem number of 0.43 was increased to 0.92, the stem height of 1.53 mm was increased to 6.55 mm and the stem diameter of 0.97 mm was increased to 4.3 mm [76].

Apart from these, several other studies have been carried out on *Lilium* cultivation; however, most of them focus on microculture techniques. There are also works conducted on *L. davidii* var. *unicolor* [100] and *L. longiflorum* with IBA and NAA treatment [101], on *L. davidii* var. *unicolor* [102], *L. orientalis* and *L. longiflorum* with IAA, IBA and NAA treatment [103, 104], on *L. longiflorum* with IAA and IBA treatment [105] and on *L. japonicum* with BA and GA3 treatment [106]. However, it is difficult to compare results of these reports with those obtained in the present work, due to rather different experimental approach.

2. Conclusions

Collecting of endangered *Lilium* species for commercial purposes is a great harm to the natural populations. The most effective way to prevent the collection of endangered species from the wild is to establish simple, cost-effective and reproducible methods of cultivation. To date, most studies focus on *Lilium* cultivation using microculture techniques, which are costly and hard to apply for the villagers who collect the flowers from the wild. Therefore, the question is still open.

This report attempted to define simple, inexpensive and effective cultivation methods for *Lilium* species. The work found that hormones applied using simple mechanisms could increase rooting process to a great extent, as well as enhancing the morphological traits of newly generated plants.

The results of this study show that all hormones have been extremely effective especially in increasing germination percentage. The germination percentage of 40% in the control group increased up to 60.66, 75.34, 82.66 and 84% in the seeds treated with NAA, IAA, IBA and GA3, respectively. Besides, 100% germination percentage was achieved with 5000 ppm GA3 treatment.

In addition, the results also reveal that hormone treatments affect each treatment differently. For example, the highest rooting percentage was obtained with 5000 ppm GA3 treatment. On the other hand, the highest number of roots was obtained with 5000 ppm NAA treatment, while the highest root length, stem height and stem diameter values were obtained with 5000 ppm IBA treatment. In practice, it would be best to use the hormone which has the greatest effect on the treatment that is desired to be enhanced.

Similar works may be repeated especially on species that are important in terms of mass cultivation, such as ornamental plants or medicinal or aromatic plants, and important data may be acquired as a result. Thus, further studies will help innovating effort, time and cost-saving practices in plant cultivation.

Author details

Kerim Guney¹, Mehmet Cetin^{2*}, Hakan Sevik³ and Kudret Betül Güney⁴

*Address all correspondence to: mehmet.cetin@temple.edu

1 Faculty of Forestry, Department of Forestry, Kastamonu University, Kastamonu, Turkey

2 Faculty of Engineering and Architecture, Department of Landscape Architecture, Kastamonu University, Kastamonu, Turkey

3 Faculty of Engineering and Architecture, Department of Environmental Engineering, Kastamonu University, Kastamonu, Turkey

4 Graduate School of Natural and Applied Science, Ankara University, Ankara, Turkey

References

- [1] Yüksel ÜD: Investigation of air temperature and surface temperatures in built-up and green areas in the cities: the case of Ankara city. *Ecology*. 2008; 18 (69): 66–74 (in Turkish).
- [2] Sevik H, Karakaş H, Şenöz E: Evaluation of air quality in terms of the amount of carbon dioxide in black sea region. *International Journal of Engineering Science & Research Technology*. 2013; 2 (2): 173–177.
- [3] Konijnendijk CC: A decade of urban forestry in Europe. *Forestry Policy and Economics*. 2003; 5 (2): 173–186.
- [4] Yücel E, Ocak A, Özkan K, Soydam S: In Turkey as an ornamental plant grown trees and shrubs, III. *Ornamentals National Congress*, Ege University, Faculty of Agriculture, Department of Horticulture, Izmir, 8–10 November 2006.
- [5] Öztürk S, Bozdoğan E: Determination of the perceived quality of urban life in new and traditional housing textures. *Fresenius Environmental Bulletin*. 2014; 23 (10): 2415–2421.
- [6] Papinchak H, Holcomb EJ, Orendovici BT, Decoteau, DR: Effectiveness of houseplants in reducing the indoor air pollutant ozone. *HortTechnology*. 2009; 19 (2): 286–290.
- [7] Tani A, Hewitt CN: Uptake of aldehydes & ketones at typical indoor concentrations by houseplants. *Environmental Science and Technology*. 2009; 43 (21): 8338–8343.
- [8] Cetin M: Chapter 55: Using Recycling Materials for Sustainable Landscape Planning. *Environment and Ecology at the Beginning of 21st Century*. Ed.: Recep Efe, Carmen

Bizzarri, İsa Cürebal, Gulnara N. Nyusupova, ST. Kliment Ohridski University Press, Sofia; 2015. p. 783–788, ISBN: 978-954-07-3999-1.

- [9] Öztürk S, Bozdoğan E: The contribution of urban road trees on improving the air quality in an urban area. *Fresenius Environmental Bulletin*. 2015; 24 (5a): 1822–1829.
- [10] Sevik H, Cetin M, Belkayali N: Effects of forests on amounts of CO₂: case study of Kastamonu and Ilgaz Mountain National Parks. *Polish Journal of Environmental Studies*. 2015; 24 (1): 253–256.
- [11] Yiğit N, Öztürk A, Sevik H: Ecological impact of urban forests (example of Kastamonu urban forest). *International Journal of Engineering Sciences & Research Technology*. 2014; 3 (12): 558–562.
- [12] Sevik H, Belkayali N, Aktar G: Change of chlorophyll amount in some landscape plants. *Journal of Biotechnological Sciences*. 2014; 2 (1): 10–16.
- [13] Belkayali N, Kesimoglu MD: The stakeholders' point of view about the impact of recreational and tourism activities on natural protected area: a case study from Kure Mountains National Park, Turkey, *Biotechnology & Biotechnological Equipment*. 2015; 29 (6): 1092–1103.
- [14] Cetin M: Evaluation of the sustainable tourism potential of a protected area for landscape planning: a case study of the ancient city of Pompeiopolis in Kastamonu. *International Journal of Sustainable Development & World Ecology*. 2015; 22 (6): 490–495. DOI: 10.1080/13504509.2015.1081651
- [15] Cetin M: Determining the bioclimatic comfort in Kastamonu City. *Environmental Monitoring and Assessment*. 2015; 187 (10): 640. DOI: 10.1007/s10661-015-4861-3
- [16] Turna İ, Güney D: Altitudinal variation of some morphological characters of scots pine (*Pinus sylvestris* L.) in Turkey. *African Journal of Biotechnology*. 2009; 8 (2): 202–208.
- [17] Tekçe N, Belkayali N, Oğuz D, Baştemur CT: A survey on recreational use of domestic water supply reservoirs: a case study from Kurtboğazi–Ankara, Turkey *African Journal of Agricultural Research*. 2010; 5 (14): 1897–1907.
- [18] Talay İ, Kaya F, Belkayalı N: Socio-economic structure effects on the recreational trends and demands: a case study Bartın city. *Journal of Geographical Sciences*. 2010; 8 (2): 147–156 (in Turkish).
- [19] Djukanovic R, Wargocki P, Fanger PO: Cost-benefit analysis of improved air quality in an office building. *Proceedings of Indoor Air*. 2002; 1: 808–13.
- [20] Lohr VI, Pearson-Mims CH, Goodwin GK: Interior plants may improve worker productivity and reduce stress in a windowless environment. *Journal of Environmental Horticultural*. 1996; 14: 97–100.
- [21] Chang C, Chen P: Human response to window views and indoor plants in the work-place. *HortScience*. 2005; 40: 1354–1359.

- [22] Lohr VI, Pearson-Mims CH, Goodwin GK: Interior plants may improve worker productivity and reduce stress in a windowless environment. *Journal of Environmental Horticulture*. 1996; 14: 97–100.
- [23] Ay S: The export, problems and solution proposals of ornamental plants: investigation of sampling in Yalova. Suleyman Demirel University. *The Journal of Faculty of Economics and Administrative Sciences*. 2009; 14 (3): 423–443.
- [24] Öztürk S: Determining management strategies for the Sarikum Nature Protection Area. *Environmental Monitoring and Assessment*. 2015; 187 (3): 113.
- [25] Šálek L, Güney K: New host plant for the species *Agapanthia lateralis* Gangl. (Coleoptera; Cerambycidae). *Entomological News*. 2014; 124 (1): 29–32.
- [26] Oğuz D, Diriöz ED, Belkayalı N: Tourists' perception of landscape design: the case of resorts in the Belek specially protected area. *African Journal of Agricultural Research*. 2010; 5 (10): 1028–1035.
- [27] Belkayalı N, Sevik H, Guloglu Y: What affects perceptions of local residents toward protected areas? A case study from Kure Mountains National Park, Turkey. *International Journal of Sustainable Development & World Ecology*. 2016; 23 (2): 194–202. DOI: 10.1080/13504509.2015.1098743
- [28] Aricak B, Kucuk O, Enez K: Determining a fire potential map based on stand age, stand closure and tree species, using satellite imagery (Kastamonu central forest directorate sample). *Croatian Journal of Forest Engineering*. 2014; 35 (1): 101–108.
- [29] Canbulat S: Checklist of Turkish Raphidioptera on the basis of distribution pattern and biogeographical analysis. *Turkish Journal of Zoology*. 2015; 39(2): 225–234.
- [30] Cetin M, Sevik H: Evaluating the recreation potential of Ilgaz Mountain National Park in Turkey. *Environmental Monitoring and Assessment*. 2016; 188 (1): 52. DOI: 10.1007/s10661-015-5064-7
- [31] Gumus S, Aricak B, Enez K, Acar HH: Analysis of tree damage caused by rockfall at forest road construction works. *Croatian Journal of Forest Engineering*. 2009; 30 (2): 151–158.
- [32] Aricak B: Using remote sensing data to predict road fill areas and areas affected by fill erosion with planned forest road construction: a case study in Kastamonu Regional Forest Directorate (Turkey). *Environmental Monitoring and Assessment*. 2015; 187 (7): 1–10.
- [33] Sevik H, Cetin M: Effects of water stress on seed germination for select landscape plants. *Polish Journal of Environment Studies*. 2015; 24 (2): 689–693.
- [34] Topacoglu O, Sevik H, Akkuzu E: Effects of water stress on germination of *Pinus nigra* Arnold. *Seeds*. *Pakistan Journal of Botany*. 2016; 48(2): 447–53.

- [35] Kesik HI, Korkut S, Hiziroglu S, Sevik H: An evaluation of properties of four heat treated wood species. *Industrial Crops and Products*. 2014; 60: 60–65.
- [36] Öztürk S, Bilgili B: The use of natural plant species of Kastamonu University campus in landscape. *Kastamonu University Journal of Forestry Faculty*. 2015; 15 (1): 175–182.
- [37] Sevik H, Topacoglu O: Variation and inheritance pattern in cone and seed traits of Scots pine (*Pinus sylvestris* L.) for evaluation of genetic diversity. *Journal of Environmental Biology*. 2015; 36 (5): 1125–1130.
- [38] Sevik H, Ayan S, Turna İ, Yahyaoglu Z: Genetic diversity among populations in Scotch pine (*Pinus silvestris* L.) seed stands of Western Black Sea Region in Turkey. *African Journal of Biotechnology*. 2010; 9 (43): 7266–7272.
- [39] Guney D, Yahyaoglu Z, Turna I, Muller-Starck G: Genetic variation in *Pinus brutia* in Turkey. *Fresenius Environmental Bulletin*. 2014; 23 (5): 1249–1254.
- [40] Güney D, Hatipoğlu E, Atar F, Turna İ, Kulaç, Ş: Changes of some morphological traits of *Oriental Hornbeam* (*Carpinus orientalis* Miller) seeds depending on altitude. In *International Caucasia Forestry Symposium*, 2013, July.
- [41] Kaya LG, Cetin M, Doygun H: A holistic approach in analyzing the landscape potential: Porsuk Dam Lake and its environs, Turkey, *Fresenius Environmental Bulletin*. 2009; 18 (8): 1525–1533.
- [42] Cetin M: Chapter 27: Landscape Engineering, Protecting Soil, and Runoff Storm Water. *Advances in Landscape Architecture, InTech*, Ed: Murat Özyavuz, 2013, p. 697–723. DOI: 10.5772/55812
- [43] Cetin M: Using GIS analysis to assess urban green space in terms of accessibility: case study in Kutahya. *International Journal of Sustainable Development & World Ecology*. 2015; 22 (5): 420–424. DOI: 10.1080/13504509.2015.1061066
- [44] Enez K, Aricak, B, Sariyildiz T: Effects of harvesting activities on litter decomposition rates of scots pine, trojan fir, and sweet chestnut. *Šumarski List*. 2015; 139 (7–8): 361–367.
- [45] Guloglu Y: The establishment of forest ownership and the legal regulations on the forests until the Tanzimat (Reform) period in the Ottoman State. *Kastamonu University. Journal of Forestry Faculty*. 2015; 10 (2): 180–194.
- [46] Guloglu Y: Evaluation of forest land allocation for tourism with regard to agents of administrative act. *Kastamonu University Journal of Economics and Administrative Sciences*. 2015; 10: 45–55.
- [47] Ozturk S, Enez K: Determination of the perceptions of secondary education students towards environment and nature. *Journal of Environmental Protection and Ecology*. 2015; 16 (2): 723–732.

- [48] Olmez Z, Gokturk A, Temel F: Effects of cold stratification, sulphuric acid, submersion in hot and tap water pretreatments on germination of bladder-senna (*Colutea armena* Boiss. & Huet.) seeds. *Seed Science and Technology*. 2007; 35 (2): 266–271.
- [49] Olmez Z, Gokturk A, Temel F: Effects of some pretreatments on seed germination of nine different drought-tolerant shrubs. *Seed Science and Technology*. 2007; 35 (1): 75–87.
- [50] Güney D, Kulaç Ş, Turna İ: Study on cone formation stage of Caucasian Fir (*Abies nordmanniana* ssp. *nordmanniana*). *Kastamonu University Journal of Forestry Faculty*. 2012; 12 (3): 228–233.
- [51] Gokturk A, Olmez Z, Karasah B, Surat H: Effects of cold stratification and sulphuric acid pre-treatments on germination of pomegranate (*Punica granatum* L.) seeds in greenhouse and laboratory conditions. *Scientific Research and Essays*. 2012; 7 (25): 2225–2229.
- [52] Olmez Z, Gokturk A, Gulcu S: Effects of cold stratification on germination rate and percentage of caper (*Capparis ovata* Desf.) seeds. *Journal of Environmental Biology*. 2006; 27 (4): 667–670.
- [53] Kulaç Ş, Nzokou P, Guney D, Cregg BM, Turna I: Growth and physiological response of fraser Fir [*Abies fraseri* (Pursh) Poir.] seedlings to water stress: seasonal and diurnal variations in photosynthetic pigments and carbohydrate concentration. *HortScience*. 2015; 47 (10): 1512–1519.
- [54] Kulac S, Turna I, Çiçek E, Sağlam A, Taşdemir, Ü: Arly field performance of drought-stressed scots pine (*Pinus sylvestris* L.) seedlings. *Pakistan Journal of Botany*. 2015; 47 (4): 1317–1324.
- [55] Boydak M, Dirik H, Tilki F, Çalıkoğlu M: Effects of water stress on germination in six provenances of *Pinus brutia* seeds from different bioclimatic zones in Turkey. *Turkish Journal of Agriculture and Forestry*. 2003; 27 (2): 91–97.
- [56] Ölmez Z, Akin E, Göktürk A: Effects of different growing media and polyethylene pot size on some morphological seedling characteristics of Caper (*Capparis ovata* Desf.). *Artvin Coruh University Journal of Forestry Faculty*. 2011; 12 (2): 101.
- [57] Gao YD, Harris AJ, Zhou SD, He XJ: Evolutionary events in *Lilium* (including *Nomocharis*, Liliaceae) are temporally correlated with orogenies of the Q–T plateau and the Hengduan Mountains. *Molecular Phylogenetics and Evolution*. 2013; 68: 443–460.
- [58] Godo T, Kobayashi, K, Tagami T, Matsui K, Kida T: In vitro propagation utilizing suspension cultures of meristematic nodular cell clumps and chromosome stability of *Lilium formolongi* hort. *Scientia Horticulturae*. 1998; 72: 193–202.

- [59] Lian ML, Chakrabarty D, Paek KY: Growth of *Lilium* oriental hybrid 'Casablanca' bulblet using bioreactor culture. *Scientia Horticulturae*. 2003; 97: 41–48.
- [60] Kumar S, Kanwar J, Sharma D. In vitro propagation of *Lilium*. *Advances in Horticultural Science*. 2006; 20: 181–188.
- [61] Guney K, Cetin M, Sevik H, Guney KB: Influence of germination percentage and morphological properties of some hormones practice on *Lilium martagon* L. Seeds. *Oxidation Communications*. 2016 Jan 1; 39(1): 466–74.
- [62] The Plant list. A working list of all plant species. The plant list- *Lilium artvinense* Misch. [Internet]. 2016. Available from: <http://www.theplantlist.org/tpl1.1/record/kew-280712> [Accessed: 2016-01-15].
- [63] Mitchell A: Thoughts on the classification of species lilies past and present, Sectional Species List. *Lilies and Related Plants*. Ed.: A Mitchell. The Royal Horticultural Society LILY Group, 2009; p. 113–119.
- [64] Kumlay AM, Eryiğit T: Growth and development regulators in plants: plant hormones. *Iğdır University Journal of Research Institute of Science and Technology*. 2011; 1 (2): 47–56 (in Turkish).
- [65] Turhan H: Effects of IBA (indole butyric acid) on rooting and newly stem to *Turkish lili (Lilium martagon L.)* onion [thesis]. Graduate School of Natural and Applied Sciences Department of Forest Engineering: Kastamonu University; Msc Thesis, 201552 p. (in Turkish).
- [66] Seyedi A, Esmaeili A, Zadeh K, Posiabidi M: Comparative evaluation of the rooting in cuttings in (*Bougainvillea glabra L.*). *International Journal of Farming and Allied Sciences*. 2014; 3 (8): 872–875.
- [67] Klein JD, Cohen S, Hebbe Y: Seasonal variation in rooting ability of Myrtle (*Myrtus communis L.*) cuttings. *Scientia Horticulturae*. 2000; 83: 71–76.
- [68] Sağlam AC, Yaver S, Başer İ, Cinkılıç L: The effects of different hormones and their doses on rooting of stem cuttings in Anatolian sage (*Salvia Fruticosa* Mill.). *APCBEE Procedia*. 2014; 8: 348–353.
- [69] Miransari M, Smith DL: Plant hormones and seed germination. *Environmental and Experimental Botany*. 2014; 99: 110–121.
- [70] Graeber K, Nakabayashi K, Miatton E, Leubner-Metzger G, Soppe W: Molecular mechanisms of seed dormancy. *Plant Cell and Environment*. 2012; 35: 1769–1786.
- [71] Santner A, Calderon-Villalobos L, Estelle M: Plant hormones are versatile chemical regulators of plant growth. *Nature Chemical Biology*. 2009; 5: 301–307.
- [72] Went FW: On a substance causing root formation. *Proceedings of the Section of Sciences, Koninklijke (Nederlandse) Akademie van Wetenschappen, Amsterdam*. 1929; 32: 35–39.

- [73] Grunewald W, Noorden GV, Isterdael GV, Beeckman T, Gheysen G, Mathesius U. (2009, September): Manipulation of auxin transport in plant roots during Rhizobium symbiosis and nematode parasitism. *The Plant Cell*. 2009; 21: 2553–2562.
- [74] Cetin V: Plant growth regulators in used fruits and vegetables. *Food and Feed Science-Technology*. 2002; 2: 40–50.
- [75] Şeker M, Akçal A, Sakaldaş M, Gündoğdu M A: Effects of different periods and auxins concentrations on rooting ability of strawberry tree (*Arbutus unedo* L.) cuttings. *Journal of Agricultural Faculty of Uludag University*. 2010; 24 (1): 99–108.
- [76] Sevik H, Cetin M: Effects of some hormone applications on germination and morphological characters of endangered plant species *Lilium artvinense* I. onion scales. *Bulgarian Chemical Communications*. 2016; 48(2): 259–263
- [77] Cervený C, Gibson J: Rooting hormones growers 101. *Crop Cultivation*. 2005; 1:36–44.
- [78] Swamy SL, Puri S, Singh AK: Effect of auxins (IBA and NAA) and season on rooting of juvenile and mature hardwood cuttings of *Robinia pseudoacacia* and *Grewia optiva*. *New Forests*. 2002; 23 (2): 143–157.
- [79] Stefancic M, Stampar F, Osterc G: Influence of IAA and IBA on root development and quality of *Prunus* “GiSelA 5” leafy cuttings. *HortScience*. 2005; 40 (7): 2052–2055.
- [80] Chhun T, Taketa S, Tsurumi S, Ichii M: The effects of auxin on lateral root initiation and root gravitropism in a lateral rootless mutant Lrt1 of rice (*Oryza sativa* L.). *Plant Growth Regulation*. 2003; 39: 161–170.
- [81] Nordström AC, Jacobs FA, Eliasson L: Effect of exogenous indole-3-acetic acid and indole-3-butyric acid on internal levels of the respective auxins and their conjugation with aspartic acid during adventitious root formation in pea cuttings. *Plant Physiology*. 1991; 96: 856–861.
- [82] Zenginbal H, Haznedar A: An investigation on the propagation of tea (*Camellia sinensis* L.) by grafting and budding methods. *Academic Journal of Agriculture*. 2013; 2 (2): 99–106 (in Turkish).
- [83] Polat AA, Kamiloğlu Ö, Durgaç C: The effects of indole butyric acid (IBA) on rooting of wood cuttings of can plums in open air. *MKU Journal of Agricultural Faculty*. 1997; 2 (2): 103–114 (in Turkish).
- [84] Yıldız K: The effect of IBA, CEPA and AVG on rooting of Hardwood cuttings in different fruit species. *Journal of Agricultural Science* 2001; 11 (1): 51–54.
- [85] Edizer Y, Demirel MA: A study on the some characteristics of rooting of green cuttings of the some clonal rootstock in mist propagation. *GOU Journal of Agriculture*. 2012; 29 (2): 1–8 (in Turkish).

- [86] Ayanoğlu F, Özkan FC: Change in tissue mineral elemental concentration during root initiation and development of *Salvia officinalis* L. cuttings and IBA effects. Turkish Journal of Agriculture and Forestry. 2000; 24: 677–682 (in Turkish).
- [87] Sevik H, Güney K, Topaçoğlu O, Ünal C: The influences of rooting media and hormone applications on rooting percentage and some root characters in *Schefflera arboricola*. International Journal of Pharmaceutical Science Invention. 2015; 4 (2): 25–29.
- [88] Söyler D, Arslan N: The effects of some plant growing regulators on the rooting of capers (*Capparis spinosa* L). Turkish Journal of Agriculture and Forestry. 2000; 24: 595–600 (in Turkish).
- [89] Hepaksoy S: Investigations on micropropagation of some cherry rootstocks I. shoot development and proliferation. Ege University Journal of Agriculture Faculty. 2004; 41 (3): 11–22 (in Turkish).
- [90] Aygün A, Dumanoğlu H: Shoot organogenesis from leaf discs in some quince (*Cydonia oblonga* Mill.) genotypes. Journal of Agriculture Sciences, 2006; 13 (1): 54–61 (in Turkish).
- [91] Coşge B, Gürbüz B, Söyler D, Şekeroğlu N: Caper (*Capparis* spp.) cultivation and its importance (a review). Journal of Crop Research. 2005; 2: 29–35.
- [92] Selby C, Kennedy J, Harvey MR: Adventitious root formation in hypocotyl cuttings of *Picea Sitchensis* (Bong.) Carr. —the influence of plant growth regulators. New Phytologist. 1992; 120 (4): 453–457.
- [93] Sevik H, Guney K: Effects of IAA, IBA, NAA, and GA3 on rooting and morphological Features of *Melissa officinalis* L. stem cuttings. The Scientific World Journal. 2013; 2013: 5. <http://dx.doi.org/10.1155/2013/909507>
- [94] Ünal O, Gökceoğlu M, Topcuoğlu ŞF: An investigation on seed germinating and reproduction with cutting of endemic origanum species in Antalya. Akdeniz University Journal of Agriculture Faculty. 2004; 17 (2): 135–147 (in Turkish).
- [95] Sevik H, Turhan H: Effects of IBA (indole butyric acid) on rooting and newly stem to Turkish Lili (*Lilium martagon* L.) onion. The International Conference on Science, Ecology and Technology I (Iconsete'2015 – Vienna) Abstract Book, p. 61, August 25–28, 2015, Vienna, Austria.
- [96] Yildiz K: The effect of IBA, CEPA and AVG on rooting of hardwood cuttings in different fruit species. Yuzuncuyil University Journal of Agricultural Sciences. 2001; 11 (1): 51–54.
- [97] Demiral S, Ülger S. A research on propagation of Gisela 5 cherry rootstock by tissue culture. Akdeniz University Journal of Agriculture Faculty. 2008; 21 (1): 117–121 (in Turkish).

- [98] Sevik H, Guney K: Effects of some hormone applications on morphological features of *Melissa officinalis* L. root cuttings. *Soil-Water Journal*. 2013, 2(2): 1647–1652.
- [99] Topacoglu O, Sevik H, Guney K, Unal C, Akkuzu E, Sivacioglu A: Effect of rooting hormones on the rooting capability of *Ficus benjamina* L. cuttings. *Šumarski list*. 2016 Feb 29; 140(1–2): 39–44.
- [100] LingFei X, FengWang M, Dong L: Plant regeneration from in vitro cultured leaves of *Lanzhou lily* (*Lilium davidii* var. *unicolor*). *Scientia Horticulturae*. 2009; 119: 458–461.
- [101] Bacchetta L, Remotti P, Bernardini C, Saccardo F: Adventitious shoot regeneration from leaf explants and stem nodes of *Lilium*. *Plant Cell, Tissue and Organ Culture*. 2003; 74 (1): 37–44.
- [102] Jing L: Optimization of highly efficient plant regeneration system for *Lilium davidii* var. *unicolor* (Hoog) cotton. *Journal of Southern Agriculture*. 2011; 42 (8): 839–842.
- [103] Chen L-J, Zhang X-G, Ma S, Zhong M, Guo Z-F, Ming J: Study on the rapid propagation of *Lilium oritential* and *Lilium Longiflorum*. *Northern Horticulture*. 2010; 14: 682. DOI: 10.11937/bfyy.2010014037
- [104] Yan FY, Hu XY, Pei XH, Yin DS: Effect of hormone on scale propagation of *Lilium oriental* [J]. *Liaoning Agricultural Sciences*. 2008; 6: 1–5.
- [105] Han Z: Fossilization: five central issues. *International Journal of Applied Linguistics*. 2004; 14 (2): 212–242. DOI: 10.1111/j.1473-4192.2004.00060.x
- [106] Yamagishi M: Effects of cold treatment, BA and GA3 on enlargement and leaf emergence of in vitro cultured bulblets of *Lilium japonicum* Thunb. *Journal of the Japanese Society for Horticultural Science*. 1995; 64 (2): 367–373.